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Report to the Chairman, Committee on Armed Services, House of Representatives

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NAVY AVIATION

V-22 Development — Schedule Extended, Performance Reduced, and Costs Increased

GAO

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National Security and
International Affairs Division

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The Honorable Ronald V. Dellums
Chairman, Committee on Armed Services
House of Representatives

Dear Mr. Chairman:

On October 22, 1992, the Navy terminated the V-22 full-scale development (FSD) contract, awarded a new contract to develop a V-22 variant, and awarded eight other contracts for conceptual studies of helicopter alternatives. The Department of Defense (DOD) plans to compare the V-22 variant with a new or modified helicopter design to determine which better meets Marine Corps medium-lift aircraft needs within budget constraints. For this report, you asked us to examine the development status of the V-22 at the time the FSD contract was terminated, the Institute for Defense Analyses' (IDA) 1990 report on the V-22 and helicopter alternatives,[1] and the Navy's plans to concurrently develop and produce the V-22 variant.

Background

The V-22 is a tilt-rotor aircraft designed to take off and land vertically like a helicopter and to fly like a fixed-wing aircraft by tilting its wing-mounted rotors to function as propellers. The V-22 was being developed to meet joint service operational requirements that would satisfy various combat missions, including medium-lift assault for the Marine Corps (replacing the CH-46 helicopter), search and rescue for the Navy, and long-range special operations for the Air Force.

The Navy awarded an undefinitized letter contract to the team of Bell Helicopter-Textron, Inc., and Boeing Helicopter Company, which began full-scale development of the V-22 in July 1985. On May 2, 1986, the Navy definitized a fixed-price-incentive[2] contract with a target price of $1.7 billion and a ceiling price of about $1.8 billion, including profit. The FSD contract included a 12-aircraft pilot production option for which the Navy provided the contractors advanced procurement funding for long-lead materials in March 1989. However, in December 1989, DOD directed the Navy to terminate all V-22 contracts relating to long-lead

[1]Assessment of Alternatives for the V-22 Assault Aircraft Program, Institute for Defense Analyses, June 1990.

[2]This type of contract includes a ceiling price that limits the cost liability of the government and is generally used when costs and performance are reasonably certain.

procurement, effectively canceling the V-22 program. According to DOD, at a cost of $42.3 million each (in fiscal year 1991 dollars), the V-22 was not affordable when compared to helicopter alternatives that cost from $15.8 million to $32.5 million (in fiscal year 1991 dollars) and are also considered capable of performing amphibious assault missions.

In July 1989, Congress directed DOD to conduct a cost and operational effectiveness analysis of the V-22 and helicopter alternatives. Under contract with DOD, IDA compared the V-22 with seven helicopter alternatives and concluded that generally the V-22 would be the most cost-effective means of performing the missions studied. Congressional supporters believed the V-22 provided additional advantages. They argued that V-22 technology could be applied to both military and civilian uses. For example, the V-22 could relieve severe commercial airport congestion by landing like a helicopter in urban areas. Also, they said its technology had considerable foreign and commercial sales potential, thereby maintaining the U.S. defense industrial base by producing both a commercial and military aircraft and reducing the unit cost to the military. Even though two of the FSD test aircraft crashed and the contractors have been slow resolving V-22 performance deficiencies, Congress has supported the program. In 1992 and 1993, the Congress appropriated additional funds and directed the Navy to develop a production-representative V-22 that would meet the joint service operational requirements by December 1996. Through fiscal year 1993, Congress appropriated $4 billion for the V-22. (See app. I for a chronology of appropriated funding.)

In August 1992, the Acting Secretary of the Navy testified that a V-22 that met the joint services operational requirements could not be built by December 1996 or with the funds provided. He asked instead that V-22 funding be used to develop a variant that would meet the Marine Corps' medium-lift replacement requirements rather than joint service operational requirements. He also asked that, concurrent with development of the V-22 variant, Congress fund design studies to develop helicopter alternatives that would also meet the Marine Corps' medium-lift replacement requirements. Table 1 shows the primary differences between the joint service operational requirements and the Marine Corps' medium-lift replacement operational requirements documents.

Table 1: Marine Corps Requirements Under the Joint Service Operational Requirements and Medium-Lift Replacement Operational Requirements Documents

Capability category	Medium-lift replacement operational requirements document	Joint service operational requirements document
Self deployment	Unspecified	2,100 nautical miles[a]
Cruise speed	180 knots	250 knots
External load	10,000 pounds	8,300 pounds

[a]The capability to fly 2,100 nautical miles without the need for aerial or land refueling.

On October 22, 1992, the Navy terminated the basic V-22 FSD contract and awarded a $550 million undefinitized letter contract to begin engineering, manufacturing, and development (EMD) of a V-22 variant. According to the Navy, contract definitization has slipped from November 1993 to March 1994, and the Navy expects to award either a cost-plus-incentive fee[3] or a cost-plus-award fee contract.[4] At the same time, the Navy contracted for eight advanced helicopter concept studies totaling $19.6 million. Based on the helicopter and V-22 variant concept studies, DOD is conducting a new cost and operational effectiveness analysis to compare the V-22 variant and helicopter alternatives. This analysis was expected to be completed prior to a planned Defense Acquisition Board (DAB) meeting in November 1993. However, this DAB meeting has been rescheduled for September 1994 so the Navy can revise the V-22 program to include the development and funding of a V-22 variant to perform the Air Force's Special Operations Forces mission.

Results in Brief

In May 1986, the Navy expected full-scale development of the V-22 to be completed in June 1992 and cost about $1.8 billion. In October 1992, when the V-22's FSD contract was terminated, the V-22 had been in development for 6 years, and the contractors had spent $2 billion. However, the contractors had not assembled all six flight test aircraft planned for FSD, had not performed all planned drop and fatigue tests, and had not completed all flight testing. The V-22 was 3,500 pounds heavier than its contract empty weight specification, which limited its operational capabilities. Design work and operational testing was not completed on

[3]This is a cost-reimbursement contract used primarily in development and test activities when costs and performance are uncertain. The contract does not include a ceiling price. The contractor is reimbursed for all allowable costs and provided an incentive fee.

[4]This is a cost-type contract that contains a base fee that can be increased based on the contractor's performance. The award fee is determined by the government and cannot be disputed by the contractor.

such critical components as the wing, main landing gear, flight controls, and the rotor drive system.

Concurrent with termination of the FSD contract, the Navy awarded a contract to develop a V-22 variant. It expects the contractors to capitalize on their prior V-22 work but believes the variant will cost $2.5 billion and take 6 years to develop. Accordingly, the Navy could invest nearly 12 years and $5 billion to develop a V-22 tilt-rotor aircraft. V-22 unit procurement cost is projected to be between $49 million and $64 million (in fiscal year 1993 dollars).

In concluding that the V-22 was the most cost-effective alternative to perform the Marine Corps' medium-lift mission, IDA's 1990 cost and operational effectiveness analysis (COEA) assumed that the V-22 could achieve flight speeds of 250 knots, make three or more consecutive round-trips (sorties) from ship to shore, and carry about 10,000 pounds of external cargo slung beneath it. This sortie rate is greater than that assumed for helicopters in the Marine Corps' amphibious lift requirements study. It is used by IDA to demonstrate that 356 V-22s could accomplish the same objective as the stated Marine Corps requirement of 502 medium-lift aircraft. However, to date, the V-22 has been unable to lift 10,000 pounds, and DOD believes transporting heavy external cargo at high speeds could damage the cargo. IDA agreed that assuming slower transit speeds that would reduce the number of sorties to two would make the V-22 less effective and more expensive than most helicopter alternatives.

DOD plans to spend about $1 million to conduct a new COEA comparing the V-22 variant and helicopter options. If the V-22 variant is selected as a cost-effective alternative, the Navy might use a concurrent development and production program. Under one of the proposed acquisition strategies, 12 of the variants would be produced and 40 or more would be in various stages of production before technical and operational evaluations are begun and the Navy has determined whether the variant meets Marine Corps requirements.

V-22 Development Will Take Several Years Longer and Cost Billions More Than Planned

At FSD contract termination, V-22 development efforts had spanned 6 years, two of five V-22 prototypes built had crashed, and the contractors' design could not meet the joint service operational requirements. Nevertheless, the contractors plan to use test aircraft produced under the V-22 FSD contract to incorporate necessary design changes, perform technical risk reduction analyses, and conduct operational testing.

In developing a V-22 variant that meets Marine Corps requirements, the contractors must reduce aircraft weight by 10 percent (3,500 pounds), integrate several hundred specification changes in material and production processes, and conduct flight and operational testing. The Navy believes an improved engine and drive train will compensate for about 1,500 pounds of excess weight. As a result, only 2,000 pounds need to be removed from the airframe.

Proposed specification changes affect many components of the aircraft, including the landing gear, flight controls, the rotor drive system, and the blade-fold/wing-stow mechanism. They are aimed at resolving deficiencies in aircraft weight, vibration, avionics display latency, airframe drag, airspeed, and climatic testing (icing/de-icing capability). (See app. II for details on these deficiencies.)

Total costs to resolve existing engineering deficiencies and complete development are uncertain, but the Navy expects development of the V-22 variant to be completed in 6 years at an estimated cost of $2.5 billion.

Several IDA Study Assumptions May Not Be Realized

IDA concluded in its COEA that in general the V-22 was the most cost-effective alternative for performing the joint services' missions. However, several assumptions and parameters that influenced IDA's conclusion may not be realized. Prior to termination of the FSD contract, the V-22 had not achieved all performance parameters used in the IDA COEA. For example, to meet the joint service operational requirements, the V-22 will be required to fly 2,100 nautical miles, unrefueled, at a continuous cruise speed of 250 knots per hour. Although the V-22 achieved the speed requirement, its range was projected to be only 1,720 nautical miles at the end of FSD. Further, the V-22 must carry 24 troops 200 nautical miles and lift 8,300 pounds of external cargo and transport it 50 nautical miles. However, the Navy estimated that at the end of FSD, the V-22 would be able to transport 24 troops only 131 nautical miles and transport 8,300 pounds of cargo only 24 nautical miles.

IDA also assumed that the V-22 could achieve flight speeds of 250 knots, make three or more consecutive round-trips from ship to shore (sorties), and carry about 10,000 pounds of external cargo slung beneath it. The sortie rate is greater than that assumed for helicopters in a Marine Corps amphibious lift requirements study but was used by IDA to demonstrate that 356 V-22s could accomplish the same objective as 502 medium-lift aircraft, the stated Marine Corps requirement. However, the V-22 has not

demonstrated the capability to lift the maximum cargo weight, and DOD believes transporting heavy external cargo at high speeds could damage the cargo. IDA agreed that assuming two consecutive sorties for the V-22 would make it less effective and more expensive than most helicopter alternatives.

IDA also assumed a slower than originally planned V-22 production rate to reduce short-run program outlays, thereby making the program more affordable in the near term. However, total program costs would probably be increased. According to IDA, V-22 production facilities had not been built and could be designed to accommodate a lower production rate. IDA did not consider a slower production rate for helicopter alternatives but agreed that a reduction in near-term outlays would also be achieved for the helicopter alternatives. (See app. III for more details on IDA's assumptions.)

One V-22 Strategy Is Inconsistent With DOD Policy

One of the Navy's V-22 variant acquisition strategies being considered includes a high level[5] of concurrent development and production to meet the Marines Corps' initial operating capability date of fiscal year 1999. However, concurrency is inconsistent with DOD policy. Navy plans provide for (1) the modification of two FSD aircraft; (2) the design, development, production, test, and delivery of four production-representative aircraft; and (3) the production and delivery of 12 low-rate initial production aircraft by 1999.

Under this strategy, low-rate initial production of 12 aircraft will begin 2 years before flight tests and 3 years before the Navy begins operational tests and evaluation of the four production-representative aircraft. Planned follow-on low-rate productions could yield about 40 additional aircraft. Even though some program concurrency may be acceptable to expedite a program, such concurrency often involves high risk.[6] In our analyses of several major weapon systems that were concurrently developed and produced, we found that the systems may not perform as intended and/or may require significant funds to correct deficiencies.

Title 10, section 2399, United States Code, requires completion of initial operational test and evaluation of a production-representative system

[5]DOD considers a program to have a high level of concurrency when it proceeds into low-rate initial production before significant initial operational test and evaluation are completed.

[6]A high risk is associated with events that require rescheduling or increased overtime or workers to prevent an impact on production schedules or cost.

before a program proceeds beyond low-rate initial production. DOD Instruction 5000.2 defines low-rate initial production as "the production of a system in limited quantity to provide articles for operational test and evaluation, to establish an initial production base, and to permit an orderly increase in the production rate sufficient to lead to full-rate production upon successful completion of operational testing." Determining the quantity of articles needed for this purpose is at the discretion of DOD or the military service. An objective of this policy is to demonstrate that the system meets a military service's requirements before a commitment to production is made. If this policy is followed, system deficiencies could be identified and corrected during development, and costly corrections to units already produced could be avoided.

Recommendations

We recommend that in performing the new cost and operational and effectiveness analysis of the V-22 variant and the helicopter alternatives, the Secretary of the Navy ensure that the capabilities assumed in the analysis for the V-22 variant are more realistic. We also recommend that if the V-22 variant is selected as a cost-effective candidate, the Secretary of the Navy eliminate or significantly reduce the overlap in its development and production to ensure that it meets operational requirements before requesting procurement funds or making a commitment to production.

Agency Comments and Our Evaluation

In written comments (see app. IV) on a draft of this report, DOD agreed with our assessment of the V-22's development status and performance deficiencies at FSD contract termination. It also agreed with our recommendation that the current cost and operational effectiveness analysis include realistic assumptions of the V-22 variant's operational capabilities. However, DOD did not agree that the V-22 variant program had excess concurrency planned between development and production or that some IDA study assumptions unfairly favored the V-22 over helicopter alternatives.

Regarding concurrency, DOD's response said its plan for the V-22 variant, presented in the President's fiscal year 1994 budget, did not include the requirement for a 1999 initial operating capability and concurrency was not part of that plan. Even though DOD does not currently plan to meet the 1999 date, all alternative plans to be considered by the DAB have some degree of concurrency. To the extent that the initial operational capability date is extended beyond 1999, as suggested by DOD, the amount of concurrency in each alternative plan might be reduced. However, the

current Marine Corps' Operational Requirements Document for the Medium Lift Replacement Aircraft, dated March 24, 1992, includes a 1999 initial operational capability date.

In discussions regarding our recommendation, DOD and Navy officials told us the development and production of the V-22 variant would have some concurrency and the DAB would determine how much. The acquisition strategy discussed in this report will be considered by the DAB and has a significant amount of concurrency. As acknowledged, DOD is not in a position to say there is no concurrency planned because the DAB has not met to make that decision. Due to the V-22's developmental problems, the Secretary of the Navy should ensure that any concurrent development and production is eliminated or significantly reduced.

Our conclusion that some IDA study assumptions were not consistently applied is accurate. These assumptions systematically favored the V-22, making the program more affordable. For example, IDA assumed that 356 V-22s could accomplish the same mission as 502 alternative aircraft because of the V-22's projected speed and range advantage. IDA assumed the smaller V-22 fleet could transport the needed number of troops and heavy cargo by making three or more consecutive ship-to-shore sorties. However, the Marine Corps requires that its medium-lift objectives be met in two ship-to-shore sorties.

In commenting on our report, DOD disagreed that IDA's assumptions favored the V-22, in part because it asserted that we assumed a two sortie standard. We did not make that assumption. The two sortie rate is the standard for helicopter alternatives used in the Marine Corps' amphibious lift requirements study. IDA accepted the rate and used it in its study. IDA agreed that limiting the V-22 to the lower sortie rate would make the V-22 less effective and more expensive than most helicopter alternatives. DOD also questioned the feasibility of lifting and transporting heavy external cargo at such high speeds without damaging the cargo.

IDA assumed that avionics comparable to that planned for the V-22 would be installed on helicopter alternatives, driving up the cost of the alternatives. The unit cost of the V-22's avionics package is estimated to cost $2.6 million. However, the Assistant Secretary of Defense for Program Analysis and Evaluation said the Secretary of Defense decided to use an avionics package similar to that installed on the Army's Black Hawk helicopter. The cost of that package is about $700,000 for each helicopter alternative. Subsequently, in response to a draft of this report, DOD's

position is that the V-22's more expensive avionics are required by the helicopter alternatives to meet the Marine Corps' needs. DOD needs to resolve this conflict in positions.

DOD agrees with us that IDA used a lower V-22 production rate and extended delivery schedules to reduce near-term cash outlays and better meet near-term DOD budget constraints. DOD's disagreement is with our characterization of this as a study assumption. Although these factors did not directly impact IDA's cost effectiveness calculation, there is no doubt that IDA assumed lower V-22 production rates to support its recommendation that the V-22's near-term costs could be reduced in this manner. This favored the V-22 in that the same assumption was not made for the helicopter alternatives, even though they would have similarly benefited.

Scope and Methodology

In examining the status of the cost and the developmental progress of the V-22 FSD aircraft and the V-22 variant engineering, manufacturing, and development program, we analyzed program and financial documents and reports and interviewed officials at the Office of the Assistant Secretary of the Navy (Program Analysis and Evaluation), the Deputy Assistant Secretary of the Navy (Air Programs), the Navy's V-22 Program Office, the V-22 Procurement Contracting Office, the Naval Air Systems Command's Office of General Counsel, the Marine Corps' V-22 Osprey Requirements Office, and the Institute for Defense Analyses.

We also visited and interviewed program officials at Boeing Helicopters and the Defense Plant Representative's Office in Philadelphia, Pennsylvania. In addition, we visited the Boeing Helicopter Flight Test Center in Wilmington, Delaware; toured available V-22 prototypes; and observed flight demonstrations.

Our work was performed in accordance with generally accepted government auditing standards.

We are sending copies of this report to appropriate congressional committees, the Secretaries of Defense and the Navy, the Commandant of the Marine Corps, and the Director of the Office of Management and Budget. We will also make copies available to others as requested.

Please contact me on (202) 512-3504 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix V.

Sincerely yours,

Richard Davis
Director, National Security
Analysis

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Abbreviations

COEA	Cost and Operational Effectiveness Analysis
DAB	Defense Acquisition Board
DOD	Department of Defense
EMD	Engineering, Manufacturing and Development
FSD	full-scale development
HMD	Helmet-Mounted Display
HMMWV	high-mobility multipurpose wheeled vehicle
IDA	Institute for Defense Analyses
JSOR	Joint Service Operational Requirement
VSLED	Vibration Structural Life Engine Diagnostic

Research, Development, Test, and Evaluation Funding for the V-22

Then-year dollars in millions

Fiscal year	Appropriation	Chronology of major events
1982	$1.3	Joint Services Advanced Vertical Lift Aircraft Program (JVX) is established.
1983	34.5[a]	Bell-Boeing awards contract for the preliminary design phase of the JVX program.
1984	85.2	Phase II of preliminary design is initiated.
1985	172.4	JVX aircraft is designated the V-22 (Osprey). Bell-Boeing begins FSD under an undefinitized letter cost-type contract.
1986	524.0	Navy definitizes FSD contract as a firm fixed-price incentive contract.
1987	421.7	FSD contract is continued.
1988	462.8	FSD contract is continued.
1989	301.1	FSD contract is continued, but DOD cancels the long-lead procurement contract.
1990	253.7	FSD contract is continued.
1991	234.6	FSD contract is continued. Navy does not modify contract to reflect needed extension in completion schedule from June 1992 to April 1996.
1992	790.0	Congress provides funds for a V-22 production- representative aircraft.
1993	755.0	The Navy terminates the FSD contract and awards an undefinitized contract for a production- representative V-22 variant.
Total	**$4,036.3**	

[a]Figure reflects $29.9 million in Army funds.

Development Issues

When the V-22 full-scale development (FSD) contract was terminated in October 1992, the contractors were experiencing design and manufacturing deficiencies and flight testing delays that affected aircraft performance. Consequently, in developing the V-22 variant, design changes must be made to various aircraft components, including the landing gear, flight controls, rotor drive system, and blade-fold/wing-stow mechanism. These changes are needed to resolve deficiencies in aircraft weight, vibration, avionics display latency, airframe drag, airspeed, and rotor de-icing. The contractors plan to correct these deficiencies during development of the V-22 variant.

Weight

The FSD aircraft was expected to be about 3,500 pounds over the contract's empty weight guarantee.[1] However, the contract also included a clause that exempted the contractors from meeting the empty weight guarantee during FSD and instead required the development of a weight reduction plan to be implemented during production. According to the program office, the clause was added to reduce the contractors' risk under the fixed-price-incentive contract.

The contractors developed a plan to reduce the V-22's weight by 2,200 pounds. They expect to eliminate the remaining 1,300 pounds over specification, which causes a performance penalty, through an increase in the continuous shaft horsepower (from 4,200 to 4,570) and an upgraded drive system. However, in implementing the plan, both cost and impact on aircraft integrity will be considered. Currently, the Navy believes airframe weight will be reduced by 2,000 pounds, and the improved engine and drive train will compensate for the remaining 1,500 pounds of excess weight. Contracts for the design and development of an upgraded V-22 drive system and an upgraded engine with improved fuel efficiency were awarded in June 1991.

Vibration

Unacceptable vibration levels were identified during early government tests. To reduce the vibration, the contractors installed fin weights, pendulum absorbers, a wing fence, and a computer-driven vibration suppressor unit. According to the contractors, tests demonstrated that these modifications have reduced vibrations in the passenger and crew area and meet specifications. However, these fixes have not been tested by government pilots or at full load levels. Until flight tests are conducted at

[1]Under the V-22 variant program, the excess weight and the contractors' reduction plan remain the same.

full envelope airspeeds with a full payload, it is uncertain whether the vibration problem has been resolved. Also, these modifications added 852 pounds to the prototypes.

Avionics Display Latency

The multifunctional display unit, which is used as the primary source of flight information, currently has a display latency of 211 milliseconds. Latency affects the time required by pilots to react to the flight controls and to perform precision control tasks (for example, during flights in bad weather or at night and for shipboard approaches). However, the Navy believes a latency period of more than 150 milliseconds would not permit acceptable handling and would create flight safety concerns. Contractor laboratory testing of an alternate system indicates that the latency period can be reduced to 154 milliseconds.

Flight Control System

According to the contractors, the flight control system's ability to implement complex control commands necessary to fly the dual-mode aircraft (vertical takeoff and horizontal flight) and to achieve the system redundancy required to meet mission reliability, survivability, and vulnerability specifications is crucial to meeting performance requirements. Limited government testing and monitoring have identified concerns with the flight control system, such as the incomplete development of software and the incomplete evaluation of payloads on the integrity of the aircraft structure.

Drag

Airframe drag is 15 percent higher than the contract guarantee. The contractor is currently performing drag reduction surveys and analyses.

Level Flight Airspeed

Airspeed is 12 knots below the FSD contract guarantee.

Climatic Tests (Icing/De-Icing)

In a September 1991 report concerning the cost to complete V-22 full-scale development, the Defense Plant Representative Office (Bell Helicopter Textron, Inc.) stated there was a problem with the de-icing system for the rotor and expressed concern that climatic tests were not scheduled until the 1992/1993 time frame. According to the contractors a solution had been identified and flight demonstrations were planned. Icing tests were scheduled to occur during the climatic testing of FSD prototype number 4. Although the contractors conducted climatic tests from February 3 to

May 22, 1992, no icing tests or blade-fold/wing-stow tests were conducted. The V-22 climatic lab test final report dated May 29, 1992, stated that the scope of the tests was reduced from 24 to 15 test events. Even with the reduction, the contractors completed only nine events, which represents 37 percent of the original plan and 62 percent of the revised plan. Moreover, the tests that were conducted showed numerous deficiencies; significant ones included engine start failures in cold weather and rain, auxiliary power unit clutch problems in cold weather, blade tip delamination in the rain, and blade blister during solar tests. The Naval Air Warfare Center Aircraft Division at Patuxent River, Maryland, has responsibility for coordinating, monitoring, and participating in the contractor's V-22 climatic survey. According to these officials, another climatic survey should be conducted prior to aircraft delivery using a fleet-representative aircraft with a fixed configuration.[2]

Landing Gear

The current placement of the main landing gear affects the proper positioning of the aircraft on amphibious ships. To improve amphibious landings and increase safety, the main landing gear must be redesigned and moved to another position. This change will affect weight distribution and many other aircraft features, which must then be retested and validated.

Vibration Structural Life Engine Diagnostic

The Vibration Structural Life Engine Diagnostic (VSLED) is a built-in maintenance indicator system that monitors the aircraft's vital functions and equipment, such as vibration, the engine, the structural life, and rotor track and balance. The data generated will be used to quickly identify components that need maintenance or repair before routine planned maintenance. According to the program office, this system will lower operation and support costs. However, development of the system is 3 years behind schedule. The subcontractor has provided a system that does not meet specifications. According to the contractors, the vendor is still required to develop a unit that complies with contract specifications. The unit should be available in 1993.

Helmet-Mounted Display

The Helmet-Mounted Display (HMD) will provide sensor pivoting and targeting capabilities and enhance pilot efficiency and flight safety. The display was government-furnished equipment under the FSD contract; however, the Navy changed the specifications for this item and removed it

[2]GAO's Office of Special Investigations is conducting an inquiry into issues related to climatic tests.

from the basic FSD contract. Subsequently, the Navy modified the contract to require Bell-Boeing to obtain a vendor and manage development of the display. This development effort was expected to be completed in 1993; however, all tasks were terminated on October 22, 1992. Now, development, aircraft integration, and flight testing of this equipment are not expected until 1997.

IDA's Assessment of the V-22 and Helicopter Alternatives

Reacting to the Department of Defense's (DOD) 1989 decision to cancel V-22 pilot production because it was not affordable, Congress directed DOD to conduct an independent cost and operational effectiveness analysis (COEA) of the V-22 and helicopter alternatives.[1] DOD contracted with the Institute for Defense Analyses (IDA) to perform the COEA. In June 1990, IDA issued its report, entitled Assessment of Alternatives for the V-22 Assault Aircraft Program.

IDA's Methodology

IDA compared the performance and cost of the V-22 with those of seven medium-lift helicopter alternatives. Four helicopter alternatives considered were not capable of carrying high-mobility multipurpose wheeled vehicles (HMMWV), which are used by the Marine Corps' assault force and can weigh up to 10,000 pounds. Consequently, these aircraft had to be supplemented by heavy-lift helicopters to meet Marine Corps medium-lift requirements. (See table III.1.) Since the Marines currently use CH-53Es to transport their heaviest weapons and equipment, IDA provided the additional heavy-lift capability needed by supplementing the alternative helicopters with CH-53Es.

Table III.1: Alternative Aircraft Considered by IDA

Aircraft that can carry HMMWVs	Aircraft that cannot carry HMMWVs
V-22	CH-60 (stretched)[a]
New helicopter (model)	CH-46E+ (upgraded model)
CH-47M	Super Puma (France)
CH-53E+ (upgraded model)	EH-101 (United Kingdom/Italy)

[a]The aircraft is modified to enable the transport of more troops.

IDA assessed the cost-effectiveness of these aircraft performing four Marine missions and four missions assigned to other military services or government agencies.

IDA obtained input for its study from the military services, a DOD steering committee, Congress, the V-22 contractors, and several helicopter contractors. IDA used the Marine assault force structure defined in the

[1]National Defense Authorization Act for fiscal years 1990-91: House Conference Report 101-331, 460 (1989); House Report 101-121, 54 (1989).

Navy's Lift I[2] and Lift II[3] studies to determine the needs of vertical assault forces. These studies considered Marine Corps assaults against a Soviet motorized rifle division and a third-world (Soviet-style) division, respectively.

Using computer simulations of a conventional assault, IDA considered differences in (1) force composition, (2) threat response time, (3) terrain type (flat or rolling), and (4) tactical factors such as the time of assault (day versus night operations) and the launch ships' distance from the shore. Since the Marines employ a large number of HMMWVs in their assault force, IDA also considered situations in which half the heavy-lift aircraft transported HMMWVs externally, either one at a time (single sling) or two at a time (dual sling). A total of 390 simulations were examined.

IDA structured its cost comparison so that the peacetime cost to develop, purchase, and operate the various aircraft alternatives over a 20-year period was the same. This is called the equal systems cost approach. Due to the capability differences among the alternatives examined, IDA chose to hold costs constant. IDA then determined the level of equipment and capability each alternative offered for the same 20-year and 30-year systems costs. Costs are presented in constant fiscal year 1988 dollars,[4] and the present value was computed using a 10-percent discounted rate.

Comparisons were made at two funding levels. Funding level I, set at $33 billion, was the estimated cost for the 502 V-22s required to meet the Marine Corps' requirements. Funding level II, set at $24 billion, was the estimated cost for the required number of CH-60/CH-53E+ that would be needed to meet the Marine Corps' requirements.[5] Table III.2 indicates the number of aircraft that could be acquired at each funding level.

[2]Department of the Navy Long-Term Amphibious Lift Requirement and Optimal Ship Mix Study, Office of the Chief of Naval Operations/Marine Corps Headquarters, May 25, 1983.

[3]Department of the Navy Integrated Amphibious Operations and USMC Air Support Requirements Study, Office of the Chief of Naval Operations/Marine Corps Headquarters, April 5, 1990.

[4]All costs incurred prior to fiscal year 1990 were not included in IDA's cost-effectiveness assessment.

[5]The CH-60/CH-53E+ mixed fleet was comparable to DOD's preferred substitute for the V-22 when the V-22 program was canceled.

Table III.2: Marine Corps Medium-Lift Alternatives That Could Be Acquired at Two Funding Levels

Marine Corps medium-lift assault aircraft	Aircraft acquired at cost level I ($33 billion)	Aircraft acquired at cost level II ($24 billion)
V-22	502	356
New helicopter	634	450
CH-47M	673	527
CH-60(S)/CH-53E+	287/347	241/284
CH-46E+/CH-53E+	317/336	252/259
Super Puma/CH-53E+	330/322	261/247
EH-101/CH-53E+	252/335	201/257

Table III.3 shows the factors used to determine the measures of effectiveness for the Marine missions.

Table III.3: Measures of Effectiveness for Marine Corps Missions

Mission	Measures of effectiveness
Amphibious assault	The fraction of the assault force lost during combat operations and the ability to establish a combat force ratio of 3 to 1[a] over the enemy
Sustained operations	The number of equivalent payloads that could be delivered from ship to shore per day over a 30-day period
Hostage rescue and raid	The maximum distance between the ship and the hostage site and the time needed to reach the hostage site from the same initial position offshore
Overseas deployment	The time to complete aircraft deployment from the United States and move troops overseas

[a]At a combat force ratio of 3 to 1, the larger force is assumed to have a substantial combat advantage over the enemy.

Generally, IDA found that for the amphibious assault mission, the greater survivability of the V-22 provided a slight to moderate advantage over the helicopter alternatives. For the sustained operations, hostage rescue and raid, and overseas deployment missions, IDA found the V-22 to be the most cost-effective alternative. Also, according to the study, all alternatives considered provided greater capability than the current Marine Corps' medium-lift fleet. In our analysis, we concentrated on test assumptions for Marine Corps missions that were based on the Lift II study profile at cost level II because $24 billion was approximately the amount DOD was willing

to spend for a fleet of aircraft to meet the Marines Corps' medium-lift requirement.

IDA Projected Lower Life-Cycle Cost for the V-22

According to IDA, the V-22 fleet operating and support costs would be lower than a fleet of the alternative helicopter options, particularly options requiring a mix of CH-53Es. (See table III.4.)

Table III.4: Annual Operating and Support Cost Per Aircraft

Dollars in millions

Alternative	Quantity	Annual cost per aircraft	Annual fleet cost
V-22	356	$2.276	$ 810.3
CH-60(S)/CH-53E+	525	$2.136	$1,121.4

Because a cost-estimating model for operating and support of a tilt-rotor aircraft did not exist, IDA adapted both the helicopter (rotary-wing) and airplane (fixed-wing) cost models in developing the V-22's operating and support cost. IDA's methodology was based on the Naval Rotary-Wing Aircraft Operating and Support Cost-Estimating Model except for maintenance materials and component rework. IDA substituted the results derived from the Fixed-Wing Aircraft Operating and Support Cost-Estimating Model for these two elements. This model includes historical maintenance data for jet airplanes that can fly at speeds similar to the V-22's expected speed.

Substituting the factors derived from the fixed-wing model for these two elements may have lowered the overall operation and support cost estimates for the V-22. The IDA COEA project leader acknowledged that the methodology and the models used to develop the operating and support cost data are open to question.

IDA Assumptions

The IDA study included three other assumptions that influenced the study's results concerning the V-22's cost-effectiveness. IDA assumed that (1) the sortie rate for military operations would be higher than the standard rate, (2) the production rate for the V-22 would be slower than the rate for the helicopter alternatives, and (3) avionics similar to the V-22 would be installed in the helicopter alternatives.

Assumption 1: V-22 Higher Sortie Rate

According to the IDA COEA, the Marines Corps could develop, purchase, and operate 356 V-22 aircraft for a 20-year period at a cost of $24 billion. Because the buy of 356 is less than the 502 aircraft the Marine Corps now requires, a higher sortie rate was used to accomplish the Marines' medium-lift mission. As noted in the baseline case, the round-trip, ship-to-shore (sortie) rate is higher than the standard rate used for the Marine Corps' amphibious lift requirements study. Although the V-22's speed of 250 knots per hour or more may enable a higher sortie rate, DOD questions the feasibility of lifting and transporting heavy external cargo at such high speeds without damage to the cargo. In closeout discussions, the Navy informed us that flight testing to support this assumption began in April 1993.

IDA agrees that limiting the V-22 to the sortie rate prescribed by the Marines Corps' amphibious requirements would make the V-22 less effective and much more expensive than most of the helicopter alternatives. IDA noted that if this limitation is imposed, the number of V-22s acquired must be increased from 356 to 502 aircraft to move the prescribed number of troops and their combat equipment ashore.

Assumption 2: V-22's Slowed Production Rate

IDA assumed a slowed production rate for the V-22 to reduce near-term cash outlays. According to IDA, since production facilities for the V-22 have not yet been built, facilities could be designed to accommodate a slower production rate than originally planned. The study indicates a slowed V-22 production rate would reduce near-term costs and make the program more reasonable under DOD budget constraints.

However, IDA did not consider a slower production rate for any of the other alternatives that did not have existing production facilities or the helicopter alternatives that have existing facilities. IDA agrees that a reduction in near-term outlays would also be achieved for the helicopter alternatives if production rates were slowed.

Assumption 3: Comparable Avionics Installed

IDA assumed that avionics comparable to those on the V-22 would be installed in all helicopter alternatives. The V-22's avionics package was estimated to cost $2.6 million. However, DOD planned to use an avionics package that is similar to the one intended for the Army's Black Hawk helicopter and costs about $700,000. According to IDA, the V-22's night piloting system allows the V-22 to fly at low altitudes, thus limiting its

exposure to air defenses. This feature in the V-22's avionics system enhances night operations and increases the V-22's survivability rate.

Using the $2.6 million avionics package for the helicopter alternatives increases their cost, making the V-22 a more cost-effective option. Although the upgraded system makes the helicopters more capable, DOD indicated that a less costly package is sufficient to meet the Marines' amphibious assault missions.

Joint Service Operational Requirement Standards May Not Be Achieved

The Joint Service Operational Requirement (JSOR) range of 2,100 nautical miles without refueling and speed of 250 knots effectively eliminate the helicopter alternatives for Marine Corps missions. These requirements are greater than those used in prior analyses of other ship-to-shore aircraft. However, the V-22 has not been able to achieve the 2,100 nautical mile range without en route refueling.

Technical problems continue to delay development and performance testing schedules and increase costs. Some IDA COEA assumptions that influenced the V-22's cost and performance have not been realized. For example, although the V-22's projected weight was 32,000 pounds (including 1,600 pounds for estimated growth), its actual weight during FSD was 35,350 pounds, 3,350 pounds over specifications. Speed and range are directly affected by an aircraft's weight. The required payload and range cannot be achieved if the aircraft is overweight. Table III.5 includes other study assumptions that were not realized during the V-22's FSD testing. If these performance limitations are considered, the V-22's cost-effectiveness would be adversely affected.

Table III.5: Comparison of the V-22's Payload and Range Under JSORs and Estimated at the End of FSD

Mission[a]	JSOR	Navy's estimate at end of FSD	Difference between JSOR and estimate (percent)
Land assault /troops	Carry 24 troops 200 nautical miles	Carry 24 troops 131 nautical miles	65
Land assault /external cargo	Carry 8,300 pounds 50 nautical miles	Carry 8,300 pounds 24 nautical miles	48
Marines' self-deployment	Fly 2,100 nautical miles without refueling	Fly 1,720 nautical miles without refueling	82

[a]These missions are sensitive to fluctuations in aircraft weight.

Comments From the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON, DC 20301-3000

23 SEP 1993

ACQUISITION

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and International
Affairs Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Conahan:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "NAVY AVIATION: V-22 Development--Schedule Extended, Performance Reduced, and Cost Increased," dated August 5, 1993 (GAO Code 394434), OSD Case 8665-A. The DoD partially concurs with the report.

The GAO expressed concern with development and production concurrency planned for the V-22. The GAO report, however, does not reflect the changes to the V-22 program that were included in the FY 1994 President's budget. Under that plan, concurrency is no longer included in the V-22 program. The overall program plan, acquisition plan, and possible alternatives will be considered further at the next Defense Acquisition Board review, scheduled for November 1993.

The report also stated that the performance requirements assumed in the Institute for Defense Analyses study may not be realized. The GAO cites the design deficiencies in the Full Scale Development aircraft, but does not mention that the Engineering and Manufacturing Development effort is designed to address most of those shortfalls. The GAO also faulted the cost estimating approach and assumptions used in the report. The GAO interpretation of the Institute for Defense Analyses assumptions and results, however, is not accurate. The DoD carefully reviewed the Institute for Defense Analyses study and determined that the estimating approach and assumptions were sound.

The detailed DoD comments on the draft report findings and recommendations are provided in the enclosure. The DoD appreciates the opportunity to comment on the draft report.

Frank Kendall
Director
Tactical Systems

Enclosure

GAO DRAFT REPORT - DATED AUGUST 5, 1993
(GAO CODE 394434) OSD CASE 8665A

"NAVY AVIATION: V-22 Development--Schedule Extended, Performance Reduced, and Costs Increased"

DEPARTMENT OF DEFENSE COMMENTS

* * * * *

FINDINGS

FINDING A: V-22 Development Will Take Several Years Longer and Cost Billions More Than Planned. The GAO reported that, in developing the V-22 variant, the contractors plan to build upon the experience gained under the prior full-scale development contract. The GAO observed that the contractors plan to use test aircraft, produced under the V-22 full-scale development contract, to incorporate necessary design changes that include (1) reducing aircraft weight by 10 percent (3,500 pounds) and (2) integrating several hundred specification changes in material and production processes--and conducting operational testing. The GAO noted that the Navy expects development of the V-22 variant to be completed in 6 years at an estimated cost of $2.5 billion and 6 years already invested. The GAO observed that the Navy could eventually spend nearly $5 billion and take 12 years to develop a tilt-rotor aircraft. (pp. 9-10/GAO Draft Report)

Now on pp. 4-5.

DOD RESPONSE: Partially concur. The program scope increased from full scale development to include four additional production representative aircraft and modification of two existing full scale development aircraft. The Navy will reduce 2,000 pounds on each of the four engineering and manufacturing development aircraft, not 3,500 pounds on the two full scale development aircraft. Only 2,000 pounds of weight reduction is required for the engineering and manufacturing demonstration aircraft, since engine/drive train improvements are equivalent to 1,500 pounds of weight reduction.

FINDING B: Concurrent Development and Production Are Inconsistent With DoD Policy. The GAO asserted that United States Code, title 10, section 2399, requires initial operational test and evaluation of a production representative system to be completed and the results reported to the Secretary of Defense and the Congress before a program proceeds beyond low-rate initial production. The GAO further asserted that DoD Instruction 5000.2 implements that statute and defines low-rate initial production as "the production of a system in a limited quantity to provide articles for operational test and evaluation,

Enclosure

to establish an initial production base, and to permit an orderly increase in the production rate sufficient to lead to full-rate production upon successful completion of operational testing."

The GAO concluded that, notwithstanding statutory requirements and DoD policy, the Navy V-22 variant acquisition strategy includes a high level of concurrent development and production of the aircraft to meet the Marine Corps initial operational capability milestone set for FY 1999. The GAO determined that, according to the program schedule, low-rate initial production of 12 aircraft will begin two years before flight tests and three years before operational tests and evaluation of the four production representative aircraft are begun. The GAO further concluded that planned follow-on low-rate production lots could yield about 40 additional aircraft. In summary, the GAO concluded that, even though some program concurrency may be acceptable to expedite a program, such concurrency often involves high risk. (pp. 10-12/GAO Draft Report)

Now on pp. 6-7.

DOD RESPONSE: Partially concur. While concurrency was included in prior V-22 program plans, the GAO draft report does not reflect the latest plan for the V-22 included in the FY 1994 President's budget. The V-22 program no longer includes a FY 1999 initial operational capability. In addition, no concurrent development and production is planned. The Under Secretary of Defense for Acquisition directed the Navy and Special Operations Command to prepare funding alternatives for consideration at a Defense Acquisition Board review in November 1993 to support the FY 1995 - FY 1999 Future Years Defense Program. The Defense Acquisition will consider statutory requirements, DoD policy, degree of concurrency, and associated level of risk in approving the acquisition strategy for the V-22 program.

FINDING C: Several Institute for Defense Analyses Study Assumptions May Not Be Realized. The GAO reported that several of the Institute for Defense Analyses Study assumptions and parameters, which influenced its conclusion that, in general, the V-22 was the most cost-effective alternative for performing the missions studied--were not demonstrated under the full-scale development contract and may not be realized in developing the variant. The GAO observed that, to meet joint operational service requirements, the V-22 will be required to fly 2,100 nautical miles, unrefueled, at 250-knots per hour. The GAO pointed out that, although the V-22 had achieved the 250 knot speed requirement, its range was projected to be only 1,720 nautical miles at the end of full-scale development. The GAO further observed that joint service operational requirements require the V-22 to carry 24 troops 200 nautical miles and lift 8,300 pounds of external cargo and transport it 50 nautical miles. The GAO noted, however, the Navy estimated that, at the

end of full-scale development, the V-22 would be able to transport 24 troops only 131 nautical miles and transport 8,300 pounds of cargo only 24 miles.

The GAO also noted the Institute for Defense Analyses assumed that the V-22 could achieve flight speeds of 250 knots, while making three daily or more round trips from ship to shore (sorties) and carrying external cargo slung beneath it. The GAO found, however, that the V-22 had not demonstrated the capability to lift the maximum cargo weight--that it is the DoD position transporting heavy external cargo at high speeds could damage the cargo. The GAO reported that, in addition, the Institute for Defense Analyses also assumed a slower than originally planned V-22 production rate to reduce short-run program outlays--thereby making the program more affordable in the near term. The GAO concluded, however, that total program costs would probably increase. (pp. 12-14/GAO Draft Report)

Now on pp. 5-6.

DoD RESPONSE: Partially concur. The GAO report mentions three key performance requirements that cannot be fulfilled by the end of full scale development. The transport of 24 troops 200 nautical miles and carrying 8,300 pounds of external cargo 50 nautical miles will be met with the reduction of 2,000 pounds in the engineering and manufacturing development program. While the estimate for the unrefueled 2,100 nautical mile self-deployment requirement in the engineering and manufacturing development program is approximately 1,720 miles, the self-deployment requirement will be a subject of review at the Joint Requirements Oversight Council--that will support the Defense Acquisition Board Review in November 1993.

Now on p. 15.

FINDING D: Development Issues. The GAO reported that, when the V-22 full scale development contract was terminated in October 1992, the contractors were experiencing design and manufacturing deficiencies and flight testing delays that affected aircraft performance. The GAO indicated that, in developing the V-22 variant, design changes must be made to various aircraft components, including (1) the landing gear, (2) the flight controls, (3) the rotor drive system, and (4) the wing fold mechanism. The GAO explained that those changes are needed to resolve deficiencies in aircraft weight, vibration, avionics display latency, air-frame drag, airspeed, and wing de-icing. The GAO noted that contractors plan to correct those deficiencies during development of the V-22 variant. The GAO discussed the following deficiencies:

- Weight--The GAO pointed out that the full-scale development aircraft was expected to be about 3,500 points over the contract empty weight guarantee. The GAO found that the contractors did develop a plan to reduce the weight of the V-22 by 2,200 pounds. The GAO learned that the contractors expect to

eliminate the effects of the remaining 1,300 pounds of over specification, which causes a performance penalty, through an increase in the continuous shaft horsepower (from 4,200 to 4,570) and an upgraded drive system.

- Vibration--The GAO reported that unacceptable vibration levels were identified during early Government tests. To reduce the vibration, the GAO found that the contractors installed fin weights, pendulum absorbers, a wing fence, and a computer-driven vibration suppressor unit. Until flight tests are conducted at full envelop airspeeds with a full payload, the GAO concluded that it is uncertain whether the vibration problem has been resolved. The GAO noted that the modifications also added 852 pounds to the prototypes; however, the contractor expects to reduce the weight by 280 to 600 pounds in the production aircraft.

Now on p. 15.

- Avionics Display Latency--The GAO explained that the multifunctional display unit, which is used as the primary source of flight information, currently had a display latency of 211 milliseconds. The GAO reported, however, it is the Navy view that a latency period of more than 150 milliseconds would not permit acceptable handling and would create flight safety concerns. The GAO noted that contractor laboratory testing of an alternate system indicates the latency period can be reduced to 154 milliseconds.

Now on p. 16.

- Flight Control System--The GAO pointed out that the limited Government testing and monitoring have identified concerns with the flight control system, such as the incomplete development of software and the incomplete evaluation of payloads on the integrity of the aircraft structure.

- Drag--The GAO found that the airframe drag is 15 percent higher than the contract guarantee. The GAO noted that the contractor is currently performing drag reduction surveys and analyses.

- Level Flight Airspeed--The GAO further found that the airspeed is 11 knots below the full-scale development contract guarantee.

- Climactic Tests--Due to aircraft anomalies associated with cold weather testing, the GAO found that the scope of the test plan was revised from 24 to 15 test events and only 62 percent of the revised test plan was completed. The GAO pointed out that no icing tests or bladefold wing stow tests were conducted. The GAO indicated that, according to the Navy, another climactic survey should be conducted prior to aircraft delivery using a fleet representative aircraft with a fixed configuration.

- Landing Gear--To improve amphibious landings and increase safety, the main landing gear must be redesigned and moved to another position. The GAO concluded that the change will affect weight distribution and many other aircraft features, which must then be retested and validated.

- Vibration Structural Life Engine Diagnostic--The GAO explained the Vibration Structural Lift Diagnostic is a built-in maintenance indicator system that monitors the vital functions and equipment of the aircraft, such as vibration, engine, structural life, and rotor track and balance. The GAO learned that the data generated will be used to quickly identify components that need maintenance or repair before routine planned maintenance. The GAO further learned that the unit should be available in 1993.

- Helmet-Mounted Display--The GAO explained that the display will provide sensor pivoting and targeting capabilities and enhance pilot efficiency and flight safety. The GAO noted that development, aircraft integration, and flight testing of the equipment are not expected until 1997. (pp. 20-25/GAO Draft Report)

Now on p. 17.

DoD RESPONSE: Concur. The purpose of the engineering and manufacturing development program is to correct the deficiencies noted during full scale development.

FINDING E: Institute for Defense Analyses Assessment Methodology for the V-22 Helicopter Alternatives. The GAO reported that, reacting to the DoD 1989 decision to cancel the V-22 pilot production phase because it was not affordable, the Congress directed the DoD to conduct an independent cost and operational effectiveness analysis study of the V-22 and helicopter alternatives. The GAO noted that the DoD contracted with the Institute for Defense Analyses to perform the cost study. The GAO observed that the Institute for Defense Analyses compared the performance and cost of the V-22 with those of seven medium-lift helicopter alternatives. The GAO explained that four of the helicopter alternatives considered were not capable of carrying high-mobility multipurpose wheeled vehicles. The GAO also explained that, consequently, those aircraft would have had to be supplemented by heavy-lift helicopters to meet Marine Corps medium-lift requirements.

The GAO reported that the Institute for Defense Analyses assessed the cost-effectiveness of those aircraft performing four Marine missions and four missions assigned to other Military Services or Government agencies. The GAO noted that the Institute for Defense Analyses obtained input for its study from the Military Services, a DoD steering committee, the Congress, the V-22 contractors, and several helicopter contractors. The GAO learned

that, using computer simulations of a conventional assault, the Institute for Defense Analyses considered differences in (1) force composition, (2) threat response time, (3) terrain type (flat or rolling), and (4) tactical factors--such as the time of assault (day versus night operations) and the distance of the launch ship from the shore.

The GAO reported that, generally, the Institute for Defense Analyses found that, for the amphibious assault mission, the greater survivability of the V-22 provided a slight to moderate advantage over the helicopter alternatives. The GAO observed that for the sustained operations, hostage rescue and raid, and the overseas deployment missions, the Institute for Defense Analyses found the V-22 to be the most cost-effective alternative. The GAO further observed that, according to the study, all the alternatives considered provided greater capability than the current Marine Corps medium-lift fleet. (pp. 26-31/GAO Draft Report)

Now on p. 19.

DoD RESPONSE: Concur.

FINDING F: ***The Institute for Defense Analyses Projected Lower Life-Cycle Cost for the V-22.*** The GAO observed that, according to the Institute for Defense Analyses, the V-22 fleet operational and support costs would be lower than a fleet of the alternative helicopter options--particularly options requiring a mix of CH-53Es. The GAO pointed out that, because a cost-estimating model for operation and support of a tilt-rotor aircraft did not exist, the Institute for Defense Analyses adapted both the helicopter (rotary-wing) and airplane (fixed-wing) cost models in developing the V-22 operational and support cost. The GAO found that the Institute for Defense Analyses substituted the results derived from the Fixed-Wing Aircraft Operating and Support Cost-Estimating Model for those two elements. The GAO concluded that substituting the factors derived from the fixed-wing model for operation and support elements may have lowered the overall operation and support cost estimated in favor of the V-22. (pp. 31-32/GAO Draft Report)

Now on p. 22.

DoD RESPONSE: Nonconcur. On an annual operating and support cost per aircraft basis, the V-22 is 6.6 percent more expensive that an average of the annual operation and support cost of helicopter operations. However, projected fleet size (356 V-22s versus 525 helicopters) was the significant factor contributing to the lower V-22 annual fleet cost, not a lower V-22 annual cost. The Institute for Defense Analyses approach of substituting cost estimating equations from the Navy Fixed-Wing Operating and Support Cost Model for maintenance materials and component rework is appropriate. As stated in the V-22 cost and operational effectiveness analysis report (Volume IV, chapter V, page V-13), "two cost elements in the Rotary-Wing Cost Model gave cost results for the V-22 that were significantly higher than any

of the rotary-wing aircraft." That occurred because the cost estimating relationships used to estimate the two elements have maximum speed and range as dependent variables. Since the V-22 maximum speed and range significantly exceed the maximum speed and range of any of the helicopters in the database used to develop the cost estimating relationship, it is understandable that the resulting cost predictions were outside the range of expected results. It is not good analytical practice to use estimating relationships to predict the costs of systems whose performance characteristics are outside the range of the data used to develop the cost estimating relationship. Thus, the Institute for Defense Analyses approach to estimating maintenance materials and component rework was appropriate. While the approach still has some degree of cost uncertainty, use of the maintenance materials and component rework cost estimating relationships from the Rotary-Wing aircraft model would not have withstood analytical review within the Institute for Defense Analyses or the DoD.

FINDING G: Institute for Defense Analyses Assumptions. The GAO asserted that three other assumptions influenced the study results in favor of the V-22, as follows:

- Assumption 1: V-22 Higher Sortie Rate--The GAO reported that, according to the Institute for Defense Analyses study, the Marines could develop, purchase, and operate 356 V-22 aircraft for a 20-year period, at a cost $24 billion. The GAO concluded, however, that because the buy is less than the 502 aircraft the Marine Corps now requires, a higher sortie rate than was used to accomplish the Marine Corps medium-lift mission would be required. The GAO pointed out that actual flight testing to support the assumption had not been done. The GAO indicated that the Institute for Defense Analyses acknowledged that, if the limitation is imposed, the number of V-22s acquired must be increased from 356 to 502 aircraft to move the prescribed number of troops and their combat equipment ashore.

- Assumption 2: A Slowed V-22 Production Rate. The GAO also observed that the Institute for Defense Analyses assumed a slowed production rate for the V-22 near term cash outlays. The GAO learned that the study indicated a slowed V-22 production rate would reduce near-term costs and make the program more reasonable under the DoD budget constraints. The GAO found, however, the Institute for Defense Analyses did not consider a slower production rate for any of the other alternatives that did not have existing production facilities, or the helicopter alternatives that have existing facilities.

- Assumption 3: Comparable Avionics Installed. The GAO further reported the Institute for Defense Analyses assumed that avionics comparable to those on the V-22 would be installed in

Now on p. 23.

all helicopter alternatives. The GAO observed that the V-22 avionics package was estimated to cost $2.6 million. The GAO asserted that, using the $2.6 million avionics package for the helicopter alternatives increased their cost--making the V-22 a more cost-effective option. The GAO pointed out that, although the upgraded system provides the helicopters with increased capability, the DoD had indicated that a less costly package (about $700,000) is sufficient for meeting the Marine Corps missions. (pp. 32-35/GAO Draft Report)

DoD RESPONSE: Nonconcur. The DoD disagrees with the GAO description of the Institute assumptions, as follows:

- **Assumption 1:** The Institute for Defense Analyses study structured its cost comparison of the V-22 and the helicopter alternatives at two funding levels of life cycle cost over a 20-year period. The higher funding level corresponded to an inventory objective of 502 aircraft over the life of the V-22 program, which includes attrition and pipeline aircraft. The lower funding level represented the best estimate for what the DoD was willing to spend on the Marine Corps medium-lift requirement and represented 356 V-22 aircraft compared to a mix of 525 CH-60(S)/CH-53E+ helicopters. The GAO incorrectly assumed that, because the buy is less than the 502 aircraft requirement, the Marine Corps now requires a higher sortie rate than the perceived standard rate of two sorties. The Institute for Defense Analyses study used three sorties for the V-22, versus two sorties for the helicopter mix because of the additional speed and range of the V-22. The GAO report also suggests that flying at the 250 knots speed for the V-22 would cause significant damage when carrying external cargo. The study clearly states, however, that the speed of the V-22 would clearly fall to 195 knots when carrying an external load. Additionally, the study further included an excursion at the slower speed of 130 knots (but still allowing the V-22 to fly 253 knots when carrying troops or returning empty) with the negligible drop in effectiveness. The Navy is doing flight testing to determine the impacts of higher speeds on external lift and has currently flown the High Mobility Multi-Purpose Wheeled Vehicle at 167 knots. Also, an appendix to the Department of the Navy Lift Study II is being prepared that includes fewer external lifts in the initial assault waves. Those results will be factored into the Medium Lift Replacement Cost and Operational Effectiveness Analysis which will be completed in October 1993 to support a November 1993 Defense Acquisition Board Review.

- **Assumption 2:** Institute for Defense Analyses did not use reduced production rates for their study. The Institute only suggested that lower production rates would mitigate the near-term budget constraints.

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- Assumption 3: The Institute for Defense Analyses study looked at both avionics suites for the V-22 and the helicopter alternatives and determined that the same relative rankings in effectiveness would have applied, with the V-22 still the more cost-effective alternative. Also, the more expensive suite used on the V-22 is required to meet the minimum Marine Corps requirement.

FINDING H: Joint Services Operational Requirement Standards May Not Be Achieved. The GAO reported that the Joint Services Operational Requirement requires the aircraft to fly 2,100 nautical miles without refueling and at speeds of 250 knots or more per hour. The GAO observed that those requirements are greater than those used in prior analyses of other ship-to-shore aircraft. The GAO found that the V-22 had not been able to meet those requirements. The GAO concluded that some of the assumptions influencing the V-22 cost and performance in the Institute for Defense Analyses study have not been realized. (The GAO illustrated other study assumptions in report table III-5--assumptions that were not realized during the V-22 testing. (pp. 35-36/GAO Draft Report)

Now on p. 24.

DoD RESPONSE: Partially concur. See the DoD response to Finding C.

* * * * *

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Now on p. 7.

Now on p. 7.

RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommended that, to ensure that the limited Defense funds are invested wisely, the Secretary of the Navy ensure the capabilities assumed for the V-22 variant in the cost and operational effectiveness analysis comparison with the capabilities of the helicopter alternatives have a high probability of being achieved. (p. 14/GAO Draft Report)

DoD RESPONSE: Concur. The Navy and U.S Special Operations Command will be completing cost and operational effectiveness analyses by October 15, 1993, to support a Defense Acquisition Board Review in November 1993. That analysis will include comparison of the V-22 variant with helicopter alternatives. As the analyses are conducted, monthly status reviews are presented to the upper echelons within DoD to review the integrity of the study. The Defense Acquisition Board will review the results in November 1993 to support the FY 1995 - FY 1999 Future Years Defense Program.

RECOMMENDATION 2: The GAO also recommended that, if the V-22 variant is selected as a cost effective candidate, the Secretary of the Navy should (a) eliminate or significantly reduce the overlap of development and production of the V-22 variant and (b) ensure that the V-22 variant meets operational requirements before requesting procurement funds or making a commitment to production. (pp. 14-15/GAO Draft Report)

DoD RESPONSE: Partially concur. The November 1993 Defense Acquisition Board will consider the degree of concurrency and associated level of risk in approving the acquisition strategy for the V-22 program. The Defense Acquisition Board decision will support the FY 1995 - FY 1999 Future Years Defense Program and may include funds and a commitment to production, if appropriate.

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