BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Mission Effectiveness Of The AV-8B Harrier II Could Be Improved If Actions Are Taken Now

The AV-8B vertical and short-takeoff and landing aircraft will be a substantial improvement over the Marine Corps' AV-8A. However, potential shortages of maintenance personnel and support equipment could adversely affect the aircraft's readiness and mission capability. According to Navy officials, opportunities exist to improve survivability. However, improvement would be at the expense of increased cost and reduced aircraft performance.

For training purposes, the Navy proposed purchasing an existing trainer aircraft (TAV-8A) rather than design and develop a new one (TAV-8B). When initially proposed, purchase of TAV-8As was considered less costly. However, several factors suggest that the TAV-8A is not the best choice.

AV-8B program cost increased approximately $2.9 billion since 1979, due to inflation and other factors. There will be future increases in excess of $1 billion in AV-8B program's cost. The Navy is taking action to reduce program costs.

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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 report presents our views on the major issues concerning the Navy's AV-8B Harrier II aircraft designed to perform close-air-support missions for the Marine Corps.

For the past several years, we have reported annually to the Congress on the status of selected major weapon systems. This report is one in a series that is being furnished to the Congress for its use in reviewing fiscal year 1983 requests for funds.

We are sending copies of this report to the Director, Office of Management and Budget, and to the Secretary of Defense.

Charles A. Bowsher

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

MISSION EFFECTIVENESS OF THE AV-8B HARRIER II COULD BE IMPROVED IF ACTIONS ARE TAKEN NOW

D I G E S T

The AV-8B Harrier II is a light attack aircraft with vertical and short-takeoff and landing capability being developed by the Navy to provide close air support for Marine Corps amphibian forces. The AV-8B is designed to be a substantially improved version of the AV-8A currently used by the Marine Corps.

GAO reviewed this program to provide the Congress a report on the status of the AV-8B Harrier II development. Special emphasis was given to existing and potential problems related to program cost and schedule, aircraft technical performance, and AV-8B mission capability.

Potential maintenance personnel shortages, shipboard space constraints, limited repair capability, and inadequate ground-support equipment could adversely affect the ability of the AV-8B to perform its mission. (See pp. 4 to 7.)

The Navy currently plans to purchase AV-8A trainer aircraft (TAV-8A) to use in training AV-8B pilots. The Navy proposed using TAV-8As for this purpose because developing an AV-8B trainer aircraft (TAV-8B) would be more costly. However, due to changes in production cost, discontinuation of AV-8A production, major TAV-8A and AV-8B differences, and the ineffectiveness of the TAV-8A as a trainer for AV-8B pilots, the TAV-8A may not be the best choice for training AV-8B pilots. A better choice may be to develop a TAV-8B. (See pp. 8 to 10.)

The AV-8B program cost is currently estimated at $9.1 billion for 342 prototype, development and production aircraft, a unit program cost of about $27 million. AV-8B program cost increased approximately $2.9 billion since 1979 and will continue to increase. The largest single reason for past growth has been inflation. Future increases in program cost will result because present estimates do not provide for the procurement of trainer aircraft (over $700 million), a 25-mm. gun system (over $300 million), and a stretched out production schedule which

will result in purchasing more costly aircraft in the future. (See pp. 11 to 15.)

Opportunities exist to improve AV-8B survivability. Major improvements could include reducing the AV-8B's vulnerability to enemy ordnance, adding fire or explosion suppression systems, and reducing the engine's infrared signature. Survivability improvements can be made, but at the expense of increased program cost and reduced aircraft performance. (See pp. 16 to 19.)

RECOMMENDATIONS

GAO recommends that the Secretary of Defense:

--Require the Navy to develop adequate logistics support and support equipment to achieve the weapon system's operational mission. In addition, direct the Navy to plan for the quantity and skills of maintenance personnel needed to support the aircraft when it becomes operational.

--Direct the Navy to reevaluate its plan to purchase TAV-8As and consider developing a TAV-8B after examining the relative costs and benefits of the two trainer aircraft.

--Direct the Navy to determine the costs of developing and procuring a trainer aircraft, the 25-mm. gun system, and other aircraft changes and include these costs in the AV-8B program cost estimate.

--Direct the Navy to reevaluate the current AV-8B program to determine whether reduced annual procurement rates will adversely affect the Marine Corps' ability to meet its mission objectives.

--Direct the Navy to evaluate the cost effectiveness of increasing AV-8B combat survivability. If cost effective, design changes should be made before aircraft production, if possible.

VIEWS OF AGENCY OFFICIALS

GAO did not request official comments on this report because of the need to issue the report in time for congressional consideration of the

fiscal year 1983 defense budget request. GAO did, however, discuss a draft of the report with high level officials associated with the management of the program. These officials agreed with the facts presented in this report and their views are incorporated as appropriate.

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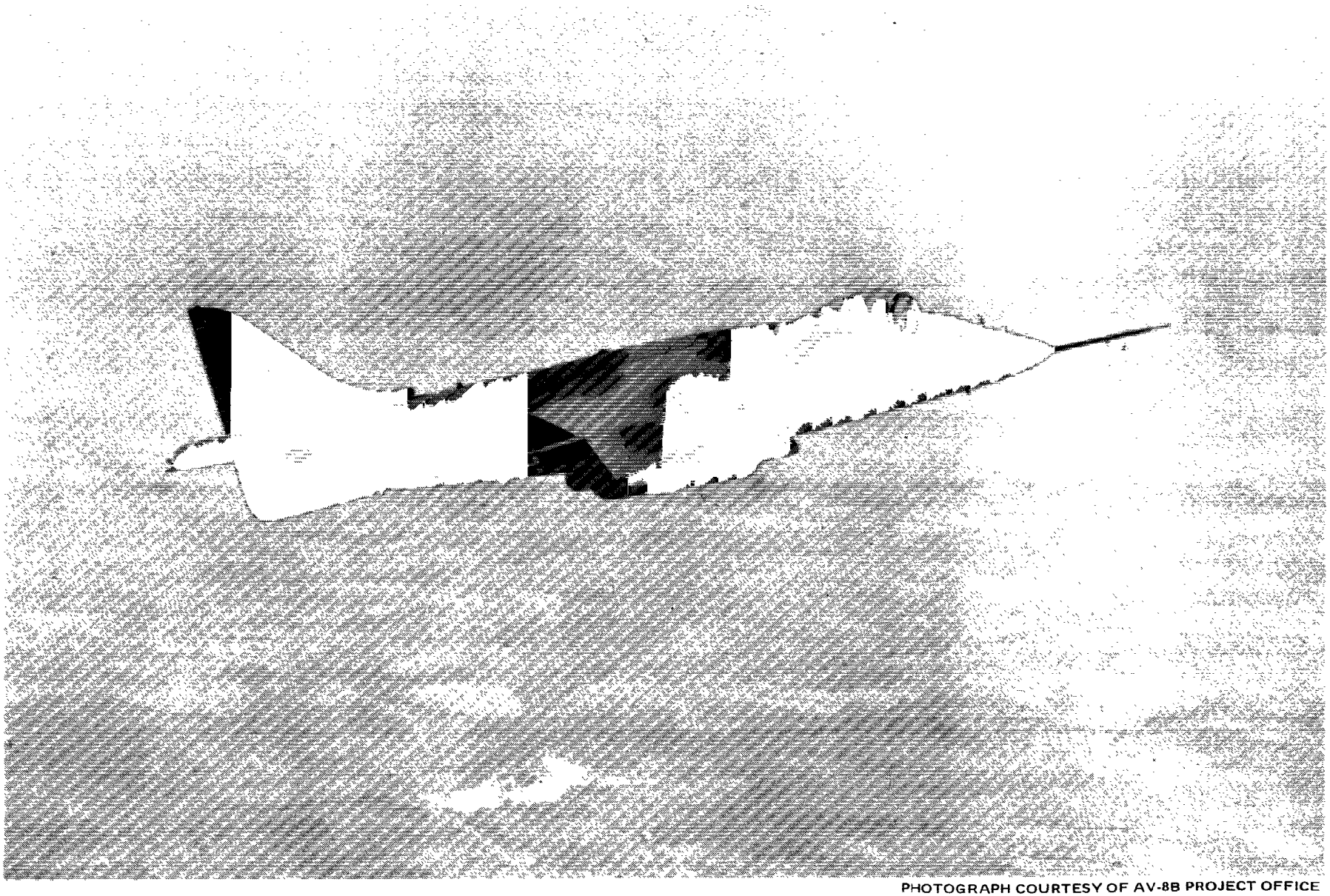

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AV-8B HARRIER II AIRCRAFT

CHAPTER 1

INTRODUCTION

The AV-8B Harrier II is a single-seat, light attack aircraft with vertical and short-takeoff and landing capability. Its primary mission is close air support for the Marine Corps amphibious forces. The vertical and short-takeoff and landing concept allows operations from ships or unprepared bases in close proximity to the battle area, thereby providing rapid response to the ground commander. Secondary mission capability includes interdiction and combat air patrol or deck launched intercept.

The AV-8B is an improved version of the AV-8A which has been in the Marine Corps inventory since 1971. The AV-8A, procured from the United Kingdom, has demonstrated the vertical short-takeoff and landing concept in the Marine Corps scenario. Based on this design, an American contractor, McDonnell Douglas, has refined and improved the airframe to significantly enhance performance while using the basic AV-8A engine. The AV-8B will replace AV-8A and A-4M aircraft currently in the Marine Corps' inventory.

Improvements in the AV-8B design resulted in twice the mission performance of the AV-8A. The AV-8B provides double the payload/radius, reduced pilot workload, thrust vectoring throughout the flight envelope, reduced transonic drag and improved maneuverability, and improved weapons delivery.

New technological features of the AV-8B include an onboard oxygen generating system, a flight stabilization system, modern avionics, an angle-rate bombing system, a 25-mm. gun, composite wing, lift improvement devices, improved engine inlets, and a composite tail section and forward fuselage.

The Navy tested 2 prototype, is building 4 development, and plans to buy 336 AV-8B Harrier II production aircraft for the Marine Corps at an estimated cost of approximately $9 billion. Initial operational capability for the aircraft is scheduled for June 1985.

PROGRAM MANAGEMENT

The AV weapon system project manager, Naval Air Systems Command, Washington, D.C., is responsible for all management and technical aspects of the AV-8B aircraft program.

The McDonnell Douglas Corporation, St. Louis, Missouri, is the prime contractor for the AV-8B. The major subcontractor for the aft fuselage is British Aerospace and the contractor for the engine is Rolls Royce, Ltd. of the United Kingdom. The AV-8B gun system is being developed and produced by General Electric, Burlington, Vermont, and the bombing system is manufactured by the Hughes Aircraft Company, Tucson, Arizona.

The United States and the United Kingdom signed a Memorandum of Understanding covering the proposed procurement of 60 AV-8Bs for the British Royal Air Force. In addition, McDonnell Douglas and British Aerospace signed a licensing/teaming agreement to allocate the production workload. According to this agreement, McDonnell Douglas will perform 60 percent of the airframe work and British Aerospace will perform 40 percent of this work and final assembly of the British AV-8Bs.

PROGRAM STATUS

Full-scale development of the AV-8B Harrier II began in April 1979 and is currently in progress. Design and testing of four full-scale development aircraft is planned at a cost of almost $1 billion (escalated dollars). One of these was delivered and the other three are scheduled for delivery in March and April 1982.

McDonnell Douglas received $60 million in April 1981 for long-leadtime funding of the pilot production program. The first of these aircraft is scheduled for delivery to the Marine Corps in October 1983.

Currently, the approved AV-8B program plan projects an average monthly production rate of 4.5 aircraft, or 54 aircraft per year, beginning in fiscal year 1984. However, because of budget constraints, this plan is likely to be revised to procure 12, 18, and 30 aircraft in fiscal years 1982, 1983, and 1984, respectively.

OBJECTIVE, SCOPE, AND METHODOLOGY

The objective of our review was to provide the Congress with a report on existing and potential problems and other significant matters relating to the development, production, and acquisition of the AV-8B Harrier II weapon system. Specifically, we focused on current program status, including cost, schedules, technical performance, and mission capability.

We based the information in this report on interviews with Navy and contractor officials; reviews of records, regulations, and reports provided by those officials; research of published Department of Defense studies and reports; and research of our previous studies. Although we contacted and attempted to visit British Ministry of Defence officials, they were unwilling to meet with us to discuss their AV-8A experiences and their decisions related to the AV-8B program. We made our review at the following locations:

--AV Weapon System Project Office, Naval Air Systems Command, Washington, D.C.

--McDonnell Douglas Corporation, St. Louis, Missouri.

--Marine Corps Air Station, Cherry Point, North Carolina.

--British Aerospace, Kingston, England.

--Rolls Royce Limited, Bristol, England.

Our review was performed in accordance with our standards for audits of governmental organizations, programs, activities, and functions.

VIEWS OF AGENCY OFFICIALS

We did not request official comments on this report because of the need to issue the report in time for congressional consideration of the fiscal year 1983 defense budget request. We did, however, discuss a draft of the report with high level officials associated with management of the program. These officials agreed with the facts presented in this report and their views are incorporated as appropriate.

CHAPTER 2

ACTIONS TO ENSURE FUTURE OPERATIONAL SUPPORT SHOULD BE TAKEN

Unless steps are taken to overcome known problems, the Navy will experience problems in adequately maintaining the AV-8B upon its delivery to the fleet. Navy officials acknowledged that limited maintenance personnel, shipboard space constraints, and inadequate logistics support may hamper the aircraft's ability to effectively perform its mission.

AV-8B RELIABILITY AND MAINTAINABILITY IMPROVED

During the YAV-8B Prototype Flight Demonstration Program, the AV-8B contractor identified several areas in which AV-8B reliability and maintainability could be improved over that of the AV-8A. These improvements included

--increased use of composite material in the forward fuselage, horizontal tail, and ventral fin;

--replacing the liquid oxygen system by the onboard oxygen generating system;

--improved avionics and instrumentation; and

--an improved engine.

These and other improvements have been made, and AV-8B reliability and maintainability should be improved over that of the AV-8A.

MAINTENANCE PERSONNEL SHORTAGE MAY DIMINISH AV-8B MISSION CAPABILITY

The Navy, like other services, is currently plagued with personnel shortages in its enlisted ranks. These shortages are reflected in the current workload of the AV-8A maintenance personnel.

We were informed that adequate maintenance personnel are not available to support existing AV-8A squadrons, which consist of 9 to 12 aircraft each. According to a Navy official, AV-8A maintenance personnel are currently working an average of 10 hours a day, 5 to 6 days a week to meet routine maintenance requirements.

Furthermore, officials at one Marine Air Wing said that maintenance personnel shortages are so severe that when one AV-8A squadron travels to another area, personnel must be taken from the other two AV-8A squadrons to provide adequate maintenance

support for the one detached squadron. This mode of operation further diminishes the maintenance capability of the remaining squadrons. These severe maintenance constraints continue to occur even though AV-8A squadron deployments over the past 2 years have been reduced by 50 percent.

A recent Navy personnel assessment indicated that 325 maintenance personnel are planned to support a 20-aircraft AV-8B squadron during wartime contingencies. To support a 20-aircraft AV-8A squadron under similar conditions, 320 personnel are required. The Navy agrees that currently available AV-8A maintenance personnel are well below requirements. An assessment of AV-8B maintenance requirements compared with actual experience on maintaining the AV-8A indicates that 30 percent more personnel would be needed to adequately meet wartime AV-8B maintenance requirements.

Based on existing circumstances, the Navy believes that the delivery of more aircraft will compound existing maintenance problems. Navy officials said that unless personnel recruitment, retention, and training are significantly increased, the operational readiness of the AV-8B will be impacted, adversely affecting the mission capability of the AV-8B squadrons.

SPACE CONSTRAINTS AND INADEQUATE MAINTENANCE AND SUPPORT LIMIT AV-8B OPERATION

In performing its mission of close air support, the AV-8B may be sea based as well as shore based. Although the AV-8A has been successfully deployed on Navy helicopter escort ships, effectiveness of sustained sea-based deployment of the AV-8B will be impeded due to shipboard space constraints, limited repair capability, and a lack of support equipment. Also, inadequate ground-support equipment could limit the shore-based operation of the AV-8B.

Space constraints

Shipboard repair of aircraft components is limited because space constraints prevent the inclusion of intermediate repair and test facilities aboard ship. According to the Navy, for conditions requiring sustained sea-based deployment, repair and test facilities are essential for full-mission capability.

Limited repair capability

The Navy will not have shipboard repair capability for the AV-8B engine. According to a Navy official, two spare engines will be allotted to each six aircraft detachment operating aboard ship. The three permanent locations which will have full engine repair capability are Cherry Point, North Carolina; Yuma, Arizona; and Iwa Kuni, Japan. Engines requiring repair or maintenance will be sent to one of these three locations.

The Navy acknowledges that purchasing additional spare engines, which cost over $3 million each, is an expensive way to provide engine maintenance capability. They maintain that this is more cost effective than deploying an engine repair shop for small detachments of aircraft.

Limited support equipment

The lack of necessary support equipment also presents problems in shipboard maintenance of the AV-8B. According to the Navy, ships without adequate flight and hangar deck hoist facilities create maintenance difficulties for the removal of the AV-8B wing and engine. A portable "A" frame hoist, which was designed for use during shore-based operations, can be used in the absence of adequate shipboard hoist facilities. On some ships, however, the use of the "A" frame hoist is cumbersome and unsafe.

We found that ships on which the AV-8A has operated were not equipped with a shipboard hoist. Consequently, the removal and repair of larger aircraft parts, such as the wing, was not possible without the aid of the portable "A" frame hoist. Furthermore, the absence of both a shipboard and portable hoist makes engine removal and replacement appear impossible, since the aircraft wing must be removed to gain access to the engine.

No adequate equipment exists which can be used for shipboard bomb loading. Shipboard bomb loading for the AV-8A has traditionally been done manually. The pitch and role motion of the ship, however, creates an awkward and unsafe condition for this method. Navy officials said that shipboard bomb loading equipment is currently being developed.

Inadequate ground-support equipment

There is also a problem with adequate ground-support equipment for shore-based operations. For example, the Navy used an MF-40 tow tractor as the AV-8A tow vehicle for rough terrain. However, logistics support for this tractor was no longer available. Consequently, the Navy discontinued the use of the tractor and replaced it with the AMS-32 tractor, which is not a rough terrain vehicle. According to the AV-8A squadron personnel, it is essential that they have an off-road rough terrain tractor, and they do not consider the new AMS-32 tractor to be an adequate replacement.

CONCLUSIONS

Although the reliability and maintainability of the AV-8B should be improved over that of the AV-8A, the limited availability of maintenance personnel, inadequate logistics support, and other constraints may limit the operational readiness of the AV-8B.

RECOMMENDATION

We recommend that the Secretary of Defense require the Navy to develop adequate logistics support and support equipment to achieve the weapon system's operational mission. We also recommend that the Secretary direct the Navy to plan for the quantity and skills of maintenance personnel needed to support the aircraft when it becomes operational.

CHAPTER 3

TAV-8A INAPPROPRIATE AS TRAINER FOR AV-8B PILOTS

The Navy is currently considering purchasing the AV-8A trainer aircraft (TAV-8A) to use as trainers for AV-8B pilots. However, several factors, such as the discontinuation of AV-8A production in the United Kingdom, increases in production costs, major TAV-8A and AV-8B differences, and the questionable effectiveness of the TAV-8A as a trainer aircraft, indicate that the TAV-8A is not the wisest choice for AV-8B training. Current Navy training evaluations suggest that a better course of action is the development and production of an AV-8B trainer aircraft (TAV-8B).

AV-8A AIRCRAFT NO LONGER IN PRODUCTION

The Navy's current proposal is to purchase 18 two-seat TAV-8As from British Aerospace. However, the AV-8A production line in the United Kingdom has been closed down. A large number of AV-8A parts are either no longer in production or are going out of production shortly. The purchase of the TAV-8A would require the Marine Corps to establish and maintain two separate maintenance and logistics systems because TAV-8A parts and components are not compatible with the AV-8B.

TAV-8A COSTS MAY EXCEED THAT OF TAV-8B

When the proposal to purchase the TAV-8A was made in 1979, the costs of procuring the aircraft were significantly less than the costs of developing and producing a United States made TAV-8B. However, due to increasing inflation in the United Kingdom and the discontinuation of AV-8A production, Navy officials now believe that the costs of procuring and supporting the TAV-8A may exceed the costs of developing, producing, and supporting the TAV-8B.

Preliminary Navy cost estimates indicate that the cost of procuring 18 new TAV-8As and extending the service life of 6 existing TAV-8As would be $677.3 million while the cost of procuring 24 new TAV-8Bs would be $722.5 million. The TAV-8B cost estimate includes the cost of research and development. However, the TAV-8A estimate does not include the costs associated with retooling and restarting the production line. Neither estimate includes operating and support costs, but the Navy projects that these costs will be significantly less for the TAV-8B because of the commonality of parts. These estimates are preliminary in nature and McDonnell Douglas is currently conducting a study to establish cost estimates which include these variables.

A Navy official projected that the difference in the costs of maintaining and supporting the two aircraft would result in the TAV-8B costing less than the TAV-8A over the expected life of the aircraft.

TAV-8A AND AV-8B ARE DIFFERENT AIRCRAFT

Although the TAV-8A and the AV-8B both operate under the vertical and short-takeoff and landing concept, they are entirely different aircraft with different cockpit instrumentation, systems, and handling and flight characteristics. For example, of 315 panels, controls, displays, and switches which were identified for both aircraft, 99 are unique to the TAV-8A, 100 are unique to the AV-8B, and 116 are common to both aircraft.

An examination of 13 abnormal/emergency operating procedures, such as engine fire, uncommanded roll on vertical takeoff, and compressor stall, revealed that of the 66 common controls and indicators which are used by the pilot during these procedures, 21 are in different locations and 4 serve different functions in the 2 aircraft. Pilot reaction to the wrong control or indicator during an emergency or abnormal situation could jeopardize flight safety.

In addition, the new wing, engine inlet system, lift improvement devices, and other AV-8B aerodynamic improvements create differences in the flight control inputs for the two aircraft. For instance, lateral movement of the control stick the same distance in both aircraft will result in approximately 67 percent more roll in the AV-8B than in the TAV-8A.

TAV-8A INEFFECTIVE AS TRAINER FOR AV-8B PILOTS

The differences between the TAV-8A and AV-8B impose two constraints on the AV-8B training program. First, they limit the amount of positive transfer of training from the TAV-8A to the AV-8B. According to a recent TAV-8A/AV-8B commonality analysis conducted for the Navy, very little positive transfer of training will be achieved through the progression from the TAV-8A to the AV-8B. In fact, there is a high probability that negative transfer of training will occur, depending on the student's level of proficiency. Secondly, aircraft differences limit the design and reduce the effectiveness of the AV-8B training syllabus. An assessment of the training benefits that may be achieved by using the TAV-8A or the TAV-8B in the AV-8B flight training syllabus indicates that the use of the TAV-8B would decrease the minimum pilot training period from 91 to 79 days.

Another concern is that if the TAV-8A is procured, additional training would be required to transition TAV-8A trained pilots to the AV-8B. This training program would include a 7-day ground school to teach all AV-8B systems, blind flight simulation training, and a minimum of five training flights to familiarize the pilot with the AV-8B. According to the Navy, use of the TAV-8B would eliminate this additional training requirement.

NAVY OFFICIALS PREFER TAV-8B

According to Navy officials, it is more reasonable to produce the TAV-8B because it would be more compatible with the AV-8B, would reduce the pilot training requirements, and might be more economical. Navy and contractor officials believed that the TAV-8B could be integrated into the AV-8B program in an efficient manner through the engineering change proposal process. According to the Navy, the TAV-8B could be delivered to the AV-8B training squadron by mid-1986 with proper management of the design, test, and evaluation of the aircraft and with initial long-lead funding provided by March 1983.

Producing the TAV-8B would require extending the AV-8B's forward fuselage to accommodate the second seat, redesigning the cockpit, and instituting several minor changes. These modifications may effect the center of gravity of the aircraft and may result in additional research and development efforts and testing. The Navy, however, contends that the production of the TAV-8B is the better course of action, although their plans have not been changed to indicate this preference.

CONCLUSIONS

The Navy currently proposes purchasing 18 two-seat TAV-8As. When this decision was made, purchase of the TAV-8A appeared to be a viable alternative for the Navy's training requirements. However, the discontinuation of AV-8A production and the TAV-8A's ineffectiveness as a trainer for AV-8B pilots indicate that the aircraft is not the best choice for AV-8B pilot training.

RECOMMENDATIONS

We recommend that the Secretary of Defense direct the Navy to reevaluate its plan to purchase TAV-8As and consider developing a TAV-8B after examining the relative costs and benefits of the two trainer aircraft.

CHAPTER 4

AV-8B PROGRAM COSTS HAVE INCREASED AND FUTURE COST INCREASES ARE ANTICIPATED

AV-8B program cost estimates have been steadily increasing. In addition, future cost increases are anticipated due to inflation and a proposed reduction in the production rate. Other increases will occur to provide for the procurement of trainer aircraft, a change to the leading edge of the wing, and the purchase of a 25-mm. gun system.

To compensate for increasing costs, the Navy has initiated several cost reduction actions which include plans to contract directly with the AV-8B engine contractor, use of existing subsystems common to other aircraft, and the use of less expensive material in certain sections of the aircraft.

FUNDING EXPERIENCE

In May 1977 the Department of the Navy submitted a Five-Year Defense Plan to the Secretary of Defense which included approximately $488 million for AV-8B research, development, test and evaluation and $1.2 billion for AV-8B aircraft procurement during fiscal years 1979-83. In August 1977 the Secretary of Defense delayed the program due to the Department of Defense's budget decreases. In the spring of 1978, the Congress restored the AV-8B research, development, test and evaluation program to its initial funding level.

In January 1979 the Secretary of Defense deferred $108 million of fiscal year 1979 AV-8B research, development, test and evaluation funds and did not request AV-8B program funds in the fiscal year 1980 budget submission to the Congress. However, due to congressional support of the program, the Secretary of Defense released the fiscal year 1979 funds and the Congress subsequently appropriated $180 million in fiscal year 1980 to continue the AV-8B program.

The Secretary of Defense again did not request AV-8B funding in the fiscal year 1981 budget submission. The Congress, however, continued to support the program and appropriated fiscal year 1981 AV-8B funding of $243 million for development and $90 million of long-lead money toward procurement of 12 production aircraft in fiscal year 1982.

The Secretary of Defense included $231 million for AV-8B research, development, test and evaluation in the fiscal year 1982 budget submission. However, the budget request was amended in February 1981 reducing funding to $227 million. A supplemental of $657 million was added to fund completing the first 12 AV-8B production aircraft and to initiate long-lead procurement in support of 24 production aircraft in fiscal year 1983.

AV-8B PROGRAM HAS EXPERIENCED COST INCREASES

AV-8B estimated program cost has increased significantly. In our last AV-8B report, 1/ we showed that program cost estimates had increased from $6.2 billion in 1979 to over $7.1 billion in 1980. In 1981 the Department of Defense program cost estimate had increased an additional $2 billion to $9.1 billion (escalated dollars). Average unit program cost for 2 prototype, 4 development, and 336 production aircraft is about $27 million. Inflation accounts for a large amount of these increases in estimated program cost. Other factors contributing to these increases include

--late release of funds by the Office of the Secretary of Defense and a delay in the initial operational capability date from 1984 to 1985;

--evolution of support spares requirements; and

--contract overruns, increased potential of contract award fees, and foreign exchange rate adjustments.

It appears that AV-8B program cost estimates will continue to increase because of higher than anticipated inflation as well as other factors.

POTENTIAL EXISTS FOR FUTURE COST INCREASES

Several factors exist which may have an effect on future AV-8B program costs. These factors include the procurement of trainer aircraft, a change to the leading edge of the wing, the purchase of the 25-mm. gun system, and a stretched out production schedule.

TAV-8B

The cost to develop and procure a trainer aircraft is currently not included in the total AV-8B program cost estimate. A preliminary AV-8B project office estimate indicates that procurement of 18 TAV-8As would cost approximately $677.3 million. However, this estimate does not include costs associated with any required retooling and production line startup at British Aerospace, the manufacturer of the AV-8A aircraft.

The AV-8B project office estimates the cost to develop, produce, and procure 24 TAV-8Bs at approximately $722.5 million. The

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1/"A Decision by the Secretary of Defense Is Needed on the AV-8B Aircraft Program" (PSAD-80-23, Feb. 8, 1980).

Navy believes TAV-8B total cost would be less than TAV-8A total cost. The cost estimates for both trainer aircraft do not include operation and support costs.

Wing leading edge change

There is a proposal by the British Royal Air Force to incorporate a leading edge root extension on the AV-8B. The leading edge root extension is an airfoil that fits between the leading edge of the wing and the forward fuselage. It is designed to improve aircraft agility by increasing the instantaneous turn rate.

According to a Navy official, the cost to develop this modification to the AV-8B is estimated between $15 million and $20 million. This cost, which includes the cost for design, development, tooling, fabrication, and flight tests, will be paid by the United Kingdom. The United States will pay the production cost, such as parts and labor, if this proposed modification is accepted.

25-mm. gun system

A 25-mm. gun system was selected as the AV-8B gun in March 1981. However, the estimated costs of the gun system have not been included in the AV-8B program cost estimate.

The Navy estimated development cost of the system at approximately $36.8 million. Also, the production cost of the 25-mm. gun system was estimated at $900,000 per unit, which amounts to over $300 million for the total production quantity. Navy officials project that this cost will decrease in the later years of the program because of manufacturing learning and procuring additional quantities for other users.

Stretched out production schedule

According to the approved AV-8B program plan, the Navy anticipates procuring 24 AV-8Bs in fiscal year 1983 and 54 AV-8Bs in fiscal year 1984. However, the Department of Defense has proposed that procurement quantities be reduced to 18 and 30 AV-8Bs for fiscal years 1983 and 1984, respectively.

According to a Navy official, the proposed reduction in procurement quantities during fiscal years 1983 and 1984 would result in a projected cost decrease for the 2-year period of approximately $765 million. However, the official also said that total program costs would increase over the long run, since the 30 deferred aircraft would eventually be purchased in future years at higher costs resulting from inflation.

Furthermore, a Navy official noted that the AV-8B prime contractor has fixed-price cost options with its AV-8B subcontractors for fiscal years 1982-84. If the 30 deferred aircraft are

purchased after these subcontractor options expire, prices will probably be higher due to increased contractor costs.

According to the Navy, the most economic procurement quantity for the AV-8B is 78 aircraft per year. Navy officials agreed that substantial cost savings could be realized if this quantity were procured annually.

NAVY TAKES ACTION TO REDUCE PROGRAM COSTS

The Navy initiated several actions to control AV-8B program costs. Currently, the Navy contracts with the United Kingdom Ministry of Defence for the AV-8B engine rather than the engine contractor. Planning is currently underway to begin contract negotiations directly with the engine contractor. According to a Navy official, this will result in better management control and reduced costs.

Also, the Navy will use existing subsystems that have been developed for and are common to other aircraft, such as the Navy F/A-18 aircraft.

Finally, the use of graphite epoxy composite material for the aircraft wing and portions of the fuselage reduces the effect of price escalations of strategic metals such as titanium.

CONCLUSIONS

The AV-8B program experienced funding delays which, along with other factors, contributed to increases in program cost. Estimated program cost increased from $6.2 billion in fiscal year 1979 to $9.1 billion in fiscal year 1981 and further increases are anticipated.

Factors which could potentially increase estimated AV-8B program costs include

--higher than anticipated inflation,

--the procurement of trainer aircraft,

--the wing leading edge change,

--the purchase of the 25-mm. gun system, and

--a stretched out production schedule.

Current estimates do not provide for the procurement of trainer aircraft (over $700 million), a 25-mm. gun system (over $300 million), and a proposed reduction in production rate buildup which will result in uneconomical production rates. Several actions have been initiated by the Navy which should help control costs. These actions include plans for direct contract

negotiations with the AV-8B engine contractor, the use of existing subsystems that are common to other aircraft, and the use of the less expensive composite material in place of metals.

RECOMMENDATIONS

We recommend that the Secretary of Defense direct the Navy to:

--Determine the costs of developing and procuring the trainer aircraft, the 25-mm. gun system, and other aircraft changes and include these costs in the AV-8B program cost estimate.

--Reevaluate the current AV-8B program to determine whether reduced annual procurement rates will adversely affect the Marine Corps' ability to meet its mission objectives.

CHAPTER 5

AV-8B SURVIVABILITY CAN BE IMPROVED

The Navy's and the contractor's assessments of the AV-8B indicate that survivability improvements can be made to the aircraft. The AV-8B is susceptible to damage from enemy ordnance, has no fire or explosion suppression system, and emits a high infrared signature. According to the Navy, opportunities currently exist to enhance AV-8B survivability by modifying the design of the aircraft; however, modification would increase program cost and degrade aircraft performance.

DESIGN IMPROVEMENTS WOULD MAKE AV-8B LESS VULNERABLE

Survivability, the capability of an aircraft to avoid and withstand the threats of a hostile environment without diminishing its ability to accomplish its designated mission, consists of two areas--vulnerability and susceptibility. The AV-8B could be improved in these two areas; however, the aircraft would require design changes.

Vulnerability

Vulnerability relates to weaknesses of a system which allow degradation of an aircraft's capability to perform its mission. The AV-8B could be improved in several areas, thereby reducing its vulnerability. These areas are similar to those of other single-engine aircraft, such as the A-4 and the A-7, which were designed before the inclusion of survivability specifications in aircraft program requirements.

AV-8B vulnerability improvements affect aircraft subsystems essential for pilot safety and for aircraft performance. For example, there is little protection from enemy ordnance. The AV-8B survivability specification for projectiles applies only to aircraft parts that are unique to the AV-8B. Parts that are common with the AV-8A have no requirement to meet the survivability specifications. Navy officials said that the small size and the maneuverability of the AV-8B reduces its chances of being hit by projectiles, thereby minimizing the effect of its low tolerance.

Another vulnerability improvement that could be made to the AV-8B is the inclusion of a fire and explosion suppression system. The AV-8B fuel system, which is located in the aircraft fuselage and wing, is the largest contributor to aircraft vulnerability. Although Navy officials refer to the AV-8B's small size as an advantage, the relatively large size of the wing makes it a prominent target. Potential explosions and fires resulting from hits in tanks containing fuel as well as the presence of explosive vapors in the fuel tank contribute to fuel system vulnerability.

When a full or partially full fuel tank is penetrated by a projectile or fragment, there is a transfer of energy from the moving body to the fuel which causes a surge of greatly increased pressure in the tank. This effect can be sufficient to rupture the tank. Although fuel would probably continue to flow to the engine because of redundant fuel flow systems, the primary hazard is the possibility of the fuel flowing into compartments adjacent to the engine causing a fire or explosion and the subsequent loss of the aircraft.

A fire hazard is also created when the leading and trailing edges of the wing are penetrated below the fuel level. An ignition of the fuel could occur in the void space of the leading and trailing edges resulting in a sustained fire fed by the flow of fuel. The fire could eventually spread to the wing fuel tank where a great potential for an explosion exists.

Finally, during a typical combat mission, the fuselage fuel tanks are completely full; however, the wing tank is only partially full. The fuel vapors in the wing tank can be explosive depending on aircraft altitude, fuel temperature, and fuel type. An explosion of these vapors could create sufficient overpressure to cause a failure of the wing tank and probable loss of the aircraft.

Although the AV-8B currently has no fire and explosion suppression system to counteract the possible occurrence of these situations, Navy officials said that several alternatives exist which would reduce the probability of fires and explosions.

In the opinion of a Naval Air Systems Command official, the AV-8B would have serious survivability problems if their recommendations to improve survivability in many of the areas discussed above were not accepted by the project management.

Navy officials said they are still considering survivability/vulnerability changes to the AV-8B. A partial list, cited by the Navy, of potential improvements to AV-8A components or design features used in the AV-8B includes duplicate control cables, structural radar absorbent materials, gold canopy flashing for radar cross-section reduction, dry bay foaming, duplicate engine feed lines, self-sealing fuel lines and tanks, foam in fuel tanks, nitrogen inerting systems, and engine bay fire extinguishers.

Susceptibility

Susceptibility is the probability that an aircraft will be damaged by the enemy while operating under combat conditions. Improvements could be made to the current design of the AV-8B to reduce the aircraft's susceptibility. The major improvement involves reducing the AV-8B's infrared signature.

Engine thrust for the AV-8B is provided by a thrust vectoring nozzle system. The engine has four rotatable nozzles which are mechanically interconnected. The nozzles, which protrude out from the aircraft, emit infrared signatures which, in some cases, allow the AV-8B to be tracked and fired on from maximum missile ranges. Also, missiles travel faster than the AV-8B, further increasing its susceptibility. According to the Navy, countermeasures are not an adequate solution to this problem.

OPPORTUNITY EXISTS TO ENHANCE SURVIVABILITY

According to the Navy, it is less costly to design survivability into an aircraft than to modify existing aircraft for survivability. Navy officials acknowledged that it is possible to make many of the survivability improvements to the AV-8B before the aircraft goes into full production. They noted, however, that the changes necessary to enhance survivability will increase program costs and will diminish aircraft performance.

Methods of improving the survivability of the AV-8B include installing armor plating, including filler material in the wing fuel tank, and modifying the engine nozzles.

Use of armor plating

Decreased vulnerability to projectiles may be accomplished by hardening the aircraft with the use of armor plating. However, the use of armor plating is not recommended by the Navy because it adds weight to the aircraft which results in decreased range and aircraft performance. According to a Navy official, armor plating would also increase AV-8B program costs.

Use of filler material in the wing fuel tank

The dangers of wing tank explosions can be reduced by the use of an expanded aluminum foil mesh material or a foam substance in the fuel tank. When vapors are ignited and an explosion occurs, the aluminum foil mesh material absorbs the heat from the flame and prevents a buildup of extreme heat and pressure. This material which would have to be installed throughout the entire wing tank should require no maintenance and last the life of the aircraft. However, small metallic particles which could contaminate the fuel system and damage the fuel system and engine components could result from the use of the aluminum material.

The potential of a fire in the wing leading and trailing edges can be significantly reduced or eliminated by installing a filler material in the void area within the leading and trailing edges. This eliminates either the airflow or fuel vapor which is essential for sustaining a fire in the wing fuel tank. Foam has

been cited as a potential filler material. The foam slightly increases aircraft weight.

An alternative way of reducing the overpressures caused by vapors in the tank is by using polyurethane foam blocks to subdivide the tank into a number of smaller compartments. If a projectile or fragment causes an explosion in one compartment, the combustion gas volume expansion is relieved into adjacent compartments through the foam, thus retarding any existing fire and confining the explosion to one cell.

Reduction of the infrared signature

According to the Navy, an alternative to the AV-8B infrared signature problem is to transfer the signature to the back of the aircraft by modifying the engine nozzles. This solution would increase costs and add weight to the aircraft, but it would enhance engine performance by increasing engine thrust by 200 pounds.

CONCLUSIONS

The AV-8B has several areas where survivability could be improved, enhancing the safety of the pilot and the life of the aircraft in a combat environment. The AV-8B currently is liable to be damaged by enemy ordnance, contains no fire and explosion suppression system, and emits a high infrared signature.

However, the changes necessary to make improvements will increase weight and program costs and will diminish aircraft performance.

RECOMMENDATIONS

We recommend that the Secretary of Defense direct the Navy to evaluate the cost effectiveness of increasing AV-8B combat survivability. If cost effective, design changes should be made before aircraft production, if possible.