United States General Accounting Office

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Report to Congressional Requesters

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APACHE HELICOPTER

Serious Logistical Support Problems Must Be Solved to Realize Combat Potential

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National Security and
International Affairs Division

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The Honorable Les Aspin
Chairman, Committee on Armed Services
House of Representatives

The Honorable John D. Dingell
Chairman, Subcommittee on Oversight
and Investigations
Committee on Energy and Commerce
House of Representatives

This report on the logistical support, reliability, and other problems that are affecting the Army's ability to maintain high availability rates with its Apache helicopter is in response to your request. It contains recommendations to the Congress aimed at improving Apache operations and support.

This report was prepared under the direction of Richard Davis, Director, Army Issues, who may be reached on (202) 275-4141 if you or your staff have any questions. Other major contributors are listed in appendix I.

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Executive Summary

Purpose

The Apache—the Army's premier attack helicopter—is considered the most advanced attack helicopter in the world. Estimated to cost $12 billion, the Apache program is nearing the end of production. Upon receiving indications that the Apaches were experiencing low availability in the field, the Subcommittee on Investigations and Oversight, House Committee on Energy and Commerce, and the House Committee on Armed Services requested GAO to determine Apache availability rates and if it found these rates to be low, to determine (1) the causes of low availability, (2) the implications of low availability for combat operations, and (3) the Army's corrective actions.

Background

The primary mission of the Apache, which was designed for high-intensity battle in day or night and adverse weather, is to find tanks and other targets and destroy them with its laser-guided Hellfire missile, its 30-mm gun, or its 2.75-inch rockets. The Army plans to procure 807 Apaches, of which 741 are under contract and about 600 have been delivered. The Congress has appropriated funds for the remaining 66 Apaches. Critical to making effective use of its capabilities is how often the Apache is available to perform missions. The Army's peacetime goal—that at least 70 percent of the Apaches are to be available to perform any mission at a given point in time—is referred to as the "fully-mission-capable rate."

Results in Brief

Apache availability rates fall well short of the goal and decrease as battalions accumulate flight hours. Below the surface of the low availability rates are serious logistical support problems such as undersized maintenance organizations, weaknesses in repair capabilities, and frequent component failures. Given that the Apache has not been able to attain availability goals in peacetime despite favorable conditions, it is questionable whether it can meet the far more strenuous demands of high-intensity combat. However, this is a question for which there is not a good answer because the Army has not realistically tested the basic Apache combat unit—the battalion—under conditions that simulate sustained combat.

The Army has initiated numerous corrective actions to improve aircraft reliability and maintenance capabilities. While these actions offer potential improvements in peacetime availability, they will not necessarily ensure that the Apache can be sustained in high-intensity combat. It will be difficult to assess the effectiveness of corrective actions in terms of combat capability until the Army determines the Apache's logistical support demands under combat-representative conditions. Improving the Apache's logistical support to maintain high availability during combat is likely to require substantially more personnel, maintenance and test equipment, repair parts, and component reliability. Devoting more resources to overcoming key support problems will be difficult when one considers that fielding additional Apaches will demand more support resources at a time when overall resources for conventional forces are declining.

In April 1990, GAO recommended in testimony that the 132 Apaches not yet under contract at the time not be produced so that more resources could be applied to address logistical support shortfalls. The Congress did not act on this recommendation, and the Army has since contracted for 66 more Apaches. GAO believes that the Department of Defense's (DOD) actions do not go far enough and that the difficult choice of buying fewer aircraft to better support those in the field must still be made. If DOD buys all 807 Apaches, it may be necessary to field fewer battalions to provide a greater concentration of resources—people, aircraft, and equipment—to each battalion.

Principal Findings

Availability Rates Are Low

The Apache falls far short of meeting the Army's fully-mission-capable goal. The 11 combat battalions in the field at the time GAO's review began achieved a 50-percent fully-mission-capable rate from January 1989 through April 1990. More significantly, fully-mission-capable rates tend to decline as battalions accumulate flying hours. Rates are low despite favorable operating conditions such as few flying hours relative to the other services, contractor support, and infrequent weapons firing.

Maintenance Units Have Not Been Able to Keep Up With Apache's High Logistic Support Demands

The frequent failure of components and the consequent demand for maintenance and for parts are major contributors to the Apache's low fully-mission-capable rates. The Apache's numerous complex components present a high work load in the form of corrective and preventive maintenance. Tests show that Apaches require essential maintenance actions (maintenance needed to correct the more significant problems) about every 2.5 flying hours. Maintenance units cannot keep up with the Apache's unexpectedly high work load because they are too small and are hampered by Army management practices and because test equipment has not performed as needed. For these and other reasons, the

Army has departed from its basic support premise that failed components are to be easily detected and quickly repaired close to the helicopter. The Army has turned increasingly to contractors for assistance; contractor personnel routinely assist in unit- and intermediate-level maintenance and perform most depot-level maintenance.

Combat Operations Will Place Greater Demands on Apache Availability and Support

Army tactics call for 15 of the 18 Apaches in a battalion to fly missions at one time during combat—an availability rate of 83 percent. At the same time, the Army expects to fly each Apache about 4 hours a day in combat. This far exceeds the peacetime average of about half an hour per day. Yet availability would likely be lower during combat because of the greater burden posed by high flying hours, frequent weapons firing, and battle damage. The Army has conducted one battalion-sized test under less strenuous conditions and found the Apache's availability to be insufficient despite substantial contractor support. Considering these results, along with known shortfalls in people and test equipment, it is questionable whether 15 of a battalion's 18 Apaches could be sustained as needed during high-intensity combat. Apache operations in Panama involved less than a battalion but indicated the high concentration of resources that are needed to support the aircraft in combat—a concentration of resources not normally available to Apache battalions.

Key Problems Originated Early in the Program

Army test and evaluation agencies have warned of serious logistical support problems since before the 1982 production decision. Some of these problems are hurting fully-mission-capable rates today. Testing did not fully disclose the problems' seriousness because of narrowly defined performance measurements and the limited realism of test conditions. Despite known problems and test limitations, the Apache proceeded to full-rate production without further operational testing or decision points. The persistence of basic logistical support problems after the bulk of production was completed suggests that production took priority over logistical supportability.

Planned Corrective Actions Do Not Go Far Enough

The Army has been forthright in acknowledging the Apache's availability problems. It is taking numerous corrective actions, including steps to improve reliability, test equipment, and spares availability. The Army has decided to increase the number of people in the Apache battalion to partially fill the personnel shortfall but has not determined the source for these increases. The Army also plans to field more contractor repair facilities and, as a short-term measure, will hire more contractor maintenance personnel. These actions are likely to increase Apache availability, at least during peacetime. However, it will be several years before the reliability and test equipment improvements are demonstrated, and some of these problems have proven difficult to correct despite previous attempts. In addition, the Army's reliance on contractor support to ease logistical support problems may not be practical for combat.

In April 1990 testimony, GAO recommended that DOD conduct combat-representative testing of the Apache and apply the lessons learned by the other services in supporting their aircraft. DOD agreed that, while corrective actions and logistical structure needed to be verified in an operational environment, this verification could be done by evaluating performance during planned exercises. GAO believes such verification would be of limited benefit, however, because exercises have not been of sufficient duration to approach sustained combat, and previous evaluations have not accurately disclosed problems because of limitations in performance measurements and data collection. DOD also stated that existing mechanisms were sufficient for applying lessons learned by the other services. However, the fact that the other services fly their aircraft significantly more hours, devote many more people to aircraft support, and appear to have more complete data suggests that the Apache has not benefited from this experience.

Recommendations and Matters for Congressional Consideration

GAO believes the Congress should consider transferring the funds appropriated for the procurement of the last 66 Apaches to other appropriation accounts to provide the increased logistical support the Apache requires. If the Congress decides against such a transfer, GAO recommends that the Congress direct the Secretary of Defense to determine whether fewer Apache battalions should be fielded than planned to provide a greater concentration of resources to each battalion. GAO also recommends that the Congress direct the Secretary of Defense to (1) operationally test the Apache in battalion-sized or larger units; (2) form an interservice team to apply the experience of the other services in improving the Apache's logistical support; and (3) implement the changes, emanating from the above efforts, necessary to sustain desired peacetime and wartime operations for the Apache. These and other recommendations are presented in full in chapter 7.

Agency Comments

As requested, GAO did not obtain official comments from DOD on this report. However, DOD formally responded to GAO's testimony, and GAO has considered this response in preparing this report.

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Abbreviations

DOD	Department of Defense
GAO	General Accounting Office

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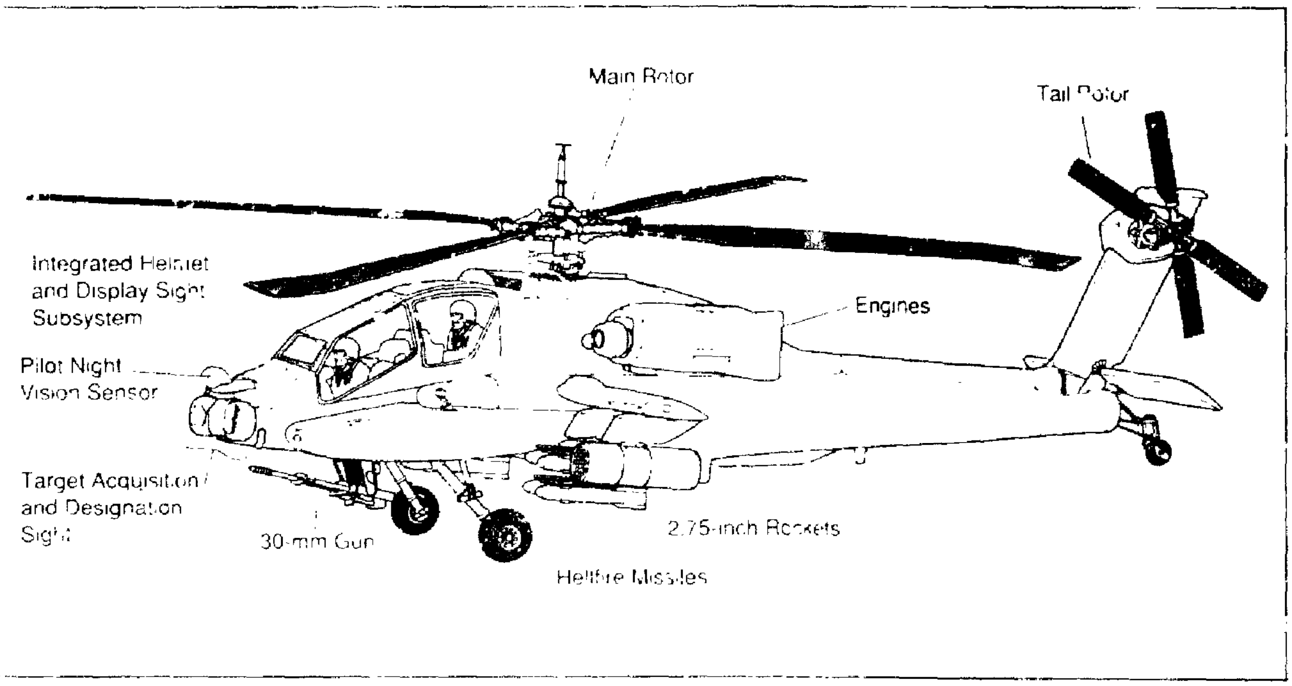
ntroduction

The Apache— Army's premier attack helicopter—is considered the most advance ack helicopter in the world. It is a two-seat, twin-engine helicopter armed with the Hellfire antitank missile system, a 30-mm cannon, and 2.75-inch rockets. The Apache's basic mission is to support ground forces by destroying enemy tanks and other ground targets from the air. Besides this anti-armor mission, the Apache assists air cavalry operations by providing firepower and security and provides armed escort for unarmed helicopters. The Apache is considered part of the combat maneuver force and, as such, will not operate from a fixed base in combat; rather, its operations and maintenance will be conducted in forward areas and will move as the needs of battle dictate.

The Apache was designed for high-intensity conflicts against heavy forces. To be survivable and effective in this environment, the Apache was designed to detect and engage targets from long ranges, to fly and fight at night and in adverse weather, and to evade enemy air defenses and withstand hits when necessary. These requirements dictated the Apache's sophisticated systems and advanced features, some of which are depicted in figure 1.1.

gure 1.1. The Apache's Essential Systems



The copilot/gunner, who sits in the front seat, uses the Target Acquisition and Designation Sight to find targets from long ranges with infrared, television, and direct-view optics. After finding a target, the copilot/gunner designates it with the sight's laser and guides the laser-seeking Hellfire missile to impact. Just as the copilot/gunner uses the infrared sensor to find targets at night and during obscured conditions, the pilot uses an infrared night vision sensor to fly the Apache under the same conditions. These sensors are the Apache's most important systems because they give the Apache its stand-off range, its night vision, and its ability to guide the Hellfire missile—capabilities that set the Apache apart from other helicopters.

Another important feature is the Apache's Integrated Helmet and Display Sighting System, which displays critical flight and target information on lenses mounted on the crew's helmets. The targeting and night vision sensors move with the crew's head movements, and, using their helmet displays, the crew can see everything the sensors see without having to look down into a cockpit screen. The Apache has aircraft survivability equipment that can inhibit the enemy's ability to engage the aircraft. The Apache is designed to withstand hits from munitions up to 23-mm in size. It also uses an automated navigation system to guide its flight close to the ground.

Because of all these capabilities, coupled with the Apache's abundant power, Army aviators find it to be far superior to the Cobra helicopter in all performance dimensions, including flight performance, night vision, target attack, and survivability.

Program History and Current Status

Apache development began in 1973, and in 1976 Hughes Helicopters was selected, after competition, to complete development and production. Production began in 1982, and the first aircraft was delivered in 1984. McDonnell Douglas Helicopters has since bought Hughes and is now the prime contractor. Other major contractors include Martin Marietta Orlando Aerospace, which produces the targeting and night vision sensors, and General Electric, which produces the engines.

The Army plans to buy 807 Apaches at a total acquisition cost of \$11.8 billion—about \$14.6 million per aircraft. At the time we completed our audit work in April 1990, 675 Apaches were under contract; nearly 600 had been delivered; and funds for the remaining 132 Apaches had been appropriated. Since then, the Army has contracted for 66 of the 132 Apaches and plans to contract for the remaining 66 by October 1990. The contractor is currently producing about 6 per month and plans to deliver all 807 by the end of fiscal year 1993. As of January 1990, the Army had fielded 14 Apache battalions and plans to field 26 more by 1995. The battalion, which is the basic Apache organizational unit, normally has 18 Apaches, along with scout and utility helicopters.

The Army has established a requirement for 1,031 Apaches based on its force structure for active, reserve, and National Guard units. However, the number of Apaches the Army plans to fund depends on the affordability of the Apache program and the needs of other programs. Because of these and other reasons, such as cost increases, Apache procurement quantities have fluctuated considerably over the years. These fluctuations are shown in table 1.1.

Table 1.1: Fluctuations in Apache Procurement Quantities

Year	Quantity
1980	536
1981	446
1982	515
1983	515
1984	675
1985	675
1986	593
1987	675
1988	975
1989	807
1990	807

In April 1990, we testified before the Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, on the results of our work.[1] On the basis of the severity of the Apache's logistical support problems and the need to devote significant resources to resolve the problems, we recommended that the Congress limit the Apache's procurement to 675 helicopters, forgoing the last 132 Apaches that were not under contract at that time. We recommended that the funds not spent on the additional Apaches be transferred to other appropriation accounts to improve logistical support. The Congress did not act on our recommendation, and the Army has since contracted for

[1] Army's Apache Helicopter Has Proven Difficult to Support (GAO/T-NSIAD-90-33, Apr. 19, 1990).

66 of the remaining 132 Apaches. Our testimony also included recommendations to the Secretary of Defense. These recommendations, along with the Department of Defense's (DOD) response, are discussed in the relevant sections of the report.

Significant Improvements Are Planned for the Apache

In 1989, the Army began engineering development on a $3.4 billion program to enhance the war-fighting capability of the Apache. This improvement, which will convert about 227 Apaches to "Longbow" Apaches, involves placing a targeting radar above the rotor mast and replacing the Hellfire's laser seeker with a radar seeker. A decision on incorporating the modifications is scheduled for October 1992. Essentially, the Longbow will give the Apache a "fire and forget" capability with the Hellfire missile. Other changes will be made to the airframe to accommodate the Longbow modifications and associated avionics, including an enhanced cooling system for the avionics bay, an enlarged avionics bay to house additional components, increased electrical power, and an advanced cockpit.

In addition to the Longbow, the Army plans other improvements for the Apache, such as adding the air-to-air Stinger missile system and an airborne target handover system. The Stinger will give the Apache a defensive air combat capability, and the target handover system will facilitate passing target information between helicopters.

Primer on Apache Maintenance

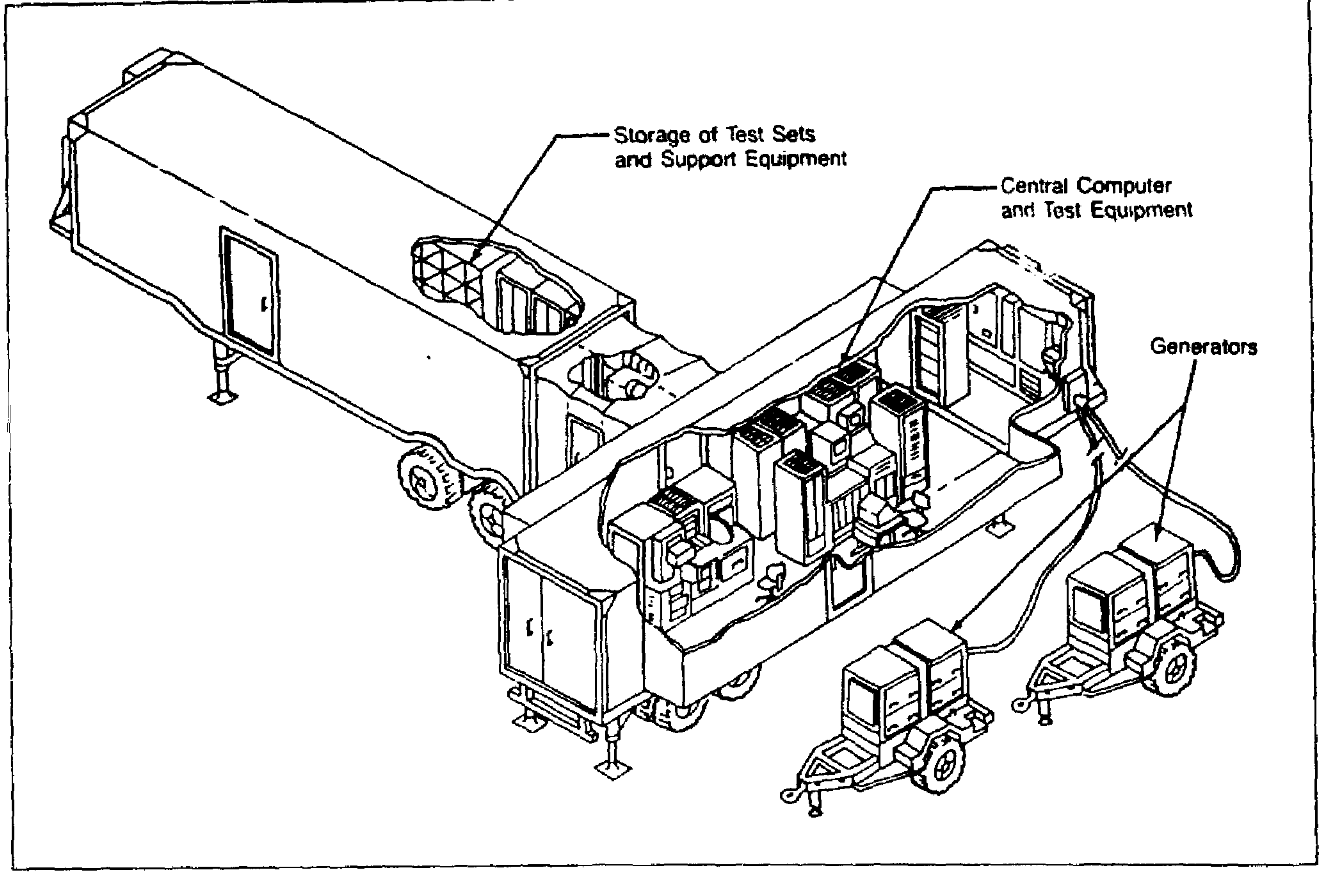
Apache maintenance is performed at three hierarchical levels: unit, intermediate, and depot. Its maintenance concept is predicated on the aircraft's modular design, whereby components referred to as "line replaceable units" are to be quickly removed from the aircraft and replaced at the unit level. Component repairs and other heavier maintenance tasks are handled by the intermediate and depot levels.

Unit-level maintenance is performed by personnel in the Apache battalion. These individuals generally perform the frequent, "on-aircraft" maintenance tasks required to return the aircraft to a serviceable condition—such as removing and replacing line replaceable units. They are also responsible for performing major and minor inspections, preparing aircraft for flights, and tracking the availability status of each aircraft. The unit level contains the Apache crew chiefs, who are primarily responsible for the daily maintenance of the aircraft, supported by technicians with disciplines such as armament, avionics, and engines, as well as by inspectors and other general Apache repairers.

Intermediate maintenance companies are primarily responsible for component repairs, although they routinely handle some unit-level tasks such as major inspections. These companies do not fall under the command of the Apache battalions but rather are assigned to a higher echelon, such as a division or a corps. They are usually located close to the battalion. Intermediate-level work generally takes place in specialized shops, including avionics, armament, airframe and sheet metal, power train, welding, hydraulics, machine, and engine shops.

A key responsibility of intermediate maintenance is to test and repair electronic components. The Apache is a sophisticated aircraft that contains numerous electronic line replaceable units, or "black boxes," comprised of a variety of intricate printed circuit cards. Intermediate maintenance units assigned to a corps are equipped with an Electronic Equipment Test Facility that diagnoses the black boxes. The test facility is depicted in figure 1.2.

Figure 1.2: Apache Electronic Equipment Test Facility



Source U S Army

The Electronic Equipment Test Facility is housed in two 35-foot semi-trailer vans. One van houses the computer equipment used to diagnose components, while the other van contains the test sets for the components and support equipment for the facility. Each facility costs about $10 million. The test facility was designed to be mobile so it could move to provide quick repairs of electronic components close to the user. Ideally, when a black box fails, the aircraft's built-in Fault Detection and Location System discovers the problem and displays a failure message in the cockpit that cues unit-level personnel to remove and replace the box. Intermediate-level personnel connect the failed box to the facility's test bench and use computer-run diagnostic software to identify the faulty circuit card within the box. The card can then be replaced and the box returned to service. The Army viewed the fault detection system's ability to quickly find problems and the test facility's ability to quickly repair components as key elements of the original maintenance concept and critical to aircraft availability.

At the depot level of maintenance, those components requiring extensive skills, capital equipment, and other immobile fixtures and facilities are overhauled or repaired. Generally, depots are central facilities not necessarily located near the aircraft. However, the Army has fielded contractor-run depot facilities near Apache battalions.

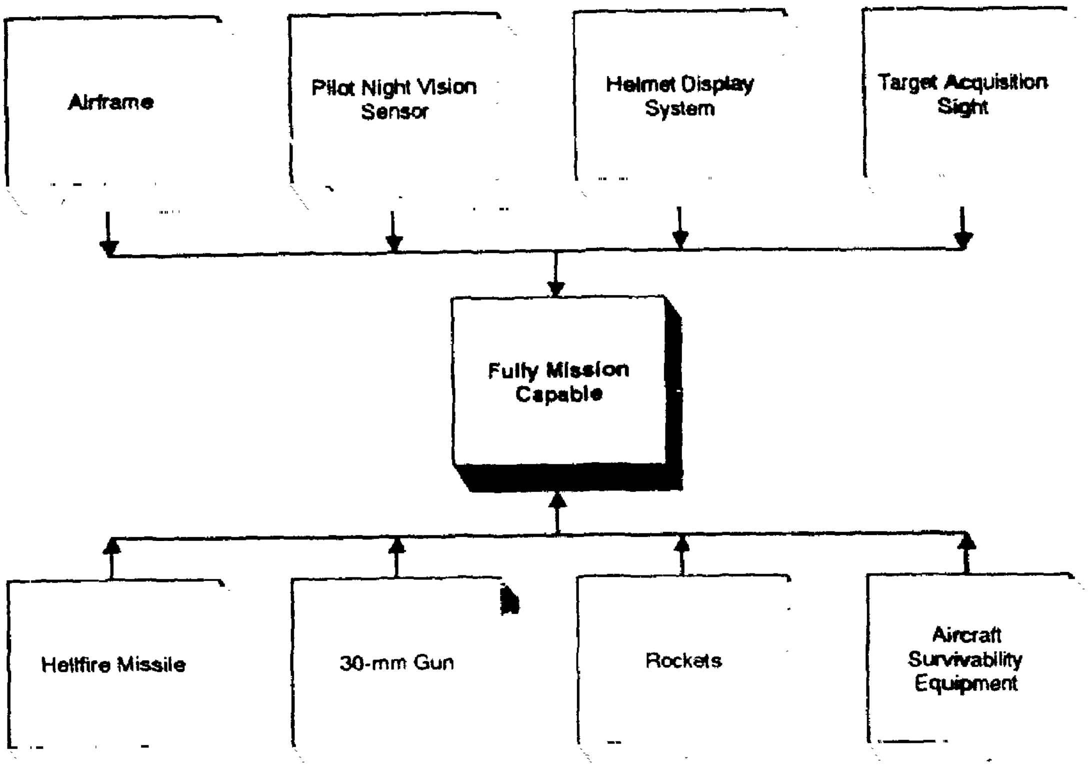
Measuring the Apache's Availability in the Field

"Availability" refers to a weapon system's ability to be in working condition when it is needed. It is largely the byproduct of (1) reliability—how often a weapon breaks down—and (2) maintainability—how long it takes to repair the weapon. How quickly a weapon can be repaired is further affected by how quickly parts can be obtained and by the capabilities of maintenance personnel and equipment. Availability is thus not only a key performance measurement itself; it can also indicate underlying reliability, maintainability and other problems.

Army Regulation 700-138 sets forth the availability tracking requirements for the Apache. Basically, availability is calculated by dividing the number of hours an aircraft is operable by the total number of hours on hand. However, any time the aircraft spends in depot maintenance is excluded from the total number of hours on hand in calculating availability. Thus, if an Apache were operable for 18 hours on a given day, its availability for that day would be 18 hours divided by 24, or 75 percent. If that same aircraft had been down for 4 hours of depot repairs, its availability would be 18 hours divided by 20, or 90 percent.

The Army's measures of availability are "fully mission capable," "partially mission capable," and "non-mission capable." The Army considers an Apache fully mission capable if it can perform all of its assigned missions. This means that the Apache must be flyable and have all of its mission-essential equipment working. The Army has established a goal that the Apache achieve a fully-mission-capable rate of 70 percent once the aircraft was considered mature. Figure 1.3 shows the basic systems that must be operable for an Apache to be considered fully mission capable.

Figure 1.3: Systems Required for a Fully-Mission-Capable Apache



Source U S Army

An Apache is classified as "partially mission capable" if it can fly and perform at least one, but not all, of its missions. The Army's goal specifies that an Apache should be partially mission capable no more than 5 percent of the time at maturity. Normally, an Apache is partially mission capable because some of its mission-essential equipment is not working. However, in peacetime, one of the Apache's missions is training, and it can be classified as partially mission capable even if none of its mission-essential equipment is working as long as it can be flown for training. When an Apache is not flyable, or is not capable of performing any missions, it is classified as "non-mission capable." The Army's goal is for Apaches to be non-mission capable no more than 25 percent of the time at maturity. The Army's reporting system further distinguishes between the Apache's being non-mission capable due to maintenance and non-mission capable due to supply.

Each battalion summarizes the availability of its Apaches and reports the information monthly, along with the number of hours flown and the major causes of aircraft downtime. Thus, a battalion of 18 Apaches that typically met the Army's availability goals would be expected at a given point in time to have 12 or 13 Apaches fully mission capable, 4 or 5 non-mission capable, and 1 partially mission capable.

Objectives, Scope, and Methodology

We conducted our review of the Apache program at the request of the Chairmen of the Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, and of the House Committee on Armed Services. The request was prompted by concerns that the Apache was experiencing low availability rates in the field. Accordingly, the objectives of our review were to determine the Apache's availability in the field as measured by fully-mission-capable rates and if we found the rates to be low, to (1) determine the causes of low rates, (2) identify the potential implications for combat operations, and (3) identify the Army's corrective actions.

We conducted our audit work from May 1989 through April 1990 in accordance with generally accepted government auditing standards. At the direction of the requesters, we did not obtain official comments from the DOD on this report. However, we did discuss its contents with DOD officials and have included their comments where appropriate. In addition, DOD formally responded to our testimony, and we have taken its response into consideration in preparing this report.

We conducted the majority of our work at (1) the U.S. Army Aviation Systems Command, St. Louis, Missouri; (2) eight Apache battalions located at Ft. Hood, Texas; Illesheim, West Germany; Wiesbaden, West Germany; and Ft. Bragg, North Carolina; and (3) Headquarters, Departments of Defense and the Army, Washington, D.C. We visited the Army Aviation Center, Ft. Rucker, Alabama; Ft. Eustis, Virginia, where Apache maintenance personnel are trained; the U.S. Army Materiel Systems Analysis Activity, Aberdeen, Maryland; the U.S. Army Operational Test and Evaluation Agency, Alexandria, Virginia; the Special Repair Activity at Killeen, Texas; and the McDonnell Douglas Helicopter Company, Mesa, Arizona. We also observed an Apache field training exercise at the National Training Center, Ft. Irwin, California, and a gunnery exercise in West Germany.

At the U.S. Army Aviation Systems Command, we interviewed personnel and reviewed and obtained records from the various command directorates, the Advanced Attack Helicopter Program Manager's Office, the Target Acquisition and Designation Sight/Pilot Night Vision Sensor Project Manager's Office, and the Automatic Test Equipment Product Manager's Office. Topics covered were Apache fleet readiness, Army studies and analyses of Apache availability problems, the supply of spare and repair parts, individual component reliability, corrective actions, maintenance man-hours expended, and warranty information.

A major focus of our work at the Aviation Systems Command was our analysis of the Apache readiness database. Using the Army's data, we performed detailed analyses on the availability rates of the 11 Apache combat battalions in the field at the time we began our review. We excluded such data for other Apache units, such as training units, because their operations did not necessarily reflect those of combat units. We performed a limited reliability assessment of the Army's database by testing the accuracy of input data for 1 of the 11 fielded combat units. We found an input error rate of less than 1 percent for input data and concluded that the accuracy of the database was acceptable for review purposes. However, we found a system error that resulted in the omission of 1 month's data from the database for that unit. While the omitted data had no material effect on our work, it does have a potential impact on the Apache's reported readiness rates. We discussed this situation with Command representatives, and they are taking appropriate action to correct the system error. They also stated that, while omission of such data does distort readiness reporting, such omissions occur infrequently.

At the eight Apache combat battalions where we conducted on-site audit work, we analyzed individual Apache readiness reports to ensure that (1) they had been prepared accurately and in compliance with Army regulations and (2) the readiness database was reliable. Overall, we found a low incidence of errors in recording readiness data at the combat units. One battalion in West Germany had erroneously overstated fully-mission-capable rates by 11 percent in the data we examined. Also, the Ft. Bragg battalion had excluded the condition of aircraft survivability equipment in its calculation of fully-mission-capable rates. However, we did not find these occurrences to a significant degree in the other battalions, and we do not think that they had a significant effect on the overall availability rates.

We spent a considerable amount of time at these battalions with maintenance personnel, pilots, and command personnel to fully understand the factors affecting the Apache's availability. In particular, we discussed individual components' reliability, preventive and corrective maintenance, the supply of spare and repair parts, diagnostic equipment, training, contractor support, expended maintenance man-hours, the adequacy of the battalion's size, and the amount of time productively spent on maintaining the aircraft. Although we covered many topics during our visits to Ft. Eustis and Ft. Rucker, the most significant concerned the basis for the Apache battalion's current design and the results of the Army's manpower requirements analysis regarding the Apache battalion organization.

Throughout our review, we were concerned with the effects of a severe storm at Ft. Hood, Texas, which damaged over 100 Apaches in May 1989. We examined the readiness database before and after the storm to ensure that our analysis of fully-mission-capable rates and accumulated flying hours was not unduly influenced by the storm damage. Even with these allowances, the storm's influence could not be completely eliminated because of the longer term effect it had on the overall demand for critical parts. In the final analysis, we believe that the storm did lower fully-mission-capable rates significantly during the latter half of 1989. However, while the storm exacerbated the Apache's availability problems, it did not cause them. Before the storm, fully-mission-capable rates were already significantly below the Army's goal and had declined with accumulated flight hours.

We discussed the Apache's availability and logistical support problems with headquarters officials from DOD and the Army. We talked with several people who had been involved with the Apache program in years past to gain perspective on past decisions and events that could shed light on some of the Apache's current problems. We discussed the interpretation of requirements and test results, the status of the Apache program at the time of the production decision, and lessons learned. We obtained and analyzed reports from key tests and evaluations of the Apache conducted since 1981. We also held discussions with Air Force and Marine Corps personnel to gain their insights on aircraft maintenance, support, expended man-hours, flying hour rates, training, and contractor support.

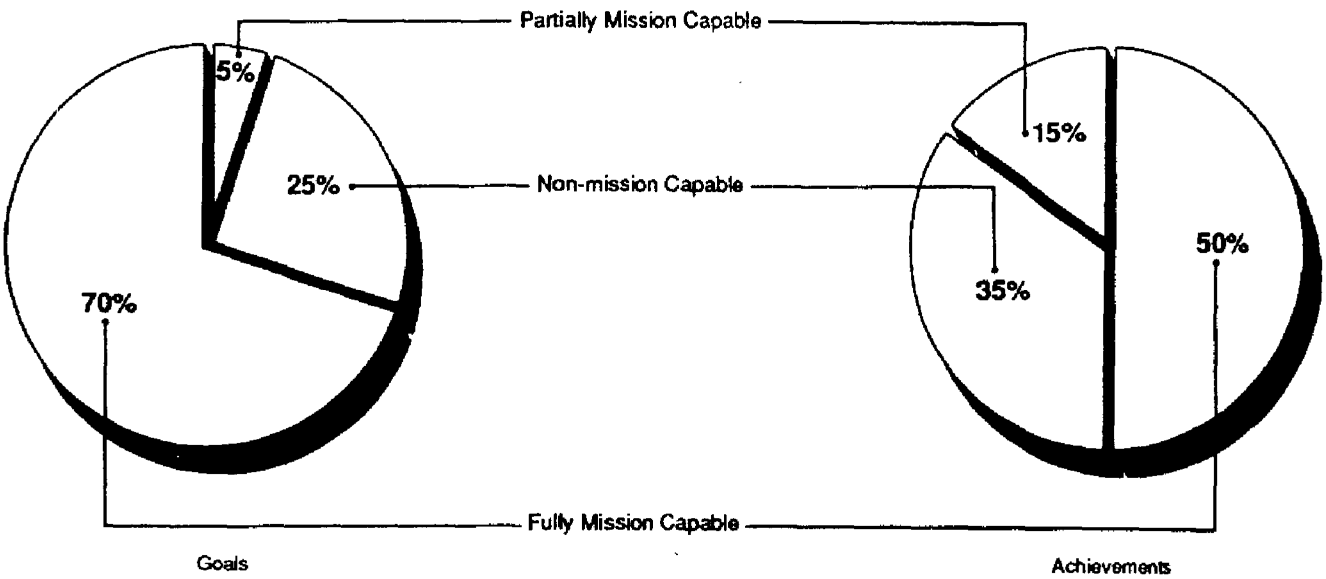
Low Apache Availability Rates Indicate Significant Logistical Support Problems

Apaches have fallen considerably short of meeting the Army's fully-mission-capable goal. More significantly, fully-mission-capable rates tend to decline as battalions accumulate flying hours. Apache fully-mission-capable rates would likely be even lower if Apaches were flown as much as aircraft from other services are flown. Although somewhat imprecise, the fully-mission-capable rates have illuminated a basic problem: the Apache demands a high level of logistical support that the Army has not been able to provide.

Apache Fully-Mission-Capable Rates Fall Short of Army Goals

The 11 Apache combat battalions in the field when our review began averaged a 49.9-percent fully-mission-capable rate from January 1989 through April 1990—well short of the Army's 70-percent goal. As a fleet, the Apaches did not meet the goal during calendar years 1986 through 1988, nor any month during calendar year 1989. Figure 2.1 compares the Army's availability goals with the demonstrated performance of the 11 Apache combat battalions from January 15, 1989, through April 15, 1990.

Figure 2.1: Apache Availability Goals and Performance

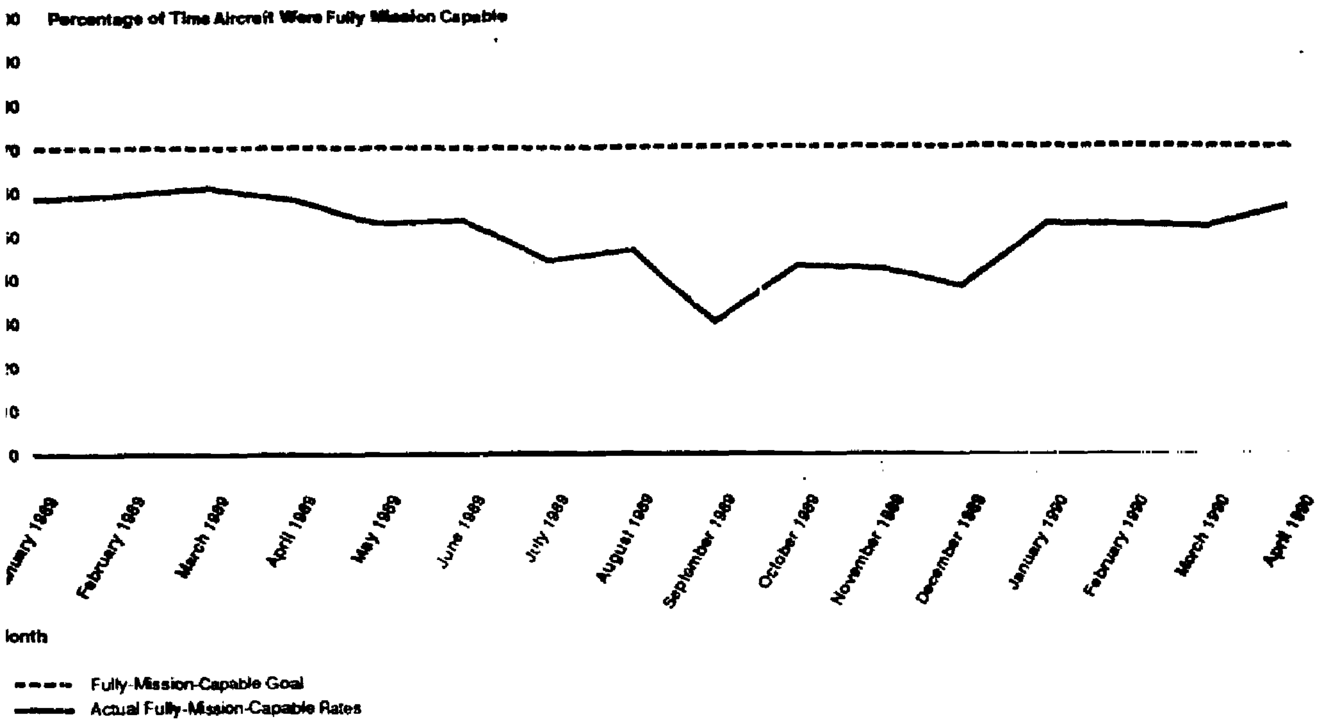


Source: U S Army data.

As can be seen in the figure, Apache downtime—including both non-mission capable and partially-mission capable times—was about equal to the fully-mission-capable rate during the period. The amount of downtime is directly related to the Apache's demand for maintenance and parts, as well as to the Army's ability to meet those demands.

Although fully-mission-capable rates can be expressed as an average, they in fact fluctuate considerably from month to month. Figure 2.2 shows the monthly fully-mission-capable rates for the 11 combat units for January 1989 through April 1990.

igure 2.2: Monthly Fully-Mission-Capable Rates



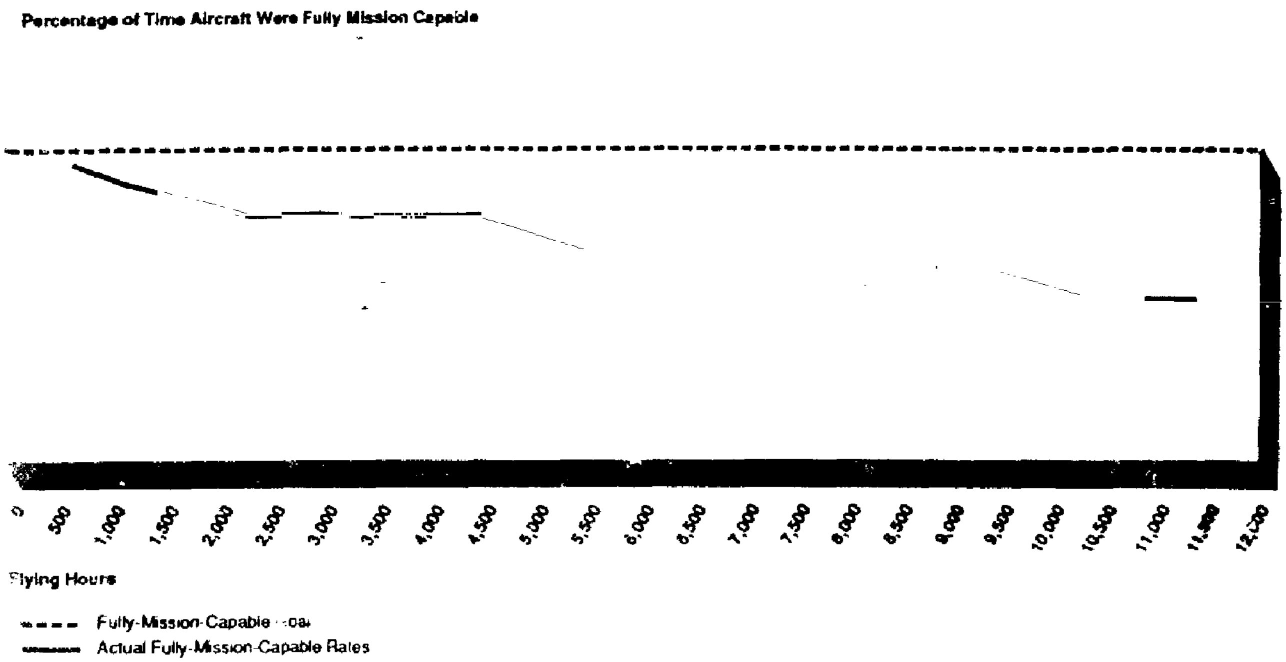
Source U S Army data

During this time period, fully-mission-capable rates ranged from 29.6 to 60.8 percent. Rates showed a general decline from July to September 1989, which the Army primarily attributes to two factors: (1) a severe storm in May 1989 that damaged over 100 Apaches at Fort Hood, Texas, and (2) the discovery of two aircraft component problems whose seriousness required maintenance personnel to perform inspections and modifications. While it is clear that these factors lowered fully-mission-capable rates, they were not the cause of the overall problem because rates were already significantly below the Army's goal before May 1989. For example, the average fully-mission-capable rate for 1988 was 56 percent. Apache fully-mission-capable rates have improved since October 1989 and approximate their pre-May 1989 levels. This improvement reflects recovery from both the storm and from other problems in 1989, as well as some of the steps the Army has taken to improve the Apache's logistical support.

'ully-Mission-Capable ¿ates Decline as \paches Accumulate Iours

While monthly fully-mission-capable rates are low, further analysis shows that as Apaches accumulate flight hours, rates tend to decline. Using Army data from the time fielding began in 1986 through April 1990, we calculated the fully-mission-capable rates as the combat battalions reached increasing levels of accumulated hours. By using flight hours rather than calendar months, we adjusted for the fact that the 11 battalions were fielded at different times and have accumulated flight hours at different rates. Figure 2.3 shows the pattern of declining rates that emerges from this analysis.

ıre 2.3: Apache Fully-Mission-Capable Rates and Accumulated Flying Hours



This analysis shows that older battalions with more flight hours generally experience lower rates than the newer battalions. From the time each of the 11 combat battalions was fielded to the time when each had accumulated its first 500 flight hours, the battalions averaged a 67-percent fully-mission-capable rate. Six battalions had flown at least 5,500 hours, and they averaged a 49-percent rate. Only 2 of the 11 battalions had accumulated over 10,000 flight hours, and these averaged a 37-percent fully-mission-capable rate through April 1990. The Army's computation of monthly fleet-wide averages dampens the effects of accumulating hours and aging because it combines the rates for new and old battalions.

While it is difficult to precisely discern the reasons for declining fully-mission-capable rates, Apache battalion personnel cited two main factors. First, as the aircraft gain flight hours, they require more maintenance and parts, thereby increasing downtime. This increased demand occurs because of component wear, major prescribed maintenance inspections that are conducted on each Apache every 250 hours, and th longer term effects of aging. Second, after the first year of fielding, turn over begins among battalion maintenance personnel, which degrades maintenance capability because personnel are either replaced by less experienced people or not replaced at all. This degradation of maintenance capabilities prolongs the amount of time it takes to perform mair tenance—at a time when maintenance demands tend to increase.

DOD disagreed that fully-mission-capable rates decline because of accumulated hours. Rather, DOD believes that declining rates during 1989 were caused by the storm at Fort Hood and by serious problems with tl 30-mm gun and a main rotor component. As we note in the report, these problems lowered rates in 1989. However, our analysis of the declining rates was relatively unaffected by the storm at Fort Hood because it encompassed 4 years of data and was based on accumulated flying hours rather than on calendar dates. Furthermore, the pattern of declining rates existed before the storm occurred. While the storm was an anomalous occurrence, significant problems with components have occurred in previous years. Excluding them would clearly increase ava ability rates but would render the rates meaningless.

The Apache's Availability May Actually Be Lower Than Reported

The reported fully-mission-capable rates for the Apache may be higher than the actual availability of fully operational aircraft. Apaches are not flown as much as other services' aircraft are flown; the Apache's lower numbers of flying hours lessen the demand for maintenance and parts. Apaches also benefit from contractor support and from the basir of operations in prepared airfields with permanent hangars. Finally, fc several reasons, the availability reporting system does not capture all c the factors that lower fully-mission-capable rates.

Apache Availability Benefits From Favorable Operating Conditions

Normal Apache operations involve few flying hours, infrequent weapons firing, prepared airfields with permanent hangars, and contractor logistical support. These conditions reduce maintenance and parts demands on the one hand, while facilitating the ability to perforr maintenance on the other. While it does not necessarily follow that the Apache should be flown harder and maintained under poorer conditior the favorable impact of the Apache's operating conditions must be considered when interpreting fully-mission-capable rates.

Apaches in the 11 combat battalions have flown an average of 12.9 hours per month since fielding began. As shown in table 2.1, the Apache flies far fewer hours than do tactical aircraft in the other services.

Table 2.1: Comparison of the Apache's Monthly Flying Hours With Those of Other Aircraft

Service	Aircraft	Monthly flight hours per aircraft
Army	AH-64 Apache helicopter	12.9
	AH-1 Cobra helicopter	11.2
Air Force	F-16 Falcon (fixed wing)	29.7
	A-10 Thunderbolt (fixed wing)	35.8
Navy/	F/A-18 Hornet (fixed wing)	39.0
Marines	AV-8B Harrier (fixed wing)	33.6
	AH-1 Cobra helicopter	27.7

As shown in the table, both the Apache and the Army's Cobra fly significantly fewer hours than do aircraft from other services. This suggests that the problems limiting the Apache's flying hours may apply to Army aviation in general. While several factors affect the numbers of hours that can be flown, Apache battalion personnel informed us that a major constraint is the battalion's limited ability to meet the helicopter's logistical support demands. If the Apaches flew more hours, the demands for replacement parts and preventive and corrective maintenance would increase, although not necessarily proportionately. Given the battalion's limited resources, these additional demands would likely degrade fully-mission-capable rates.

Other aspects of the Apache's normal operating environment also benefit aircraft availability. For instance, the firing of weapons such as the missile and gun takes place during a small portion of the Apache's flying hours. According to the Army, gunnery exercises are limited by the cost of munitions and by an inadequate number of firing ranges. As with an increase in flight hours, if weapons were fired more frequently, more maintenance and parts would likely be needed to keep the Apaches fully mission capable. Except during exercises, Apache battalions operate their aircraft from prepared airfields, thereby minimizing the amount of sand and dirt the helicopters ingest. Also, the battalions perform a significant amount of maintenance inside permanent hangars at the airfields. The hangars facilitate the performance of maintenance tasks that would be more difficult, if not inadvisable, to perform outdoors or on unprepared surfaces. For example, the hangar provides the clean environment required for performing maintenance on the night vision and targeting sensors, and the hangar's overhead hoist facilitates the removal of major components such as the main rotor head. The Apache also benefits from a substantial amount of direct and indirect contractor support, which is discussed in chapter 4.

The effects of favorable operating conditions are perhaps most evident in the three Apache battalions located in West Germany when our work began. These battalions tend to have higher fully-mission-capable rates than those in the United States. The battalions in West Germany enjoy top priority for personnel and replacement parts and are thus less affected by parts shortages and personnel turnover than are other battalions. They also had full-time contractor personnel to help perform unit-level maintenance who were not available to other battalions at the time of our review. The battalions in West Germany also have extra Apaches that are used as "float" aircraft—they replace Apaches in need of repair so that the battalions can have more operational aircraft available.

Army Reporting System May Lead to Some Overstatement of Availability Rates

Several exclusions and omissions within the Army's reporting system result in the overstatement of the Apache's availability status. These primarily involve portions of maintenance downtime that, for several reasons, are not fully reported. While availability rates would be somewhat lower without these reporting system flaws, the flaws were generally not so severe as to render the data unreliable or substantially inaccurate.

Several omissions are allowed by regulations. For example, depot-level maintenance is excluded from calculations of fully-mission-capable rates, as directed by Army and DOD regulations. However, such maintenance is regularly performed on-site, and the aircraft are not available for use during this time. When aircraft downtime that is attributable to depot maintenance is counted in the January 1989 through April 1990 period, fully-mission-capable rates for the 11 combat battalions decrease by 2 to 5 percentage points. Similarly, the availability of float aircraft to some battalions increases availability rates because the aircraft in need of repair are no longer reported by the battalion once they are exchanged. We found that the use of float aircraft assigned to two battalions in West Germany increased fully-mission-capable rates by about 5 percentage points.

We also found several omissions that were at odds with reporting regulations. For example, the battalions located in West Germany generally excluded downtime for unscheduled maintenance when the corrective action took 2 hours or less. Availability rates for one battalion at Fort Hood were about 4 percentage points higher due to random errors in reporting aircraft as fully mission capable when they were partially mission capable. We found a higher error rate in battalions located in West Germany because in some cases unit- or intermediate-level maintenance was performed while aircraft were receiving depot repairs. In one instance, aircraft were classified as being down for depot repairs longer than justified because they were awaiting parts that had been removed to repair other Apaches. Also, the battalion at Fort Bragg, North Carolina, excludes aircraft survivability equipment from its calculations of fully-mission-capable rates, even though by regulation such equipment is defined as "mission-essential."

Other aspects of the reporting system result in understatements of the amount of supply-driven downtime at the expense of maintenance-driven downtime, without necessarily affecting availability rates. For example, parts shortages are not counted as long as any other maintenance actions can still be performed while the parts are on order. The practice of taking components from an aircraft already in need of repairs to fix others—referred to as "controlled substitution"—reduces the downtime that would have occurred if the components had been obtained through the supply system, even though the maintenance time associated with exchanging the components is recorded. In addition, while "non-mission-capable" time is distinctly subdivided into "supply" and "maintenance" categories, no such distinction is made for "partially-mission-capable" time, even though this category is a major source of downtime. The Vice Chief of Staff of the Army has commissioned a formal study of ways to improve the reporting system, and the Army has allowed battalions to informally report partially-mission-capable distinctions.

Fully-Mission-Capable Rates Indicate Underlying Logistical Support Problems

While fully-mission-capable rates are somewhat imprecise and subject to fluctuations, they nevertheless reflect the serious logistical support problems occurring in Apache battalions. These problems were particularly evident as flight hours accumulated and aircraft aged. We found that fully-mission-capable rates suffer because of (1) the frequent failures of components that create a large demand for maintenance and parts and (2) the battalions' inability to meet that demand because of personnel shortfalls, weaknesses in diagnostic equipment, and parts shortages. As a result, Apache maintenance units are overburdened and dependent on contractor support. We found that these problems, which can have serious implications for combat operations, exist despite the warnings of Army logisticians and several Apache tests dating back to 1981. These issues are the focus of the remaining chapters in this report.

In February 1989, the Apache program office formed a team drawn from several organizations, including personnel from Army field units and contractors, to improve the Apache's availability. This team, referred to as the "Apache Action Team," has made a coordinated effort to identify and correct problems. As of May 1990, the team had identified 169 action items, 101 of which it considered as closed. Since 1982, various attempts have been made by Army and contractor teams to resolve technical problems on the Apache. However, the Apache Action Team is the most comprehensive effort to date. Also, in early 1990, the Assistant Secretary of the Army for Research, Development and Acquisition commissioned a "Tiger Team" to analyze the Apache program and recommend steps that could be taken to quickly improve aircraft availability until longer term corrections could take effect. The specific corrective actions taken or proposed by these teams are discussed in the following chapters.

Precautions Are Needed to Avoid Similar Logistical Support Problems With the Longbow Program

At the same time the Army is working to resolve the Apache's logistical support problems, it is developing the "Longbow" modification program for future application to the Apache. While this program offers potentially significant improvements to the Apache's combat effectiveness, it is a major modification that will require significant changes to the Apache's design and will add complex subsystems such as the mast-mounted radar. These changes could complicate the Apache's logistical support problems. In our April 1990 testimony, we recommended that DOD defer incorporation of the Longbow modification until the Army demonstrates that (1) it has overcome the logistical support problems that the Apache has experienced and (2) the Longbow's availability and flying hours will not be similarly compromised.

DOD disagreed with this recommendation on the basis that it would unnecessarily increase the cost and delay the fielding of a critical operational capability. DOD also stated that actions to correct the Apache's current problems will be completed before delivery of the first Longbow-modified Apache and that it will review the progress of these actions before deciding whether to produce the Longbow. The intent of our recommendation was not to defer the development phase of the Longbow program but to ensure that before the Army makes a production decision, it has determined that the Apache's logistical support problems will not be worsened. Demonstrating the Longbow's logistical supportability before making a production decision can prevent the occurrence of major problems during its fielding. Army officials informed us that they are making plans to operationally test the Longbow's logistical supportability before the production decision.

The Burden of Correcting Frequent Failures Is a Major Cause of Apache Downtime

The frequent failure of components and the consequent demand for maintenance and replacement parts are major contributors to the Apache's low fully-mission-capable rates. The Apache's numerous sophisticated components and subsystems present a high work load in the form of corrective and preventive maintenance, as well as a high demand for replacement parts. This work load has been heightened by reliability problems in several key mechanical components. In addition, there are indications that new problems associated with aircraft aging are beginning to emerge. The Army is striving to improve Apache reliability, maintainability, and parts availability. These actions should help improve availability rates, but their full impact will not be known for several years. Improving reliability may represent the Army's biggest challenge because of the Apache's innate complexity and because several component problems have proven difficult to correct despite previous improvements.

Apaches Generate Numerous Failures

Apaches produce a high volume of failures that require a substantial amount of maintenance and many parts to correct—resulting in reduced fully-mission-capable time. Apache battalion personnel have expressed frustration over the frequency and varied sources of these failures. In addition to the low availability rates, data from several tests bears out the high frequency of failures: Apaches require essential maintenance actions about every 2.5 hours. This is nearly equivalent to the length of a typical mission.

Some Problems Stem From the Apache's Complexity

A good deal of the Apache's work load stems from the number and complexity of its subsystems and components. The Apache is a high-performance aircraft, and Army personnel place its sophistication on a par with that of the Air Force's F-16 fighter. This complexity is a byproduct of the Apache's designed capabilities to be effective and survivable on the battlefield. The target acquisition and designation sight is a good example. The sight provides the Apache's ability to find targets and guide its weapons from long ranges, using television, infrared, laser, and direct-view optics. The sight is the Apache's most sophisticated system, involving 26 major electrical, optical, and mechanical components. Although the sight has historically fallen short of reliability requirements, it may be approaching the upper limits of its reliability, given its complexity. The sight requires frequent maintenance because of its numerous failure modes, coupled with the difficulty in accurately isolating failures in its sophisticated electronics.

Key Components Are Experiencing Frequent Failures

Some components are failing several times more often than expected. While different types of components suffer from reliability problems, some of the most pressing problems—from the standpoint of availability and work load—involve the 30-mm gun system and basic mechanical components whose failure impairs the Apache's ability to fly. Examples of these key components and their reliability are shown in table 3.1.

Table 3.1: Expected and Demonstrated Replacement/Failure Intervals for Selected Apache Components

Component	Replacement/failure interval: Expected	Replacement/failure interval: Demonstrated
Main rotor blade	1,500 hours	164 hours
Main rotor strap pack	1,500 hours	520 hours
Shaft-driven compressor	2,000 hours	400 hours
Tail rotor swashplate	1,500 hours	250 hours[a]
30-mm gun	3,838 rounds	1,048 rounds

[a]Mandated removal interval

Source: U.S. Army data

The Army has numerous corrective actions underway to improve component reliability. Program officials are optimistic that proposed fixes will solve the problems. However, they acknowledge that it will be several years before all fixes are incorporated on fielded aircraft and demonstrated. The problems with these key components and the Army's corrective actions are summarized below.

Main Rotor Blade: The Apache's four main rotor blades comprise the lifting surfaces for the aircraft. The blades are made with bonded composite materials and metal, and in several places the blade surfaces debond, or separate. If the debonding is relatively minor, Army intermediate-level maintenance units can re-glue the skin. If the debonding is more significant, the blades have to be repaired by the manufacturer under a depot repair contract. The contractor has developed several fixes, such as improved glues and skin overlays that have had limited success in the field. According to the Army, the problem is caused by gluing voids in the production process, and blades produced with an improved gluing process are performing well in testing. It should be noted, however, that the original blade also passed testing.

Main Rotor Strap Pack: The four main rotor strap packs, which are part of the main rotor hub, help secure and control the main rotor blades. The strap packs, which are comprised of a series of steel straps, crack prematurely. The component is not reparable and must be replaced. The strap pack has never passed qualification testing, according to Army personnel, and it has been a problem since 1984. The Army asked the prime contractor to analyze the stresses at the failure points on the strap pack in 1987. However, the contractor has not responded to this request. Earlier this year, the Army agreed to the contractor's proposal to pay for design changes and 390 spares.

Shaft-Driven Compressor: The shaft-driven compressor, which is part of the environmental control system on the aircraft, provides cooling to many components on the aircraft. The Army has been aware of problems with it since about 1983. The compressor is not reparable by Army units and must by repaired by the manufacturer under contract. Various subcomponents fail on the compressor, and Army engineers suggest two basic design flaws as the possible causes of failure: (1) the unit is too light and lacks the durability to operate at required high speeds, and (2) the unit's oil supply comes from the transmission, whereas most compressors of this type have self-contained oil supplies. The compressor has undergone nine configuration changes, and the most recent version has started experiencing bearing failures. Army engineers believe that problems may continue on the compressor because of its basic design.

Tail Rotor Swashplate: The tail rotor controls the lateral movement of the aircraft. The tail rotor blades, which are the control surfaces, are actuated by a rotating swashplate. The swashplate bearing fails prematurely, causing the swashplate to seize and the aircraft to lose control. Such a failure caused a fatal crash in August 1987, prompting the Army to replace the swashplate every 250 flight hours. The swashplate bearing is not reparable by the Army and is replaced by the manufacturer under contract. Army documentation indicates several factors may have contributed to the tail rotor problem, including (1) inadequate bearing load capacity (actual loads exceeded design loads by 138 percent), (2) improper design techniques regarding the use of dissimilar metals, and (3) inadequate testing. One possible cause of the increased loads was the repositioning of the tail rotor lower on the tail assembly and increasing the diameter of the tail rotor during development to improve flight-handling performance. The prime contractor redesigned the swashplate bearing, and the Army began testing the new design in October 1989. On the basis of its performance in testing, the Army is installing the new swashplate on fielded aircraft as the old swashplates reach the 250-hour replacement interval.

30-mm Gun: The 30-mm gun has had a history of problems over the last 10 years, primarily with jamming and stoppages caused by subcomponents such as the feed system and the drive motor. The gun has undergone numerous design changes, but these have been unable to bring it up to reliability requirements. Program personnel believe that ammunition round control is the most serious problem with the gun today. They cite two components that break and cause jams: (1) a series of carrier links that form a belt to convey the rounds from the ammunition box in the belly of the aircraft to the forward-mounted gun and (2) a flex chute, which guides and supports the belt as it enters and exits the swiveling gun. Army maintenance personnel can usually repair the gun by replacing failed components with new ones.

Problems Due to Aging Have Begun to Emerge

As Apaches accumulate hours in the field, emerging component and airframe problems cause maintenance downtime not necessarily experienced by newer aircraft. Battalion maintenance personnel informed us that the second major phase inspection (which is performed at the 500-flight-hour interval) revealed much more extensive damage to the aircraft than they had expected. They discovered problems such as loose rivets, deteriorated fuel cells, wire chafing, airframe cracks, and rust in major components such as the main transmission that necessitated their replacement.

The Army has had a similar experience with the "Lead the Fleet" Apache—an aircraft the Army flies at fairly high rates to determine the Apache's long-term reliability, maintainability, availability, and durability. This Apache has shown increasing faults in the airframe structure over time, particularly with working rivets, sheetmetal cracks, and abrasion between composite and sheetmetal components in the aircraft's aft section. The Apache's tail boom section may become the source of future downtime because in addition to these problems, it becomes contaminated by fluids such as oil. According to an Army official, helicopter tail booms normally experience fatigue from flight loads and are eventually replaced, but the Apache's tail boom is not removable.

Other Component Problems Affect Availability

Some component failures lower Apache availability, not because of their frequency but because they are so severe that they pose safety problems. In those cases, the Army issues safety-of-flight messages that mandate immediate corrective action and could require the grounding of the fleet. The groundings may result in a dramatic short-term effect on availability because the necessary inspections and maintenance have to be performed on large numbers of aircraft at the same time. For example, uncommanded movements made by the 30-mm gun prompted the Army to issue a safety-of-flight message in August 1989 so that contractors could perform a corrective modification. In November 1989, when a cracked main rotor retention nut was found during a 500-hour phase inspection, the Army issued a safety-of-flight message so that the nut could be removed, inspected, tested, and replaced. The Army issued 28 safety-of-flight messages for the Apache in 1987, 18 in 1988, and 24 in 1989. Two of the 1989 messages resulted in aircraft groundings.

Other component problems can occur as a result of environmental conditions. For example, in humid conditions, electronic components have suffered from moisture buildup; in the desert, sand ingestion can cause problems. Personnel from one battalion informed us that flying in the rain can cause water to leak into the cockpit and avionics components. In 1988, cold weather conditions caused a component in the tail rotor fork—the elastomeric bearing—to fail on numerous Apaches.

Component Failures Create a High Demand for Maintenance

The high volume of component failures generates a high work load in the form of corrective and preventive maintenance. Corrective maintenance is directly affected because it consists of unscheduled actions needed to correct problems. The preventive, or scheduled, maintenance work load is also increased because numerous special inspections have been added to monitor problem components, and failures are often found during major phase inspections.

Unscheduled Maintenance Burden Is High

Removing and replacing failed components require a considerable amount of effort from maintenance units and result in aircraft downtime. While the Army does not collect complete data on expended maintenance man-hours, Apache battalions provided us estimates of the amount of time it takes to remove and replace selected key components. Table 3.2 presents some of these estimates, as well as the impact of such maintenance on aircraft downtime.

Table 3.2: Estimated Hours to Remove and Replace Selected Components

Component	Maintenance man-hours	Aircraft downtime
Main rotor blade	14 to 26	8 hours
Main rotor strap pack	32 to 44	3 to 4 days
Tail rotor swashplate	8	8 hours

The maintenance associated with these repairs is fairly involved. For example, it takes six maintenance man-hours to remove and replace a main rotor blade. All four blades must then be tracked and balanced, which requires two pilots and two maintenance personnel and another 8 to 20 man-hours. The aircraft is generally non-mission capable for up to 8 hours and longer if all the work cannot be completed in 1 day or if a replacement blade is not readily available. Whenever the strap pack is changed, the procedure for tracking and balancing the rotor blades must be repeated. These estimates exclude the amount of effort required to repair the component itself; generally aircraft are returned to service by replacing components, while the failed parts themselves are repaired by Army intermediate-level units or by contractors.

Failures in electronic components are a major source of maintenance downtime because they occur frequently and, unlike failures of mechanical components, they can be intermittent and hard to pinpoint. The Commander-in-Chief of U.S. Army-Europe has stated that as much as 50 percent of the time Apaches spend in the hangars for maintenance is devoted to troubleshooting and that this time was increasing. The Army believes that troubleshooting electronics is the top problem facing Apache maintenance personnel today. Battalion maintenance personnel echoed these concerns. In Germany, we had the opportunity to observe the troubleshooting of a fault in the helmet display unit. It required a technical inspector to power up the aircraft and took two technicians about 1 hour to check the system only to find that the problem would not replicate. The problem, however, recurred on the next flight, and a contractor representative had to help identify the cause.

Safety-of-flight messages can represent sudden large demands for unscheduled maintenance. While some messages require only visual inspections, others require the removal and replacement of key components on all aircraft as soon as possible. For example, the 30-mm gun safety-of-flight message necessitated about 6 maintenance man-hours to remove the gun turret assembly so that contractors could modify it and another 3 man-hours to re-boresight the gun. The main rotor retention nut safety message required grounding the aircraft to remove, inspect, and replace the nut—a job that required about 12 man-hours per aircraft.

Scheduled Maintenance Is Also a Significant Source of Downtime

The Apache's problems have resulted in more scheduled maintenance because numerous tasks have been added to monitor problem components and failures are often discovered during regular inspections. Major phase inspections are the largest single source of maintenance downtime; one of these inspections can take an aircraft out of service for several months.

There are two primary types of scheduled maintenance inspections prescribed for the Apache: a preventive maintenance service inspection, which is performed on each Apache every 10 flight hours or 14 days, and a much more intensive phase maintenance, which is performed every 250 flight hours. According to Army guidance, the 10-hour/14-day inspection should require 1.5 hours to perform. However, as a result of the growing number of tasks, the inspection now takes about 5 hours. Maintenance personnel from one battalion informed us that it takes about 30 minutes just to read the checklist. The need to monitor problem components has been a major reason for the increased maintenance time. For example, examining the tail rotor swashplate bearing added 1 hour to the inspection, while inspecting the main rotor strap packs added another 20 minutes. To illustrate the aggregate impact of these increases, one battalion informed us that 1 year's operations required at least 327 of these inspections at about 5.4 hours each—a total of about 1,760 man-hours.

While the amount of time it takes to perform phase maintenance inspections varies widely, they generally take about a month to complete. These are detailed inspections conducted on each Apache at 250-flight-hour intervals, and they involve substantial disassembly of the aircraft. Every other phase inspection—that is, those conducted every 500 hours—is even more extensive and takes longer. Maintenance personnel from one battalion informed us that the 500-hour phase inspection had disclosed more extensive damage due to age and wear than they had expected. As a result, at that battalion, the 500-hour inspection was taking up to 3 months to complete, compared to 1 month for a 250-hour phase inspection.

There are several reasons that phase maintenance takes so long: (1) component failures and other problems are routinely discovered that necessitate corrective maintenance; (2) some less essential maintenance tasks and modifications are not performed during day-to-day operations and are accumulated for the phase inspection; (3) parts needed to correct problems or to replace components taken for other aircraft are not available and must be ordered; and (4) personnel shortages exist, and competing demands divert the maintenance personnel from performing phase maintenance.

In comparison, the Marine Corps and the Air Force estimate that phase maintenance on their tactical aircraft takes 10 days or fewer to complete. Marine Corps officials informed us that they conduct phase maintenance on helicopters at 100-hour intervals, and it takes no longer than 36 hours. The Air Force conducts phase maintenance on the F-16 every 150 hours, with minor phases being conducted at shorter flying-hour intervals. According to Air Force officials, major phase inspections are completed in 10 days, while minor phases take 5 days. These services suggested that their phase inspections take less time because their inspections are done more frequently (and thereby catch problems before they occur) and because maintenance teams are dedicated to performing the inspections.

ırts Shortages ɔntribute to ɔwntime

The supply of key replacement parts has not kept pace with demand, and this shortfall has contributed to the Apache's low fully-mission-capable rates. Many of the components in short supply are experiencing high failure rates and are not reparable at or below the intermediate maintenance level. Until replacements for failed components arrive, aircraft stay less than fully mission capable unless components are taken from other Apaches. The Army has taken steps to alleviate the supply shortages and believes that they are working.

ɛy Parts Are in Short ıpply

Supply shortages of both major components and small parts have frustrated maintenance personnel's attempts to quickly repair failures. While the shortages do not involve a large number of components relative to the total number of parts on the Apache, those not available are essential to keeping the aircraft fully mission capable. In fact, many of the components needed the most because of failures are not available in battalion supply stocks and are the hardest to obtain.

Some of the major components in short supply are main rotor blades, tail rotor swashplates, main rotor strap packs, and pitch change links (which control the pitch of the rotor blades). All of these are flight-essential and, except for the main rotor blades, are not reparable by Army personnel. Major components of the targeting sensor are also in short supply, including the turret assembly, the power supply, and the electronic unit. Many smaller parts—such as nuts, bolts, and washers—are in short supply and are essential to reinstalling major components, such as the tail rotor. These shortages affect availability directly because when a component fails, the aircraft is impaired until a replac ment part is received. Battalion personnel estimate that it takes about 35 days to obtain parts from the supply system through normal channels using the highest priority available; routine priorities generally ta 45 days or longer. To minimize the amount of downtime caused by the: delays, Apache battalions rely heavily on taking components from aircraft already down for phase or depot maintenance and using them as replacements.

Several Factors Contribute to the Inability to Meet Demands for Parts

The Apache's unanticipated high demand for replacement parts is at tl root of the parts shortage problem. However, several other factors als contribute to the shortages, including limited supplier capacities, features of the Army's supply system, and the limited component repair capability within the Army.

The demand for replacement parts is met by repairing failed components and by producing new spare components. Because of the prime contractor's long turnaround times for component repairs and slow deliveries of new spares, the supply of replacement parts has lagged behind demand. The repair of components and the production of spare must compete with the production of new aircraft, and the production line takes priority. The contractor's capacity has been a concern amon Army contracting personnel for several years, and it will be several years before deliveries catch up with demand.

The production of new spares for several key components lags behind demand, and parts have been back-ordered. Table 3.3 shows the Army estimated back-order quantities and recovery dates for spares as of January 1990.

Table 3.3: Examples of Back-Ordered Spares

Component	Number back-ordered	Recov d
Main rotor blade	233	June 1
Main rotor strap pack	176	Jan. 1
Tail rotor swashplate assembly	11	May 1
Main rotor pitch link assembly	372	Apr. 1
Main transmission	25	May 1
Target sight electronic unit	27	Nov. 1
Night vision sensor turret	25	June 1

Turnaround times for repairing key components are likewise long. For example, under the terms of the current depot repair contract, the Army expects to send 393 rotor blades for repair, and the prime contractor has agreed to repair the blades at a rate of 10 per month. At this rate, the blades sent to the contractor for repair in September 1989 will be repaired by August 1992. Repairs of target and night vision sensor components pose less of a problem because the contractor for the sensor systems has established, at the Army's expense, several special repair activities in close proximity to Apache battalions. These repair activities have greatly reduced the time it takes to repair most sensor components and have thus lessened the effect of the components' reliability problems.

In addition, the Army closely manages certain components with high dollar values and does not allow large numbers of these items to be stocked. Many of the major components in short supply are on the list of intensively managed items. Battalion personnel also stated that transportation is a source of delay. For example, in Germany, half of the time it takes to get a high priority component is spent getting the part from the receiving point in Germany to the requesting battalion.

The fact that many of the key components in short supply are not reparable by Army personnel places additional demands on the supply system. When components—particularly those with high failure rates—can be quickly repaired by Army units, fewer replacements have to be ordered, and the efficiency of the supply system becomes less important to availability. Army units do not have repair capabilities for some components because these components were not expected to fail much. In other cases, repair capabilities have been limited by the performance of support equipment. Support equipment is discussed more fully in chapter 4.

Other factors have contributed to the supply problem. Army personnel responsible for managing the supply system believe that numerous configuration changes to components have worsened the problem because of the long lead times associated with making a new component part of the supply system. In addition, the May 1989 storm at Fort Hood generated a large, unanticipated demand for key airframe parts, such as rotor blades. In January 1990, six Apaches damaged in the storm were still awaiting parts. While the storm was clearly an extreme event, it does illustrate the difficulty the supply system has in responding to demands as well as the aircraft's dependence on supply for repairs. According to one brigade commander, the storm replicates the catastrophic damage the Apache could sustain in battle and the damage's effect on supply.

The Army Is Taking Steps to Overcome Shortages

The Army has taken several actions to improve supply availability for the Apache. Recently, the Army initiated a program whereby battalions can exchange failed targeting and night vision sensor components for replacements directly at contractor special repair activities in the field. This program has resulted in shorter turnaround times for these items. Also, the Apache program office has taken over the management of several particularly troublesome items, such as the tail rotor swashplate and the shaft-driven compressor, and has been able to shorten their turnaround times. According to the Army, while deliveries of replacement parts from contractors are still slow, there has been improvement in the last year, and contractors have been able to fill a higher percentage of total orders. Army representatives believe that as a result of this action and others, fully-mission-capable rates have improved in early 1990.

Apache Warranties Prove Ineffective in Covering Frequent Failures

The Army has not been able to recoup the costs of component failures under airframe production contract warranties. Instead, financial settlements on major corrective actions are negotiated outside of the warranties, and the Army has incurred most of the costs associated with these actions. According to an Army representative, until 1989, warranty clauses contained a threshold, or deductible, for depot-reparable items that was so high that it has never been breached. According to an Army representative, difficulty in collecting under the warranties can also be attributed to broad contract specifications, vague contract language, and the incomplete reporting of failed components by field units.

The warranties also entitle the Army to seek restitution when failures are caused by a latent design or manufacturing defect. However, the Army has found it very difficult to prove that designs are defective. For example, Army representatives informed us that they had been unable to prove that the tail rotor swashplate bearing was defective, even though the component had to be removed every 250 hours rather than the required 1,500 hours. The prime contractor argued that the Army's revision of its technical manuals to reflect the mandated 250-hour removal interval constituted a revised requirement that the swashplate had met. Army representatives informed us that, while this argument had no merit, the contractor's unwillingness to acknowledge the design flaw would result in lengthy litigation, rendering this contract remedy impractical.

Financial settlements on technical problems are negotiated outside the warranties on a case-by-case basis. Settlements have been reached on several components so far, including the main rotor blade, the main rotor strap pack, the shaft-driven compressor, and the tail rotor swashplate. In general, the contractor has agreed to reengineer the components at no cost to the Army, while the costs of retrofitting Apaches with the improved components are to be shared. The Army negotiated a more favorable settlement on the tail rotor swashplate, whereby the contractor agreed to pay for the design change, retrofit 552 fielded Apaches, and upgrade 90 spares.

As of March 31, 1990, the Army estimated that negotiated and proposed settlement costs totaled $56.7 million: the Army will fund $35.0 million; the prime contractor will fund $18.5 million; and it has yet to be resolved who will fund the remaining $3.2 million. However, these settlements exclude the significant costs already paid by the Army to the contractor for the depot repair of failed components. For example, the funds paid to the prime contractor to repair all of the swashplates that had to be removed early—as well as the costs of the Army's labor and the time it expended to inspect, remove, and replace swashplates—are considered sunk costs and are not included in the settlement.

According to Army representatives, the contractor for the night vision and targeting sensors has been more willing to take responsibility for correcting reliability problems. Also, the fiscal year 1989 production contract with the prime contractor for the airframe does not have a threshold clause in the warranty provisions and should, therefore, be an improvement over the previous warranty. However, it may be several years before the effectiveness of this warranty is known.

Apache Maintenance Units Are Overburdened and Dependent on Contractor Support

Maintenance units cannot keep up with the Apache's unexpectedly high work load because (1) maintenance organizations are too small and are hampered by Army management practices and (2) maintenance equipment—particularly as it relates to troubleshooting electronics—is either unable to perform as needed or is not available. Battalion commanders have cited the manpower shortfalls as a major reason for low availability rates and flying hours. Given the mismatch between maintenance demands and capacity, the Army has turned increasingly towards contractor assistance for maintenance.

The Army has proposed several actions that should improve maintenance capabilities and aircraft availability. These include adding personnel, improving maintenance equipment, and increasing contractor support. At this time, however, the Army has not determined where it will obtain the additional people, and the sufficiency of equipment improvements has not been demonstrated. It is also uncertain whether the additional contractor support will be a lasting solution.

Maintenance Organizations Cannot Meet Apache's Work Load

Maintenance units are too small to handle the work load generated by the Apache because the Army patterned these units after units that maintained a less complex aircraft. The maintenance capacity of these austere organizations is further limited by the low productivity of and the high turnover among maintenance personnel. In 1989, the Commander of U.S. Army-Europe depicted the Apache maintenance situation as follows:

> Current readiness rates are only possible through a combination of reporting procedure shortfalls, existing contract support, LAR [Army Logistics Assistance Representative] and CFSR [Contractor Field Service Representative] assistance, and the extensive overtime contributed by our soldiers. . . . Initial data shows serious morale and re-up problems starting to occur in these units due to overwork.

Maintenance Units Are Too Small

The Apache battalion organization, which is responsible for 18 Apaches, 13 OH-58 observation helicopters, and 3 UH-60 utility helicopters, was not structured to satisfy the Apache's requirements but rather those of the less complex Cobra. The "Army of Excellence" initiative, which imposed limits on the size of Army units, made the Cobra organization itself austere and precluded attempts to make the Apache organization larger despite the support of manpower analyses. The result is an Apache organization with too few maintenance personnel to handle the job.

The Apache battalion is currently authorized 264 people, about 100 of whom are involved with performing unit-level maintenance. According to the Army's manpower analysis for the Apache, the battalion should have 366 people, including about 160 for helicopter maintenance. Even this analysis appears conservative, however, considering that it assumes that each Apache will fly about 2 hours per day in combat and will require about 7 maintenance man-hours per flight hour, whereas current estimates of man-hour requirements and combat flying hours are at least double these levels.

Given its small size relative to the work load, the maintenance organization limits the number of flying hours and the availability of the Apache; that is, a unit can fly only what it can maintain. The organization is adequate to staff one shift of maintenance per day, but one maintenance shift is not sufficient because the Apache flies a large portion of its missions at night. Maintenance personnel often have to work more than one shift to accommodate night flights and then have to be on the job the following day to coordinate repairs with intermediate maintenance personnel. Shortfalls exist in several maintenance specialties, including crew chiefs, electricians, and avionics technicians.

Both the Marine Corps and the Air Force devote much larger organizations to maintaining and supporting their tactical aircraft. The Marine Corps has 225 maintenance personnel for a squadron of 12 Cobras and 12 UH-1 Hueys—more than twice the number of people for fewer and less complex helicopters than in an Apache battalion. This level of support enables the Marines to operate two maintenance shifts per day and to conduct flight operations 24 hours a day. The Air Force devotes about the same ratio of people at the unit level to maintaining and supporting a squadron of 26 F-16s. The Air Force organization also supports two maintenance shifts per day and provides two crew chiefs per aircraft versus one for each Apache. These high levels of support are a major reason that Marine Corps and Air Force aircraft fly so many more hours than the Apache does.

Army Management Practices Further Limit Apache Maintenance Organizations

Several of the Army's practices weaken the capability of already overburdened Apache maintenance units. Maintenance personnel are able to devote less than half of their time to maintenance because of other competing demands and distractions and often work long hours to meet the high work load. Faced with this work load and a limited career path within aviation maintenance, Apache maintenance personnel leave the Army at a fairly high rate, weakening the experience base. Battalions at Fort Hood are faced with the additional burden of losing people to newly forming Apache battalions and regularly have fewer people than authorized.

Apache maintenance personnel spend only about 30 percent of their duty day performing maintenance on the Apache. This percentage amounts to about 2 to 3 hours of productive maintenance per day. The remainder of their time is spent on other required duties such as physical training, guard duty, motor pool detail, and rifle qualifications. Personnel involved with Apache operations and maintenance informed us that the prevailing philosophy within the Army is that maintenance personnel are soldiers first and Apache maintainers second. As a result, the maintenance of helicopters does not get the full attention of maintenance personnel, and availability rates suffer.

About 65 percent of first-term Apache maintenance personnel do not reenlist, despite reenlistment bonuses of up to $20,000. One reason maintenance personnel cited for leaving was the long hours associated with both the insufficient productive time and the Apache's frequent failures. Maintenance personnel also informed us that the career path for people actually performing maintenance was limited and that to advance further, they must take supervisory positions that do not entail performing maintenance.

Personnel losses in Apache battalions occur for other reasons. Some people leave the Army for the higher paying jobs and more regular hours that contractors can offer. This problem becomes worse as the amount of contractor support for the Apache increases. Apache battalions are also suffering the loss of experienced maintenance personnel who joined the Army during Vietnam and are now becoming eligible to retire. Battalions stationed at Fort Hood have an additional source of attrition: these units are required to rotate experienced personnel to new battalions being trained at the Apache Training Brigade in Fort Hood. Often, replacement personnel are inexperienced and have not gone through the training brigade themselves. Because of this and the higher priority for personnel that other battalions enjoy, Fort Hood's battalions generally have fewer people than authorized: the four battalions we reviewed at Fort Hood had between 230 and 247 people, compared to the basic authorization of 264 people.

Personnel turnover resulting from these management practices can significantly erode the battalion's maintenance expertise. This is particularly true for troubleshooting electronics because senior maintenance personnel at the Army's Aviation School informed us that it takes 8 to 12 years for an individual to become adept at troubleshooting. Air Force officials informed us that a similar level of experience is required for performing troubleshooting functions. Personnel from one battalion in Germany that consistently maintained high availability rates cited the presence of experienced people in key positions as instrumental to their battalion's performance.

Weaknesses in Test and Repair Equipment Hamper Maintenance

Apache maintenance personnel have had difficulty in locating and correcting failures because of weaknesses in automatic test equipment, tools, manuals, and training. Because of these problems, combined with the Apache's high work load, the Army has not been able to adhere to a basic premise of the Apache's maintenance concept: to ensure high availability by quickly locating and replacing failed components at unit-level maintenance and quickly repairing components at the intermediate level. Instead, unit-level maintenance personnel have difficulty troubleshooting problems, and many key components are either not reparable or take too long to repair at intermediate-level maintenance units. As a result, the Apache's availability has become more dependent on the supply system and on depot-level maintenance. Repairs are therefore slower and require more spares than they would if intermediate maintenance capabilities were greater.

Automatic Test and Diagnostic Equipment Has Not Performed as Needed

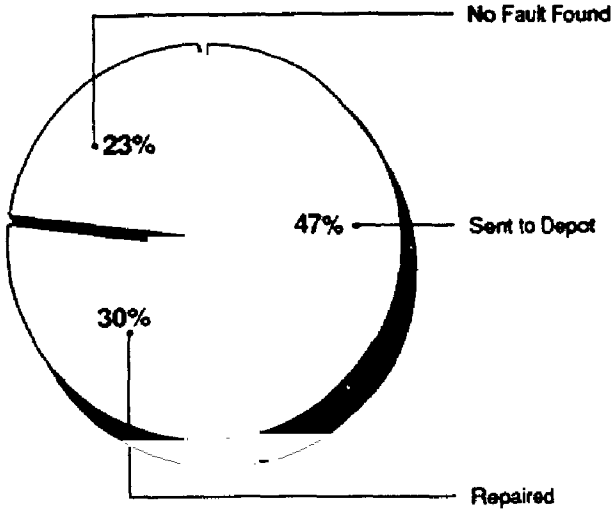
Automatic test and diagnostic equipment has not proven capable of the quick and accurate troubleshooting of faults in electronic components, or "black boxes," that is essential to high rates of availability. The on-board fault detection and location system has not proven dependable in locating valid faults. The intermediate-level Electronic Equipment Test Facility, which tests the removed components for failures, is slow and does not have the capability to repair the circuit boards within the components.

The fault detection and location system suffers from two basic problems that have caused maintenance personnel to mistrust it. First, the system does not accurately find the component that is the root cause of a particular fault indication. For example, if a power supply component fails and causes problems in other components, the fault detection system may identify the other components as the problem. Second, about

40 percent of the time the system detects faults that do not actually exist. Both kinds of problems necessitate additional maintenance time to verify and locate failures manually, place greater demands on supply, and pass a greater work load on to intermediate- and depot-level repair facilities. Troubleshooting is further hampered by the fact that maintenance manuals lack wiring diagrams, are vague, and do not provide continuity between subsystems of different manufacture. Maintenance personnel compensate for these weaknesses by using other Apaches as test beds for removed components and by using "break-out boxes"—individual testers that can verify the performance of a component. However, the fault detection system was intended to minimize the need for ground equipment and complex manual troubleshooting procedures.

According to the Army Materiel Systems Analysis Activity, the volume of components being sent to the Electronic Equipment Test Facilities is about double the volume predicted. However, the test facilities have not had the speed, the capacity, or the resources to fulfill the critical role of readily providing replacement components by quickly performing repairs in close proximity to unit-level maintenance. Army data collected on three test facilities during 1989—two run by the Army and one run by a contractor—showed that it took Army personnel an average of 36 days to test and repair target and night vision sensor components and that a significant portion of the test facilities' work load was passed on to depot repair. Maintenance personnel informed us that some components can take up to 90 days to test and repair. Data collected during 1989 on the three test facilities is displayed in figure 4.1.

Figure 4.1: Processing of Sensor Components by Electronic Equipment Test Facilities



Source U S Army data

There are several reasons that the test facilities have not been responsive to demands. First, the facilities were originally intended to have the capabilities to (1) test a black box, (2) identify a faulty circuit board within the box, (3) diagnose the fault within the board, and (4) enable the repair of the card in an adjoining electronic repair facility. Having these capabilities would have allowed the facilities to be fairly autonomous in repairing faulty electronic components. However, in 1983, the Army decided against giving the facilities the capability to test and repair circuit boards. Instead, circuit boards are repaired at contractor depots. As a result, today the facilities can test black boxes and identify failed boards, but they must requisition replacement boards, which are in short supply, to repair the boxes. Facility operators in Germany estimated that they usually did not have parts on hand for about 80 percent of repairs and that they wait about 45 days or more for the parts.

Another limitation of the test facilities is their slowness in testing electronic components. A facility can test only one component at a time, and each type of component has a test program that must be set up to diagnose the component. Maintenance personnel estimated that it can take 45 minutes to 5 hours to test one component. According to the Army, the delay is due in part to the slow processing speed of the outdated central computer and to the design of the diagnostic programs, which must run from start to finish with no option to immediately test for a suspect card. As a result, the test facilities' operations are handcuffed by their slow initial testing of a component, the time needed to obtain replacement circuit cards, and the need to retest the component to verify the repair.

The responsiveness of electronic test facilities is further slowed by the unavailability of personnel. As with maintenance personnel in the battalions, the intermediate-level maintenance personnel who operate the facilities are drawn away by other demands. This loss of productivity was indicated by the performance of Fort Hood's three test facilities: while it took the Army-run facilities an average of 36 days to repair sensor components, it took the contractor-run facility only 11 days on average.

Other Equipment Is Lacking

Maintenance personnel informed us that they did not have all of the right tools and equipment to perform needed maintenance. The tool kits issued to Apache crew chiefs are the same kits issued to mechanics in the motor pool; they are not aircraft quality and cannot withstand some of the high torque requirements for the Apache. Special equipment, including air data sensor alignment tools, rotor track and balance equipment, and pneumatic pressure testers, is in short supply and thus prolongs repair times. The air data sensor tool is perhaps the most extreme example in that there are only two such tools Army-wide. In addition, not all battalions have obtained the "break-out" boxes used to augment the fault detection system.

Maintenance Weaknesses Raise Questions About Intermediate-Level Capabilities

While the Apache's low availability rates indicate problems with unit-level maintenance, these low rates also indicate weaknesses in intermediate-level maintenance. Intermediate maintenance is essential to aircraft availability because repair capabilities determine the availability of critical components. According to the Marine Corps, intermediate maintenance personnel must be able to fix high-failure components to avoid heavy dependence on the supply system, and they must repair components within 72 hours to be considered responsive. The Marines have the capability to diagnose and repair circuit boards at the intermediate level. Many of the Apache's key components experiencing high failures have not been reparable at the intermediate level, and turnaround times for the repair of black boxes can be weeks. In addition, personnel from several Apache battalions informed us that they do not rely on intermediate maintenance because its repairs tend to take longer and its personnel are less experienced. The ability of intermediate maintenance personnel to quickly repair components has not been stressed as much as that of unit-level maintenance personnel in exercises because exercises are short enough that sufficient spares can be obtained to minimize the need for repairs.

Army Is Relying Increasingly on Contractor Assistance

The Army has come to rely on contractors in all three levels of Apache maintenance. Contractor technicians regularly assist unit and intermediate maintenance personnel. While this assistance was originally intended for newly formed units, these technicians have become essential to maintenance operations and have been retained. Several battalions actually contract out some unit-level maintenance, and the Army has proposed expanding this practice as a near-term solution to the manpower shortfall. The Apache's maintenance concept now includes contractor-run repair facilities—located near fielded battalions—to handle many of the electronic component repairs originally intended for intermediate maintenance. The Army is considering a plan to field an additional facility in West Germany to repair airframe components. In addition, while the Army was originally intended to have taken over all depot-level maintenance at this stage in the program, contractors still perform most of this maintenance.

Contractors Assist in Unit and Intermediate Maintenance

Field service representatives from the prime contractor and the major subcontractors are located at or near Apache battalions and assist in troubleshooting failures on the aircraft, advise Army personnel on maintenance procedures, and help obtain replacement parts. In general, however, they do not directly perform maintenance. These individuals regularly provide such assistance during normal operations as well as during exercises. Battalions receive similar assistance from Army technicians, referred to as "logistics assistance representatives." The field service representatives assist unit-level personnel with the aircraft itself and intermediate-level personnel with the components, particularly those that are served by the electronic test facilities.

At some locations, the Army employs service contractors that actually perform unit- and intermediate-level maintenance. U.S. Army-Europe provides 5 man-years of contracted unit-level maintenance to each of its Apache locations (some of which serve more than one battalion). The Army has proposed making this kind of support available to all U.S. battalions to boost maintenance capabilities until manpower levels can be increased. In addition, a contractor that was brought in to help repair

Apaches damaged in the May 1989 Fort Hood storm has been retained to augment Army intermediate maintenance personnel in performing routine tasks.

Contractor-Run Depots Perform Component Repairs in the Field

Contractors' special repair activities, originally fielded to alleviate production problems with the targeting and night vision systems, have become integral to the maintenance support of the Apache. Although these activities are considered depot-level, they carry much of the work load originally intended for the Army's intermediate-level electronic test facilities and repair shops. Currently there are four of these facilities: one located in West Germany and three located in the vicinities of Fort Hood, Texas; Fort Rucker, Alabama; and Fort Bragg, North Carolina. Martin Marietta fielded the four facilities and operates them at the Army's expense. In fiscal year 1989, the Army provided $13.5 million for the operation of the special repair activities.

The special repair activity originated as a production support facility established at the Apache production complex in Mesa, Arizona. Martin Marietta used the facility to correct problems with targeting system and night vision system components caused by improper installation techniques. Over time, Martin Marietta's main facility in Orlando, Florida, could not repair components fast enough to meet the high volume of demand. The contractor and the Army agreed that the demand for spares could best be met by special repair activities modeled after the production support facility.

The special repair activities repair the targeting and night vision sensor components using some special equipment, elements of the electronic test facility, and trained engineers who rely on wiring diagrams and individual testers. Using these methods, they can repair circuit cards and other items below the major component level. The facilities also modify and upgrade targeting system and night vision system circuit boards for the Army. All of the work performed by these facilities is considered depot-level work; however, they do perform the board repair function originally intended for the Army's intermediate test facilities, and they test and repair a sizable portion of the components that the Army facility is capable of handling. For example, in 1989, Fort Hood's test facilities sent 47 percent of their sensor components to the contractor repair activities, and battalion personnel bypassed the facilities altogether in sending 26 percent of all components directly to the contractor activities.

According to the Army, the special repair activities have been successful because they are cheaper and faster than the main production facility and they have greatly improved the availability of sensor components. The Army has recently started allowing Apache units to exchange components directly with the contractor facilities, a policy that it believes has increased aircraft availability. The Army is also considering a plan to establish an additional special repair activity, this time with McDonnell Douglas, to repair mechanical and other electronic components on the airframe. Army officials told us that they would like to run the repair activities with Army personnel, but such staffing would be difficult because they would have to get the personnel authorized and then provide them with career paths so that the Army could retain their expertise.

Transition to Army Depot Support Has Slipped

The Army had originally planned to assume depot maintenance in fiscal year 1988, with the Sacramento Army Depot handling the targeting and night vision sensor components and the Corpus Christi Army Depot handling airframe and engine components. However, these depots have not assumed Apache repairs, and most depot-level maintenance is still performed by contractors. Because of the initial costs and the sophistication involved, the depot repair of most major electronic components will remain with the contractors.

The Army abandoned its plans to take over the depot repair of major electronic components based on a study conducted by the Apache program manager. The study showed that, while Army and contractor operating costs were about equal for repairing the targeting and night vision sensor components, the greater expertise of the contractor personnel and the necessity for the Army to initially invest in expensive test equipment made it more reasonable to continue using contractor depots to support those components. The study further recommended that all major airframe electrical components stay under contractor depot support for the same reasons. The study did recommend that the airframe repair convert to Army depots as planned in fiscal year 1988. However, according to program officials, funds have not been sufficient to purchase the repair specifications and the required tooling, and the transition has slipped until fiscal year 1991.

Army Is Taking Several Actions to Improve Maintenance Capabilities

The Army has proposed, planned, or has underway a series of action designed to improve the capabilities of Apache maintenance personn and equipment. These actions, combined with attempts to improve ai craft reliability, should result in a better match between the Apache's demand for maintenance and the Army's ability to provide it. Howev some actions, particularly those aimed at increasing personnel streng have not been resourced. Even with improvements, it is questionable whether the fault detection system and the electronic test facility wil improve enough to fulfill their intended roles. In addition, while increased reliance on contractor support may be a pragmatic peacetir solution and the quickest way to improve maintenance capacity, it m not constitute an effective solution in combat

The Army has approved a proposal to add 35 people to the Apache b talion, 18 of whom would be devoted to maintenance. According to t this increase will provide the minimum number of people to support peacetime operations but will not fill the wartime requirement. At th time of our review, the Army had not provided the personnel for th increase The Vice Chief also directed Army units to ensure that Apa maintenance personnel put in at least 4.5 productive maintenance ho per day at the expense of other demands In May 1990, the Commanc of the Combined Arms Combat Development Activity proposed aug- menting each Apache battalion with a company of 127 Army reservi in addition to the increase of 35 already approved. This proposal wou enhance the battalion's war-fighting capabilities by increasing the number of air crews and providing another 70 maintenance personne The Army was still considering the proposal at the time of our review Within the battalion, the Army has already converted three positions unrelated to aviation maintenance to positions for aircraft electrician

The Army is purchasing additional computer codes that will enable maintenance personnel to query the fault detection system for more detailed information on indicated faults. These additional codes may improve accurate detections on a number of components, but many other components—60 percent of those testable by the electronic tes facility—are not reachable by these codes. The Army plans to furthe improve troubleshooting by purchasing more break-out boxes and improved manuals. The Army is also testing an advanced diagnostic that uses "artificial intelligence" technology. The Army believes that recent improvements to the fire control computer will reduce the fau detection system's false alarm rate. The Army plans to retrofit the el tronic test facility with an improved central computer, which the Ar estimates will increase efficiency by 25 percent. However, the facility will still be unable to test and repair circuit boards. The Army has als directed maintenance units not to bypass the electronic test facilities i forwarding electronic components for repair.

In addition to these actions, we believe that the Apache can benefit su stantially from the lessons learned by the other services. The other se vices fly their aircraft significantly more hours and devote many mor people to their support. In our April 1990 testimony, we recommende that DOD apply such experience to the Apache. DOD responded that a system already exists to document lessons learned by the services. Ho ever, given the apparent wide disparity between how the other servic operate and support their aircraft and how the Army operates and su ports the Apache and on the basis of our discussions with Apache ma tenance personnel, we do not believe that the Apache has benefited fr the experiences of the other services.

Chapter 5

Army's Ability to Support the Apache in Sustained Combat Operations Is Questionable

The Apache will face great logistical support demands in high-intensity combat. The Apache has excellent war-fighting potential, but the Army's ability to provide sustained logistical support is essential to taking advantage of this potential. The Army has not operationally tested the basic combat unit—the battalion—under conditions that approximate sustained combat. The Army has conducted one battalion-sized test under less strenuous conditions and found the Apache's availability to be insufficient despite substantial contractor support and other favorable test conditions. While the Apache's operations in Panama involved a unit smaller than a battalion, these operations did indicate the substantial resources required to support the helicopter in combat. The Apache's participation in Operation "Desert Shield" may provide additional insights into combat demands.

Combat Operations Will Place Greater Demands on Apache Availability and Support

Army combat tactics call for 15 of the 18 Apaches in a battalion to fly missions at one time—an availability rate of 83 percent. According to Army tactics, the battalion will use three primary methods of employment in combat—continuous attack, phased employment, and maximum destruction. All three call for 15 Apaches. For example, the continuous attack tactic calls for one company of five Apaches to be engaged in battle, a second company to be en route to relieve the first, and a third company to be rearming and refueling.

At the same time that the Army needs a higher availability rate for combat, it expects to fly each Apache at a wartime rate of about 4 hours a day. This rate compares with the peacetime average of about half an hour per day (12.9 hours per month). Not only would availability be expected to drop due to the increased maintenance and logistical burden of greater flying hours, it would be further degraded by the frequent weapons firing and battle damage not experienced in peacetime.

To some extent, the increased work load during combat would be offset by other factors. For example, maintenance personnel would become dedicated to maintenance (except in performing such tasks as guard duty) and would thus be more productive than they would be in peacetime. In addition, the standards for considering an aircraft flyable in peacetime may be relaxed during combat. Also, in the long term, it may be possible to increase the production of critical spare parts. However, these gains do not appear to be sufficient to make up for the great disparity between what the Army has been capable of supporting during peacetime and the strenuous demands of combat, at least not in the near term.

Shortfalls in Apache Logistical Support Could Become More Pronounced in Combat

Some of the factors limiting the Apache's availability in peacetime could be magnified in combat. Not only would limitations such as the small maintenance organization and diagnostic equipment weaknesses become more pronounced, but peacetime amenities such as contractor support and dedicated hangars could be lost.

As previously discussed, a battalion organization of 264 people is too small to maintain the Apache. In addition to being short of maintenance personnel, this organization provides only one air crew per aircraft, which may not be sufficient to sustain the Apache's combat flying hour rate and its 24-hour operations. Availability would improve if battalions were staffed with the 366 people called for by the Army's manpower analysis for the Apache. However, even staffing at this level would likely be insufficient because the manpower analysis' assumptions for a combat flying-hour rate of 2.1 hours per day and a maintenance man-hour burden of about 7 hours per flight hour are significantly understated. The Marine Corps uses a different approach in organizing for combat; according to Marine Corps officials, the service bases the size of its aviation organizations on realistic estimates of combat flying hours and maintenance man-hours and then staffs at the 90-percent level for peacetime. In effect, the Marine Corps starts with the combat requirement and scales it down for peacetime. The Army seems to reverse this process for the Apache: it has structured a peacetime organization that will have to be redefined for combat.

The Electronic Equipment Test Facility may become a bottleneck during combat because of the much greater volume of component repairs it will face, along with its having to move more often during combat. According to an Army Materiel Systems Analysis Activity study, the Army would need eight times as many electronic test facilities as are currently planned to meet the wartime work load. An additional concern is the facility's mobility. The test facility will be required to move during combat to keep it as close as possible to the Apaches it serves. In peacetime, the facility normally operates from fixed locations. Although data on how long it takes to relocate the facility is sparse because it has not been operationally tested, the facility has experienced problems returning to service after relocating because its sophisticated equipment is very sensitive to moving.

The Army's increasing reliance on contractor support to alleviate the Apache's support problems during peacetime may not prove to be a workable solution during combat. The Army recognizes that using service contractors to perform unit-level maintenance is a temporary solution until additional Army personnel can be assigned. However, the Army's reliance on contractor technical personnel for expert assistance such as troubleshooting may not be readily assumable by Army personnel.

A longer term concern is the Army's dependence on contractor-run depot facilities to repair critical components near the active units. The Army plans to expand its use of these facilities and has recently allowed units to exchange components directly with them. Although these facilities play a vital role in supporting the Apache in peacetime, their practicality and mobility in high-intensity combat have yet to be determined. According to a study commissioned by the Army, a maintenance concept that includes the use of these facilities can work if they are located in rear areas and if the Army dedicates a transportation system to moving components from the facilities to the combat units. While the contractor facilities are currently located near the Apache battalions, Army Regulation 750-1 states that civilian personnel cannot be permanently located in the corps area or closer during combat. The Army is studying ways to make special repair activities practical for use in combat, such as operating the facilities with Army personnel rather than contractors.

The Army Has Not Tested the Apache Under Combat-Representative Conditions

The Army has not operationally tested the Apache battalion under conditions that approximate sustained combat. Testing under such conditions, which will entail a high number of flying hours, frequent weapons firing, and realistic maintenance and supply resources, is essential to determining the Apache's aggregate logistics demands in terms of parts, repairs, people, and organizational structure. Such testing is also essential to determining the Army's ability to meet these demands. Army logistics officials informed us that they have previously proposed a program to fly the Apaches at high rates to illuminate some of these issues, but the program has not been funded.

The only operational test conducted for the Apache was the 1981 test that preceded the production decision. That test involved three Apaches and was substantially supported by contractor personnel. Several Apache tests have since been held, but none are considered "operational"—that is, none approximated combat conditions. Only the 1986 Attack Helicopter Battalion Training Validation tested a battalion; all the other tests were conducted with smaller units, such as a company. The 1986 test was conducted with the first fielded combat battalion, but its realism was limited by (1) having 22 Apaches rather than 18, (2) flying few hours relative to the numbers expected to be flown during combat, (3) relying on extensive contractor support, and (4) using new Apaches that had not accumulated enough hours to require phase maintenance.

Despite these limitations, the test revealed that, although the Apache was superior to its predecessor, it suffered from reliability problems with its targeting sight and its 30-mm gun and from inadequate logistical support. The test drew two other significant conclusions. First, the battalion organization did not provide adequate resources to allow the unit to perform operations and maintenance in an operational environment. Second, even under favorable operating conditions, the battalion achieved an availability rate of 73 percent (computed by combining fully-mission-capable and partially-mission-capable times), which was insufficient to meet the wartime requirement to have 15 of 18 Apaches ready for combat. On the basis of the test, the Army Operational Test and Evaluation Agency made the following comments in 1987:

> Based upon what has transpired to date with the fielding of the AH-64A [Apache], ... there appear to be three areas left unresolved with respect to the tactical employment of the Attack Helicopter Battalion: tactics and doctrine, force structure, and sustainability. Given the quantum leap in combat capability the AH-64A will provide the Army, and the relative consequences of our failure to capitalize on this capability, planning to resolve these issues should begin immediately.

> OTEA [the Operational Test and Evaluation Agency] recommends that the US Army Aviation Center initiate planning to conduct some form of an FDT&E [Force Development Test and Experimentation] that will finally lay these issues to rest and also address the broad range of aviation issues that were not resolved by the AHBTV [Attack Helicopter Battalion Training Validation test]. As it stands today, the Army has an O&O [organizational and operational] concept and force structure that it is highly dependent upon for war planning that has yet to undergo realistic testing in an operational environment, against the known and postulated Threat.

Follow-on operational testing has yet to be conducted, and the Operational Test and Evaluation Agency's comments are as germane today as they were 3 years ago.

In our April 1990 testimony, we recommended that such an operational test be conducted with at least a battalion-sized unit to illuminate the logistical support demands of combat operations and the Army's ability to meet these demands. While DOD agreed that proposed corrective actions and the logistical support structure need to be operationally verified, it did not agree that an operational test was needed, stating that the results of such a large-scale test of a battalion would not justify its expense. DOD believes that evaluating the normal operations of Apache units and those participating in exercises such as REFORGER is a better approach because data from multiple units would be used.

We believe the approach proposed by DOD will yield limited benefits. Because of shortfalls in the Army's data collection and measurement methods, data from previous Apache tests and operations did not disclose the seriousness of the logistical support problems experienced by combat units. In addition, while Apache battalions regularly conduct battalion- and company-sized exercises, these exercises do not shed much light on sustaining combat operations. Such exercises are generally short and well-prepared, and benefit from unusual logistical support arrangements. The main purpose of these exercises is to allow units to fly and train—not to exercise the logistical support system.

For example, six battalions participated in the 1990 REFORGER exercise, during which they flew at a fairly high flying-hour rate and achieved a fully-mission-capable rate of about 65 percent. However, the battalions performed a lot of preventive maintenance in advance, fired no weapons, and benefited from Army and contractor personnel who obtained parts and delivered them to the battalions outside the normal supply system. Also, the battalions flew for only about 2 weeks—not long enough, according to Army officials, to exercise the repair capabilities of the intermediate-level maintenance units. Apaches have achieved high fully-mission-capable rates during previous REFORGER exercises, yet the Apache's problems were serious enough to warrant the formation of the Apache Action Team and the Tiger Team. We also observed an exercise with nine Apaches at the National Training Center at Fort Irwin, California. The exercise lasted about 2 weeks, and battalion personnel informed us that they had brought their best aircraft and prepared them for the exercise. Only two aircraft were used for firing weapons, and 24-hour commercial express service was provided for replacement parts.

Operation "Just Cause" Highlights Logistical Support Challenges

Although Operation "Just Cause" in Panama involved less than a battalion of Apaches, it indicated both the performance strengths of the Apache and the high concentration of resources that will be needed to support the aircraft in combat—a concentration of resources currently not normally available to Apache battalions. The Apache's experience in Panama also indicates the difficulties the Army may face if it has to quickly deploy the helicopter to a remote combat location where no maintenance and supply structure is in place. Deployment of the Apache in such locations may become more likely in the future, as suggested by Operation "Desert Shield" in Saudi Arabia. Depending on the number of helicopters and the intensity level involved, operations in Saudi Arabia could shed light on the Apache's logistical support demands in combat and the means necessary to meet the demands.

Initially, six Apaches were sent to Panama, and they were later reinforced by five more. Basically, this was a company-sized operation, as no more than four or five Apaches flew missions at any one time. According to the Army, the Apaches were able to perform assigned missions successfully. The helicopter demonstrated its ability to deliver firepower accurately from long ranges (primarily during the day), to conduct missions at night, and to withstand hits from small arms ground fire.

This performance was made possible by extraordinary logistical support conditions. For instance, (1) spare parts were taken from contractor production lines and from other Apaches, and (2) the Apaches were based in an Air Force hangar, and Air Force maintenance personnel and equipment were instrumental in repairing battle damage. The Army maintenance personnel sent to Panama did not have the sheet metal repair manuals, tools, or training to repair the battle damage from small arms fire. They had to rely on the Air Force personnel to repair the damage and stated that they could not have continued to fight with those aircraft had the Air Force not repaired the battle damage overnight. According to DOD, the extraordinary support measures were necessary because (1) the entire Army support community was not involved in planning for the operation in order to ensure security and the element of surprise and (2) the roles and missions of the Apache expanded beyond what was planned. DOD believes that had the Air Force not assisted the Army, Army personnel could have repaired the Apaches in the same time frame.

The Apache encountered many of the same maintenance and spare parts problems in Panama that it had experienced in the United States, including problems with the targeting and night vision sensors, the 30-mm gun, the main rotor blade, and the tail rotor swashplate. Maintenance of these components consisted mainly of replacing them and sending the defective parts back to the United States. Because of the 30-mm gun's history of jamming, the Apache company commander chose to limit the number of 30-mm rounds to 300, even though the

Apache can hold 1,200 rounds. In addition, early in the operation, rainy and humid conditions caused moisture buildup in electronic components. Had these conditions not eased, the Apache might not have been able to operate as needed. The first mission of the operation illustrated the impact of reliability problems: one of the two Apaches assigned to the mission aborted before takeoff because of a hydraulics problem, while the second Apache, after completing its assigned mission, had an opportunity to provide additional mission support but was unable to because of an electronics failure.

Key Problems Originated Early in the Program

While the problems affecting the Apache's availability, reliability, and maintainability have become manifest over the past 2 years, to a large extent they originated much earlier in the Apache's acquisition. Because of narrowly defined performance measurements and other limitations, tests since 1981 have not captured the problems experienced by combat units in the field. Thus, despite the Apache's current problems, the Army has determined that the helicopter has met or nearly met reliability, maintainability, and availability requirements in testing. Army test and evaluation agencies warned of serious logistical support problems before the production decision was made, yet these very problems are hurting fully-mission-capable rates today. Despite known problems, the Apache proceeded to full-rate production without further operational testing or decision points. The persistence of basic logistical support problems after the bulk of production has been completed suggests that production took priority over logistical supportability.

Performance as Measured During Testing Failed to Capture Eventual Field Problems

Although the Apache is experiencing low fully-mission-capable rates in the field, in testing the Army determined that the Apache had met or nearly met its design requirements for reliability, maintainability, and availability. This seeming contradiction exists because many of the factors affecting the Apache's performance in the field were not captured by performance measurements during testing. Had the Army established more operationally realistic requirements for Apache reliability, maintainability, and availability and assessed performance against these requirements, the shortcomings of the helicopter and the Army's support capabilities would have been more evident. The Army has acknowledged the limitations of the Apache's reliability, availability, and maintainability requirements. In 1982, it issued a regulation mandating the use of more comprehensive operational requirements for new systems. However, the Apache's requirements have not been redefined in these operational terms, and performance is still measured against the limited requirements.

Apache Reliability Has Been Narrowly Measured

The Apache's reasonably good reliability during testing can be attributed to how narrowly the Army measured reliability. There are two main Apache reliability requirements: mission reliability and system reliability. Mission reliability is a measure of the frequency of failures that are significant enough to impair the performance of a mission. System reliability is a measure of all failures, regardless of their impact on missions; system reliability is thus a gauge of the aircraft's maintenance burden. The Army has used narrow measurements in determining the Apache's mission reliability and system reliability: these measurements have not proven meaningful in forecasting how often the helicopter will break down or how many maintenance actions it will require under field conditions. The Army has computed other measurements that more meaningfully and accurately depict the seriousness of the Apache's reliability problems. However, there are no standards by which to judge such measurements because the Apacne's requirements are not defined in these terms.

The Apache has a mission reliability requirement of 19.5 mean hours between failures, against which the Army measures performance in terms of inherent hardware mission failures. As defined, this measurement includes only failures that (1) are caused by hardware, (2) occur in flight, and (3) cause a mission to be aborted. Excluded are failures that occur before missions, those that degrade mission capability but do not result in an abort, and those caused by maintenance or crew error. In addition, mission reliability excludes the reliability of the 30-mm gun system. In effect, inherent hardware mission reliability excludes most failures that affect mission capabilities. Other more meaningful measures of mission reliability exist, and these show the Apache's reliability to be much lower than inherent hardware reliability. One such measurement is "operational reliability," which measures all failures during a mission, regardless of cause, that result in either a mission abort or the degradation of a mission-essential function. Another measure is the "mean time between essential maintenance events or actions," which records how often mission-essential equipment requires corrective maintenance, regardless of whether an actual mission is being conducted. Table 6.1 compares the Apache's mission reliability in testing using these different measures.

Table 6.1: Apache Mission Reliability as Measured During Testing

Mean hours between failures

	Inherent hardware reliability	Operational reliability	Essential maintenance events
Operational Test II (July-Aug. 1981)	17.9	3.5	2.2
Attack Helicopter Battalion Training Validation Test (Apr.-July 1986)	18.[illegible]	5.1	2.5
Logistics Evaluation Test (May 1986-Jan. 1988)	17.1	6.4	2.2
Follow-on Training Validation Test (July 1986-May 1987)	25.0	6.2	2.4
100,000-Hour Maturity Test (Sept. 1988-Feb. 1989)	16.8	5.5	2.4

Except in the maturity test, Apache mission reliability, as measured by inherent hardware reliability, fared well against the requirement. The requirement itself was lower during earlier tests to account for the aircraft's immaturity: it was set at 17 hours between failures for the operational test, 18.5 hours for subsequent tests up to maturity, and 19.5 hours for the maturity test and beyond. The Follow-on Training Validation Test indicated that the Apache had substantially exceeded the reliability expectations for the mature aircraft.

This performance is at odds with the Apache's reliability and maintenance work load as experienced by combat units in the field. While some of this divergence can be attributed to the artificialities of testing (such as testing's use of contractor support and its lack of phase maintenance), it is clear that most of the failures that affect mission capabilities and require corrective maintenance did not fall within the bounds of inherent hardware reliability and were thus excluded. The other measures--operational reliability and mean time between essential maintenance events—more accurately correspond with Apache reliability as it affects fully-mission-capable rates and with our discussions with maintenance personnel at the Apache battalions. However, the Army has not established standards for these measures, leaving no baseline to judge them against.

The Apache has also performed well against its system reliability requirement as measured in testing. The Apache has consistently exceeded the system reliability requirement of 2.8 hours between failures for the mature aircraft. As with mission reliability, however, the

Army does not include all failures in its calculation of system reliability. Excluded are such failures as those caused by the crew and maintenance personnel and "nuisance failures" (such as the failure of light bulbs). These exclusions seem to defeat the utility of using system reliability as a gauge for the Apache's maintenance burden.

Again, there are other measures available that more closely reflect the Apache's maintenance burden in the field. These measures are "mean time between inherent hardware system failures," which records all failures caused by hardware, and "mean time between unscheduled maintenance events," which records all actions taken to correct failures, regardless of cause. These calculations have not been consistently recorded in test reports. However, they are consistently recorded for the "Lead the Fleet" Apache—an aircraft the Army flies at fairly high rates to determine the Apache's long-term reliability, maintainability, availability, and durability characteristics. From October 1987 to August 1989, when this Apache flew over 1,700 hours, the Army reported 1.6 mean hours between inherent hardware system reliability failures and 0.8 mean hours between unscheduled maintenance events. These measures seem to be more indicative of field experience and appear to be more useful in gauging the Apache's maintenance burden.

Maintenance Man-Hours Have Been Understated

Army test data has shown that the Apache needs 5 or fewer maintenance man-hours per flight hour—well within the requirement of 8 to 13 man-hours. However, this measurement of the number of maintenance man-hours conflicts with the large maintenance work load being experienced at Apache battalions and contrasts with the much higher maintenance man-hours reported by the other services on their tactical aircraft. The recorded number of maintenance man-hours appears unrealistically low because the Army narrowly defines what maintenance man-hours are counted and because its man-hour data is incomplete.

Maintenance man-hours expended on the Apache, according to test data, are shown in table 6.2.

Table 6.2: Maintenance Man-Hours Expended per Flight Hour on the Apache

Source	Maintenance Man-hours
Operational Test II (July Aug 1981)	4.7
Attack Helicopter Battalion Training Validation Test (Apr July 1986)	4.9
Logistics Evaluation Test (May 1986 Jan 1988)	3.9
Follow on Training Validation Test (July 1986 May 1987)	4.7

The low numbers of Apache maintenance man-hours shown in the table belie the large maintenance work load experienced by combat battalions—a work load that the Army has recognized as requiring additional people to meet. In fact, if the recorded maintenance man-hours were accurate, they would lead one to the conclusion that Apache battalions have too many maintenance personnel. For example, about 65 of the battalions' 98 maintenance personnel maintain Apaches. If each person worked 20 days a month and provided 2.5 productive maintenance man-hours per day, a battalion would be able to provide 3,250 maintenance man-hours per month. If only 5 maintenance man-hours per flight hour were required per flight hour, a battalion of 18 Apaches with each aircraft flying an average of 13 hours per month would require only 1,170 total man-hours of maintenance. This figure excludes the labor hours contributed by intermediate maintenance organizations.

Maintenance man-hours recorded for the Apache are also much lower than estimates of what the other services expend on their aircraft and what expert contractor personnel expend on the Apache at the Army's aviation school. Table 6.3 shows the number of direct maintenance man-hours expended for the unit and intermediate maintenance of several Navy and Marine Corps aircraft during fiscal year 1989.

Table 6.3: Maintenance Man-Hours per Flight Hour for Navy and Marine Corps Aircraft

Aircraft	Maintenance man-hours per flight hour
A-6E Intruder (fixed wing)	53.8
A-7E Corsair (fixed wing)	43.9
F/A-18A Hornet (fixed wing)	30.9
F-14A Tomcat (fixed wing)	61.4
AH-1W Sea Cobra helicopter	15.0
UH-1N Huey helicopter	16.3
SH-2F Sea Sprite helicopter	30.2
SH-3H Sea King helicopter	37.2
CH-46E Sea Knight helicopter	18.5
CH-53E Sea Stallion helicopter	39.1
SH-60B Sea Hawk helicopter	21.0
P-3C Orion (fixed wing)	26.4
S-3A Viking (fixed wing)	45.5
AV-8B Harrier (fixed wing)	19.6

Although the table includes a variety of aircraft, the recorded numbers of maintenance man-hours for all are significantly higher than the numbers the Army reports for the Apache. There are several reasons that the other services' numbers are higher. First, the Army does not include all maintenance man-hours in its calculations. Rather, it counts only what is referred to as "wrench-turning" hours. These include only maintenance time spent working directly on the aircraft; they exclude time spent on such activities as consulting maintenance manuals, locating tools and parts, managing maintenance, performing test flights, and providing support such as ammunition loading. In addition, as maintenance tasks (such as the work performed at special repair activities) have been transferred from the intermediate to the depot level, the associated maintenance man-hours are no longer counted because depot-maintenance time is excluded from maintenance man-hour calculations.

The narrowness of the Army's definition of maintenance man-hours is illuminated by the experience of the Army's aviation school. The school uses contractors to maintain about 50 Apaches to support air crew training. According to the school, over 20 maintenance man-hours are expended for each Apache flight hour. However, only about 14 of these hours would be counted using the Army's definition. While the school's hours include some tasks that would not be performed at combat battalions, such as contract management, the time it takes to do these extra tasks is offset by the efficiency of the highly skilled contractor work force, whose personnel have an average of about 14 years' experience.

In addition to the problems of the narrow definition, maintenance man-hour data collected during Apache testing is not complete (1) because phase maintenance—a major source of maintenance downtime—was not conducted and (2) because contractors helped maintain the Apache. Similarly, data collected at selected combat battalions in the field is incomplete because it excludes hours spent on scheduled maintenance and does not capture all of the time spent on troubleshooting failures. The 6th Cavalry Brigade at Fort Hood has proposed that the partial data collection efforts being conducted at several battalions be consolidated into a more complete effort at one battalion. However, program officials informed us that, because of funding constraints, data collection efforts would have to be reduced, and the Fort Hood proposal could not be funded.

Availability Has Been Higher During Testing

The Apache's availability as measured during testing has been higher than fully-mission-capable rates in the field because (1) test results were measured against the Apache's less stringent design requirement for availability and (2) availability benefited from favorable test conditions.

The Apache's design requirement originally called for a 75- to 80-percent availability rate, but this requirement was lowered to 62 percent at the time of the production decision. During 1981 operational testing, the Apache achieved a 70-percent availability rate, and in the 1986 Attack Helicopter Battalion Training Validation Test it achieved 73 percent availability. However, performance as measured against the requirement combined fully-mission-capable time with partially-mission-capable time and therefore yielded higher availability rates than would be calculated by considering only fully-mission-capable status.

Availability during testing further benefited from contractor maintenance assistance and from the exclusion of key scheduled maintenance. For example, in the operational test, contractor personnel performed or assisted in half of all maintenance actions. In addition to using contractor assistance, the training validation test used 4 float aircraft to provide replacements as needed for the 18 battalion aircraft. In essence, only data from the best 18 aircraft was counted, and all aircraft were new. In addition to these conditions, phase maintenance was not conducted during either test. In contrast, from May 1986 through January

1988, the Lead-the-Fleet aircraft achieved availability rates of 46 percent—more in line with the combat battalions' rates. This lower rate reflects the fact that this aircraft was Army maintained, flew a lot of hours, and underwent phase maintenance.

Support Problems Were Identified Early but Not Resolved

While it would be impossible to accurately identify and correct all potential problems before a weapon system is fielded, independent Army evaluation agencies did identify key logistical support problems in 1981 such as the undemonstrated performance of the Apache's fault detection system and electronic test facility. Although these agencies reiterated their concerns over the ensuing years, the problems persist today as major contributors to low availability rates.

Logistical Support Problems Were Identified Before Production

The Apache's logistical supportability has been questioned since before the 1982 production decision was made. In October 1981, the Army Logistics Evaluation Agency completed its assessment of the Apache's integrated logistical supportability in preparation for the production decision and concluded: "From a logistics supportability regulatory standpoint, the appropriate course of action for the AAH [Apache] program is to remain in FSED [full-scale engineering development] until all significant deficiencies . . . are corrected/verified."

Among the major problems cited were the targeting system, the fault detection system, and the automatic test station (later to become the Electronic Equipment Test Facility). Rather than recommending against production, the agency recommended that the Apache enter limited procurement to be followed by another decision point to reassess the program's progress. Also in 1981, the Army Materiel Systems Analysis Activity stated that the fault detection system's ability to diagnose and locate aircraft faults had not been demonstrated and expressed concern that demonstration of the test station's performance and other key logistical support elements had been waived for the production decision. The Activity noted that waived items had to be vigorously tested so that significant shortfalls could be corrected before fielding. Both agencies reported reliability problems with components, among them the targeting sensor and the 30-mm gun.

On the basis of these evaluations and other information, in 1981 we recommended that the Secretary of Defense delay the Apache production decision until several concerns could be resolved, including the questionable ability to support the Apache given the undemonstrated performance of the fault detection system and the automatic test station.[1] In 1983, following the production decision, we reported that (1) the fault detection system had not conclusively demonstrated its ability to reliably isolate faults without experiencing the high false alarm rates found on other built-in systems and (2) the test station's ability to operate practically and reliably in a field environment was undemonstrated. We recommended that the Secretary not fund higher production rates before weighing the progress made on these and other issues and that the test station be operationally tested before its fielding.[2]

The Army's evaluation agencies have reiterated their concerns over the performance of the fault detection system, the test facility, the targeting sensor, the gun system, and other problems. In fact, since the initial production decision, the Army Materiel Systems Analysis Activity has formally recommended against subsequent releases of more Apaches to the field due to problems with logistical support, reliability, and other concerns. The Activity was overruled by higher Army officials in each case, and fielding continued despite the unsolved problems.

Quick Buildup to Full-Rate Production Worsened Fielding Problems

Although the Apache entered production with an immature design and undemonstrated logistical supportability, the Army conducted no further operational testing after the decision and proceeded to high production rates without any major decision points to reassess the progress made in resolving key problems. Subsequently, the program faced large demands stemming from high production rates and frequent design changes while at the same time known logistical support problems went unresolved. While it would be unreasonable to expect that all potential fielding problems could be identified and resolved ahead of time, the presence of previously identified support problems during fielding indicates that a higher priority was placed on production than on fielding a supportable system.

The Army made a conscious decision to enter production knowing that the Apache would require changes to meet performance specifications. While the contractor was required to bring the helicopter up to specification at no cost to the Army, improvements involved numerous design

[1] The Army's Advanced Attack Helicopter Is Not Ready for Production (MASAD-82-8, Dec. 1, 1981).

[2] The Army's AH-64 Helicopter and Hellfire Missile Retain Risks as They Enter Production (GAO/C-MASAD-83-9, Jan. 26, 1983).

changes to the Apache during production. The design instability had a ripple effect on logistical support, as support procedures, equipment, and spares had to be adjusted to accommodate new component configurations.

The magnitude of the Apache's fielding problems might have been lessened if the Army had kept the system in low-rate production, followed by additional testing and a major decision point to verify that problems had been corrected before beginning full production. Although weapon systems frequently follow this strategy, the Apache did not, moving directly into full production without another formal decision point after 1982. Army officials have stated that, in retrospect, such an approach would have been more reasonable but that at the time, the need for the system in view of the threat was seen as outweighing its problems.

Such an approach could have also provided the vehicle for the Army to operationally test the logistical support items that were waived at the production decision. Although these items—and, in essence, the maintenance concept—were required to be operationally tested as a condition of the waiver, they have not undergone such testing. For example, neither the electronic test facility nor the 30-mm gun have successfully undergone operational testing. Such testing was planned for the test facility in 1984 but was never conducted; the Army is currently considering a proposal to forgo this testing altogether.

The Army had planned to conduct a fairly comprehensive force development test following the production decision, but this was subsequently reduced in scope and became the 1986 Attack Helicopter Battalion Training Validation test. As previously discussed, although this was the most significant test of the Apache during production, it was of limited realism. For example, during the test, most of the work assigned to the electronic test facility was instead passed on to contractors; only one component was repaired by the facility.

The Apache's ambitious buildup to a production rate of 144 helicopters per year compounded logistical support problems. At one point, Apaches were being produced faster than the Army could provide pilots, and many aircraft sat at the production facility awaiting pilots. Contractors were unable to meet the competing demands of the production line and fielded aircraft. As a result, fielded aircraft suffered from parts shortages, and contractor special repair activities were placed in the field to ease the shortages. In addition, maintenance personnel from the aviation school informed us that on previous aircraft programs, deliveries had been slow enough in the early years to enable the school to work out a maintenance program. However, the Apache arrived so quickly in such large quantities that it outpaced its support system.

Conclusions, Recommendations, and Matters for Congressional Consideration

Conclusions

Despite the Apache's few flying hours, its reliance on contractor support, and its overworked maintenance units, fully-mission-capable rates have fallen far short of goals and have declined as flight hours have been accumulated. In short, the helicopter demands a high level of logistical support that the Army has not been able to provide. Below the surface of low availability rates are serious logistical support weaknesses. These weaknesses are not just problems caused by the complex helicopter and its support equipment; the Army's management practices and decisions made throughout the Apache's acquisition share responsibility as well. The depth and the multifaceted nature of the problems raise the question of whether the Army can support the Apache under the strenuous conditions of sustained combat. This is a question for which there is not a good answer because the Army has not tested the Apache battalion under combat-representative conditions.

The Army has been impressively active over the last 18 months in identifying problems and devising solutions. These actions will almost certainly improve peacetime availability rates. However, less impressive is the fact that basic logistical support problems have been known about for years and have gone unresolved. This latter fact must serve as a guard against prematurely hailing the success of current corrective actions. While the need to improve component reliability seems straightforward, other specific proposed actions must be geared toward solving the combat problem, which is not well defined. Some actions, particularly the increased reliance on contractor support, may be effective in peacetime but not workable solutions during combat. On the other hand, the Army's fielding of special repair activities, although contractor-operated, showed commitment to providing the intensive support required by the targeting and night vision sensors.

The Army's corrective actions will not necessarily ensure that the Apache can be sustained in high-intensity combat. In fact, the Apache may not be able to achieve the needed 83-percent combat availability rate with the current number of aircraft and people in the battalion and with the current support concept as it has evolved. The Army must find the optimal mix of aircraft and skilled people and provide them the logistical support structure that will enable the Army to take full advantage of the Apache's advanced war-fighting capabilities. The Apache's performance in Saudi Arabia may provide some of this needed information, depending on the number of helicopters and the intensity level involved in the operation.

To determine the support required by the Apache in combat, as well as the Army's ability to provide that support, the Army will have to operationally test the basic Apache fighting unit and develop accurate information on what it takes to support the unit in combat. DOD believes that it can make such determinations by evaluating data from scheduled exercises, rather than incurring the expense of an operational test. We believe this approach to be of limited benefit because (1) exercises have not been of sufficient duration and scope to approach sustained combat and (2) previous evaluations have not accurately disclosed problems because of limitations in reliability, maintainability, and availability measurements and data collection. The Army has not funded previous proposals to fly Apaches at combat-like flying-hour levels or to collect improved maintenance man-hour data. However, these are the kinds of efforts that must be undertaken to adequately define the problem. Without them, the Army runs the risk of defining the solution before it defines the problem.

The Apache can further benefit from the experiences of the other services regarding data collection, organizational structure and management, and other practices that enable them to get more from their aircraft. According to DOD, a system already exists to document the lessons learned by the different services, and no additional action is necessary to apply lessons learned to the Apache. However, given the apparent wide disparity between how the other services operate and support their aircraft and how the Army operates and supports the Apache, we do not believe that the Apache has benefited from the experiences of the other services.

In the case of the Apache, logistical support concerns were raised but did not carry enough weight to alter production and fielding plans. DOD must ensure that a similar situation does not arise with the Longbow improvement program. While this program may enhance the Apache's performance, it may also complicate the Apache's logistical support problems. We believe the effectiveness of current corrective actions and the logistical supportability of the Longbow Apache must be clearly demonstrated before proceeding with production of the Longbow modification.

Operationally testing the Apache battalion and providing the resources necessary to adequately support the aircraft will be costly. Army proposals to add as many as 162 people to an Apache battalion in addition to more contractor support and hardware improvements indicate the significant resources required. The challenge of devoting resources to overcome problems is even greater when one considers that (1) procuring and fielding additional Apaches will create more demand for logistical support resources, (2) additional resources will have to be obtained at a time when overall resources for conventional forces will sharply decline, (3) the likelihood for deployments into unprepared areas may be increasing, and (4) the Longbow modification could require even greater logistical support. Difficult choices will be necessary to resolve the Apache's problems at their source and to reduce the difficulty of fielding future aviation systems.

In April 1990, we recommended that the Congress forgo the last 132 Apaches that were not under contract at that time and transfer the funds not spent on the additional Apaches to other appropriation accounts to improve logistical support. The Congress did not act on our recommendation, and the Army has since contracted for 66 of the remaining 132 Apaches. We believe that the difficult choice of buying fewer aircraft to better support those in the field must still be made.

Recommendations and Matters for Congressional Consideration

We believe the Congress should consider transferring the funds appropriated for the procurement of the last 66 Apaches to other appropriation accounts to provide the increased logistical support the Apache requires. If the Congress decides against such a transfer, we recommend that the Congress direct the Secretary of Defense to determine whether fewer Apache battalions should be fielded than planned to provide a greater concentration of resources to each battalion.

We also recommend that the Congress direct the Secretary of Defense to take the following actions:

- Operationally test the Apache in battalion size or greater to illuminate the currently unknown demands that sustained combat will place on the Apache. Such a test should approach combat flying-hour rates, employ planned fighting doctrine, include extensive weapons firing, employ the maintenance concept that is intended for combat, and last long enough to at least exercise the full capabilities of intermediate-level maintenance. Rather than being success-oriented, it should be a "no-fault" test with extensive involvement by the logistics community and oriented towards discovering information. Additional testing of this type should be conducted periodically to evaluate new approaches and to reinforce lessons learned, such as those that are likely to result from the Apache's operations in Saudi Arabia.
- Form an interservice team to apply the experience of the other services in improving the Apache's logistical support, particularly in defining

their personnel and organizational requirements, managing resources, collecting key support information, and relying on contractor support.

- Implement the changes, emanating from the above efforts, necessary to sustain desired peacetime and wartime operations for the Apache. Such changes should not be limited to incremental improvements over current organizations and support equipment but should include more radical solutions if they can more fully realize the Apache's combat potential.
- Defer production of the Longbow modification until the Army clearly demonstrates that (1) it has overcome the logistical support problems with the current Apache and (2) the Longbow will not exacerbate the Apache's logistical support problems.
- Develop operational standards for Apache reliability, maintainability, and availability that can be used to realistically gauge the Apache's performance in the field and in testing.

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