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Report to Congressional Requesters

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NAVAL AVIATION

The Navy Is Taking Actions to Improve the Combat Capabilities of Its Tactical Aircraft

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National Security and
International Affairs Division

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The Honorable Carl Levin
Chairman, Subcommittee on Oversight of
Government Management
Committee on Governmental Affairs
United States Senate

The Honorable John Conyers, Jr.
Chairman, Subcommittee on Legislation and
National Security
Committee on Government Operations
House of Representatives

This report responds to your requests that we determine whether certain aircraft had the capabilities needed to perform their assigned missions during Operation Desert Storm. As agreed with your office, we focused our efforts on how naval aircraft operations were affected by the availability of performance enhancing systems used by tactical aircraft. We examined the difficulties and challenges that Navy and Marine Corps aviation units encountered when certain combat capabilities were limited or absent and the actions being taken to improve capabilities.

As agreed with your office, we plan no further distribution of this report until 30 days from the issue date, unless you publicly announce its contents earlier. At that time, we will send copies to other appropriate congressional committees; the Secretaries of Defense and the Navy; and the Director, Office of Management and Budget. Copies will also be made available to others on request.

This report was prepared under the direction of Richard Davis, Director, National Security Analysis, who may be reached on (202) 512-3504 if you or your staff have any questions. Other major contributors are listed in appendix II.

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Executive Summary

Purpose

The Chairman of the Legislation and National Security Subcommittee of the House Committee on Government Operations and the Chairman of the Oversight of Government Management Subcommittee of the Senate Committee on Governmental Affairs asked GAO to determine whether certain aircraft had the capabilities needed to perform their assigned missions during Operation Desert Storm. This report focuses on several Navy and Marine Corps aircraft.

Background

Several factors contributed to the Gulf War victory by creating favorable conditions under which to plan and fight the war, and these should be considered when assessing the effectiveness of U.S. weapons in the war. Commanders had nearly 6 months to plan and develop an air campaign that when initiated, quickly gained air superiority and effectively neutralized much of Iraq's air defense system. In addition, Iraq's forces remained in a primarily defensive posture throughout the war. These factors helped enable the Coalition to determine its tactics and decide when and where offensive air and ground actions would occur.

During Desert Storm, about 400 Navy and 280 Marine Corps aircraft flew over 29,000 missions that included long-range attack, fighter escort, fleet air defense, suppression of enemy air defenses, electronic warfare, command and control, close air support, and attacks on enemy naval forces.

Results in Brief

Desert Storm experiences highlighted equipment limitations that made it more difficult for Navy and Marine Corps air crews to locate, identify, and attack targets with precision under some battle conditions; to identify unknown aircraft beyond visual range; and to defend against some antiaircraft threats. Greater aircraft losses could have resulted from these limitations but were avoided by operating at higher altitudes that increased survivability but sacrificed bombing accuracy. If fewer U.S. aircraft had been on hand, the capabilities of individual aircraft would have been more important. Also, if greater Iraqi offensive actions had occurred, greater bombing accuracy and more effective aircraft defensive systems would have been critical to success.

The equipment limitations that air crews had to work around were caused, in part, by trade-off decisions associated with the expense, cost growth, and time generally associated with developing, acquiring, and fielding new

weapon systems. Naval aviation officials were aware of most aircraft limitations before the war and had begun some actions to resolve them.

Principal Findings

Some Aircraft Lacked Systems That Could Provide Better Combat Capabilities

Only a third of Navy and Marine Corps F/A-18 fighter/attack aircraft had forward-looking infrared targeting systems to enhance their pilots' ability to locate, identify, and precisely attack small targets, such as tanks or fortified emplacements, that required greater accuracy. These systems also lacked built-in laser target designators that prevented their pilots from using precision guided munitions. In poor visibility, pilots without the systems sometimes used the flashes from exploding bombs dropped by the plane ahead to mark their aiming point, or if in formation, they dropped their bombs at the same time that aircraft with forward-looking infrared systems did. These practices, combined with high altitude and un-guided bombs, reduced bombing accuracy. Targets not destroyed the first time were attacked until destroyed, which sometimes required more missions and placed crews and aircraft at a greater risk.

None of the Marine Corps' principal close-air support aircraft, the AH-1W attack helicopter, and the AV-8B short takeoff/landing jet had forward-looking infrared targeting systems that would have enabled their crews to better locate, identify, and attack targets.

Navy and Marine Corps F-14 and F/A-18 aircraft lacked systems to differentiate enemy aircraft from friendly aircraft beyond visual range. In the crowded Desert Storm air space, pilots had to coordinate with command and control aircraft to determine whether radar-detected aircraft were hostile. Navy officials believed pilots lost several opportunities to shoot down Iraqi aircraft because positive identification of suspected enemy aircraft took too long, allowing those aircraft to escape.

Some Navy and Marine Corps aircraft lacked adequate warning and defensive countermeasure systems to effectively protect their crews from approaching antiaircraft missiles. Several U.S. aircraft were lost in the final days of the war when pilots flew lower to provide more accurate support of ground forces, placing them in the range of portable, heat-seeking missiles and antiaircraft fire.

Historically, the expense, cost growth, and time to develop, procure, and deliver new aircraft and systems required trade-off decisions that included (1) not buying complete combat systems for all aircraft in an effort to hold down acquisition costs, (2) using funds planned for buying equipment such as forward-looking infrared targeting systems, bomb racks, and electronic self-protection jammers to pay for cost increases to the basic airframe, engines, and electronics, and (3) fielding and operating new aircraft without some systems because those systems were not developed in time to deliver them with the aircraft.

Equipment Limitations Are Being Addressed

Naval aviation officials were aware of most equipment limitations before Desert Storm and had begun some actions to resolve them. The war validated these concerns and provided impetus to their resolution. For example, the Navy plans to buy more F/A-18 forward-looking infrared targeting systems and is developing a laser capability for this system. In addition, a combined forward-looking infrared and laser targeting system is being developed for the AH-1W helicopter, as well as several improved defensive electronics countermeasure systems for fixed-wing aircraft. The Navy may begin developing a system to improve the fighter pilots' ability to identify unknown aircraft beyond visual range. In addition, up to $1.6 billion is being planned to equip 72 AV-8Bs with night combat and radar capability and other improvements, beginning in fiscal year 1996.

Observations

The world situation, and our national military strategy, have shifted from a focus on global war to smaller but lethal regional conflicts similar to Desert Storm. If U.S. forces are committed to such a conflict, it is likely that U.S. combat aircraft will face modern antiaircraft weapons that are being spread throughout the world by aggressive arm sales competition. Also, a future enemy may be more inclined to use its antiair weapons, and if U.S. aircraft must operate within the range of these weapons, the United States could experience significant losses.

Without favorable factors similar to Desert Shield/Desert Storm, U.S. forces could face the prospect of fighting their way into a country, supported primarily by carrier-based aircraft, in order to build the supporting infrastructure that was immediately available in Saudi Arabia. Under these conditions, the United States would have fewer attack aircraft available, and each mission would have to score decisively. To be effective, these aircraft need the necessary equipment to locate, identify, and attack targets day and night in poor visibility, to positively identify

enemy aircraft beyond visual range, and to defend against modern threats. Service efforts to improve combat capability of current aircraft depend on whether priority and funding in reduced defense budgets is given to these upgrades or to developing new, high technology aircraft.

Agency Comments

As you requested, GAO did not obtain written agency comments on this report. However, GAO discussed the information in the report with responsible Department of Defense and Navy officials and included their comments where appropriate. The officials generally agreed with the information as presented.

Contents

Abbreviations

ASPJ	Airborne Self-Protection Jammer
FLIR	Forward-looking Infrared

Introduction

Navy and Marine Corps aviation made a significant contribution to the successful outcome of Operation Desert Storm. These two services provided nearly 700 of the 2,700 total aircraft that comprised the Coalition air force. Their crews flew over 29,000 missions, operating day and night from aircraft carriers and amphibious ships in the Red Sea and the Arabian Gulf and from land bases in Bahrain and Saudi Arabia. (See table 1.1.)

Table 1.1: Number of Navy and Marine Corps Combat Aircraft in Desert Storm and the Number of Missions Flown

Aircraft	Service	Number of planes	Number of missions
A-6	Navy	95	4,824
A-6	Marine	20	843
A-7	Navy	24	737
AH-1	Marine	78	1,273
AV-8	Marine	86	3,380
E-2	Navy	27	1,183
EA-6	Navy	27	1,126
EA-6	Marine	12	511
F-14	Navy	99	4,124
F/A-18	Navy	90	4,449
F/A-18	Marine	84	5,239
S-3	Navy	41	1,674
Total		**683**	**29,363**

Working under the direction of the Joint Forces Air Component Commander, they flew a wide variety of missions: attack aircraft flew long-range offensive missions against Iraqi command, control, communication, and antiaircraft targets; industrial complexes; logistics infrastructure; airfields; and naval forces. They also attacked targets in Kuwait and Iraqi troop positions, tanks, artillery, and other vehicles to prepare the battlefield for the ground offensive. During the 100-hour ground war, they provided close air support to ground forces. Fighter aircraft protected naval forces in the Red Sea and the Arabian Gulf and provided long-range escort for the attack aircraft. Electronic countermeasure aircraft jammed enemy radars and communications and attacked radar sites; command and control aircraft directed aircraft to and from targets and to detect and identify unknown aircraft; and tanker aircraft provided aerial refueling.

Favorable Factors Contributed to Desert Storm Successes

Several factors contributed to the Gulf War victory by creating favorable conditions under which to plan and fight the war. These factors should be considered in weighing the effectiveness of the U.S. military in Desert Storm, including Navy and Marine Corps combat aircraft, because they may not occur again. In future conflicts, the United States may fight under less favorable conditions.

Commanders had nearly 6 months to thoroughly plan and develop an air campaign that identified, prioritized, and scheduled air attacks against key targets. This period was also used to amass a military force with the capabilities, force levels, and logistics support needed to initially defend against, and later take the offensive against a sizeable, well-armed foe. Under less favorable conditions, theater commanders could, at least initially, be limited by the capabilities of the forces at hand and would have to develop tactics that would capitalize on the capabilities available and minimize the limitations.

Another factor was the massive, well-coordinated start of the air campaign that quickly gained air superiority and effectively suppressed or destroyed a large portion of Iraq's air defense system. As a result, Iraq was unable to effectively use most of its air force and radar-guided antiaircraft missiles to pose a major antiaircraft threat. An opponent who could more effectively use its weapons could more seriously threaten U.S. forces.

In addition, Iraq's forces remained in a defensive posture throughout Desert Shield and the 43-day war. There was little or no attempt to disrupt the massive logistics buildup of material and personnel, and there were only limited offensive attacks against Coalition air, ground, and naval forces. As a result, the Coalition was able to plan a strategy and decide when its forces were sufficiently ready to begin the air campaign, and later, the ground offensive. Air power was used to attack vital strategic targets and infrastructure, methodically destroy entrenched Iraqi ground forces and weapons, and prepare the battlefield for the Coalition offensive, but did not have to react extensively to enemy offensive actions. An opponent taking the offensive could better dictate the timing and location of battle and use tactics that favored his capabilities.

A tactical decision was made early in the air war to shift air attacks from low altitudes to higher altitudes. This decision was driven, in large part, by an overriding desire to limit aircraft and crew losses, even at the expense of bombing accuracy. Aircraft and crew survivability increased by moving them above the range of much of the Iraqi antiaircraft weapons. When the

ground war began, however, some aircraft, especially those providing close air support to ground forces, flew lower to get below clouds and smoke and to provide more accurate bombing support. This brought the aircraft into the range of portable shoulder-fired, heat-seeking antiaircraft missiles, and at least three AV-8B losses were incurred.

Objectives, Scope, and Methodology

Expressing concerns over the operational capabilities and supportability of U.S. military tactical aircraft deployed in Desert Storm, the Chairman of the Legislation and National Security Subcommittee of the House Committee on Government Operations and the Chairman of the Oversight of Government Management Subcommittee of the Senate Committee on Governmental Affairs asked us to determine whether the capabilities of deployed Navy and Marine Corps aircraft affected these two services' performance.

In performing our work, we met with Navy and Marine Corps operations, logistics, and training officials who participated in Desert Shield/Desert Storm. We examined after action reports, lessons learned documents, postcruise summaries, messages, and other documentation from units and organizations that participated directly in the war as well as from units that supported the effort from the United States.

Our review was performed at the following Navy and Marine Corps locations:

Navy Locations

- Office of the Chief of Naval Operations, Washington, D.C.
- Headquarters, Naval Air Systems Command, Washington, D.C.
- Aviation Supply Office, Philadelphia, Pa.
- Commander, U.S. Naval Air Forces Atlantic, Norfolk, Va.
- Commander, U.S. Naval Air Forces Pacific, San Diego, Calif.
- Naval Air Station, Cecil Field, Fla.
- Naval Air Station, Lemoore, Calif.
- Naval Air Station, Miramar, Calif.
- Naval Air Station, Oceana, Va.

Marine Corps Locations

- Headquarters, Marine Corps, Washington, D.C.
- Marine Corps Combat Development Command, Quantico, Va.
- 2nd Marine Air Wing, Marine Corps Air Station, Cherry Point, N.C.
- 3rd Marine Air Wing, Marine Corps Air Station, El Toro, Calif.

- Marine Corps Air Station, Cherry Point, N.C.
- Marine Corps Air Station, El Toro, Calif.
- Marine Corps Air Station, New River, N.C.
- Marine Corps Base, Camp Pendleton, Calif.

Our review was performed from June 1991 to November 1992 in accordance with generally accepted government auditing standards.

As you requested, we did not obtain written agency comments on this report. However, we discussed the facts and observations in this report with Department of Defense and Navy officials responsible for the programs and have incorporated their comments where appropriate. These officials generally agreed with the information.

Desert Storm Highlighted the Importance of Some Combat Capabilities

> The lack of PGM [Precision Guided Munition] capability on many US aircraft required planners to select less-than-optimum attack options, such as delaying attacks or assigning multiple sorties with non-precision munitions. Operation Desert Storm results argue that a higher percentage of U.S. attack aircraft should have PGM capability to increase the amount of target damage that can be inflicted by a finite number of aircraft.

This quotation, contained in the Department of Defense's April 1992 report entitled Conduct of the Persian Gulf War, identifies some consequences that resulted from the lack of precision capability by many U.S aircraft, including some Navy and Marine Corps aircraft. Crews of aircraft that did not have precision targeting systems had more difficulty locating, identifying, and hitting small targets, such as tanks, from high altitude, at night, and when visibility was poor, than aircraft with these systems. As a result, aircraft without these systems generally were not assigned targets requiring precision, or if assigned targets that required precision, they sometimes had to reattack targets not destroyed the first time, exposing the aircraft and crews to additional dangers. Precision bombing could be a greater requirement in a war fought with an opponent that takes the offensive, better dictates the timing and location of the battle, and better capitalizes on its capabilities. Some aircraft also lacked defensive systems capable of detecting and defending against some sophisticated antiaircraft missiles. This could have led to greater losses had Iraq more effectively used its antiaircraft weapons to their full capability.

Precision Attack Capability Was Important in Desert Storm

The Department of Defense's statement regarding the diminished capability to deliver precision-guided munitions highlights the difficulty involved with planning and assigning missions during Desert Storm. Air crews contended with adverse conditions such as smoke, haze, darkness, altitude, and small and moving targets that hampered their ability to locate, identify, and attack enemy forces. Accordingly, more precise delivery of bombs and missiles on target requires sophisticated equipment such as forward-looking infrared (FLIR) systems, laser target illuminators, and air-to-ground radars. FLIR systems enable air crews to detect heat-emitting targets, day and night, from a greater distance and a higher altitude than crews without the systems; see magnified images of the targets; attack the targets; determine if the targets were hit; and in some cases, record the results. Laser target illuminators enable crews to illuminate targets with a laser beam and guide the accurate laser-guided bombs and missiles to the targets. Air-to-ground radars enable crews to locate and attack large targets that they cannot see, even through clouds.

Desert Storm rules of engagement required mission planners to make every effort to minimize civilian casualties and collateral damage to areas surrounding a target. Consequently, only precision-guided munitions were used to destroy key targets in downtown Baghdad, Iraq. Precision-guided munitions were also desirable against hardened targets such as aircraft shelters, Scud missile launchers, bridges, and tanks. Accordingly, the Joint Forces Air Component Commander staff planned missions and assigned targets based, in part, on whether aircraft had precision targeting systems. Aircraft with precision targeting equipment were more likely to be used for these missions. For example, Air Force F-15E, F-111, and F-117A aircraft equipped with FLIR systems and laser target illuminators were used in many instances where precision attack was required.

- The Department of Defense reported that, "On several occasions, 16 armored vehicles were destroyed on a single sortie by two F-15s carrying eight GBU-12s (500-lb. laser guided bombs) each." F-15Es were also used to attack Scud missile sites, with most missions flown at night.
- The F-111 conducted "tank plinking" missions, which involved using its FLIR systems to detect hidden Iraqi tanks that emitted heat after being warmed by the sun and then attacking them with laser-guided bombs. F-111s also attacked hardened aircraft shelters; command, control, communications, and intelligence facilities; bridges; and air defense sites.
- The F-117A stealth fighter was credited by the Department of Defense with attacking about 40 percent of the total strategic targets attacked while flying only 2 percent of total attack missions, using its stealth design to avoid radar detection to get to the target and FLIR and laser systems to attack targets. F-117s were the only aircraft to attack targets in downtown Baghdad.

Only about 42 percent of the 1,240 U.S. attack aircraft were equipped with FLIR and laser illumination capabilities (see table 2.1).

Table 2.1: Number of U.S. Attack Aircraft With FLIR and Laser Capabilities Relative to Total Participating in Desert Storm

Service	Aircraft	Total number	Total with FLIR/laser
Navy	A-6E	95	95
Marine Corps	A-6E	20	20
Air Force	A-10	136	0
Marine Corps	AH-1W	50	0
Army	AH-64	274	274
Marine Corps	AV-8B	86	0
Air Force	F-15E	48	30[a]
Air Force	F-16	251	0
Air Force	F-111F	66	66
Air Force	F-117A	40[a]	40[a]
Navy	F-18	90	0
Marine Corps	F-18	84	0
Total		**1,240**	**525**

[a]Figure is an estimate.

Approximately 9,300 laser-guided bombs were dropped in Desert Storm. Of this total, about 900, or 10 percent, were dropped by Navy and Marine Corps aircraft, primarily the A-6E aircraft.

The Ability of Navy and Marine Aircraft to Conduct Precision Attack Varied Among Aircraft

As shown in table 2.1, 115 of the approximately 425 Navy and Marine Corps attack aircraft were A-6Es. The A-6E was the only naval aircraft that had complete FLIR and laser capabilities. Some F/A-18 aircraft had FLIR systems but lacked the laser capability. Without precision systems, crews dropped unguided gravity bombs from higher altitudes with less accuracy and other ordnance such as cluster bombs against targets such as vehicle and troop concentrations that could be destroyed by the broader dispersal of cluster bomblets. The capability for precision attacks varied widely among A-6E, F/A-18, AV-8B, and AH-1W aircraft.

A-6E

Of the 425 Navy and Marine attack aircraft deployed in Desert Storm, only 115 A-6Es had FLIR systems with built-in laser illuminators, and air-to-ground radars. This equipment enabled A-6 crews to locate, identify, and more precisely attack targets from a high altitude and in bad weather. These aircraft dropped nearly all of the laser-guided bombs dropped by the Navy and Marines in Desert Storm.

F/A-18

Only about a third of the 174 Navy and Marine Corps F/A-18s in Desert Storm were equipped with FLIR systems. Consequently, squadrons tried to equip at least one of two aircraft, usually the lead attacker, with a FLIR system. Pilots without the systems either (1) watched for the lead aircraft's bomb explosions before dropping their bombs or (2) dropped their bombs at the same time the leader did. Navy after action reports indicated that target acquisitions were more difficult and bombing accuracy was reduced without FLIR systems.

Navy and Marine Corps F/A-18 pilots with Desert Storm experience told us that FLIR systems were essential for improving both air-to-ground attack and air-to-air combat capabilities because the systems enabled them to better identify targets and approaching aircraft at longer ranges. The systems also enabled them to see the target after the attack to assess the damage inflicted. In some instances, recordings of FLIR images were required for positive bomb damage assessments.

Pilots said the shortage of FLIRs limited their ability to regularly use and train with the system and to fully optimize the effectiveness of their aircraft. Navy and Marine Corps after action reports criticized FLIR shortages, supported pilots' statements, and cited a need for a laser target illumination capability. The absence of this capability in Desert Storm essentially precluded the F/A-18 from dropping precision laser-guided bombs.

AV-8B

None of the 86 deployed Marine Corps AV-8B attack aircraft had FLIR systems. According to an AV-8B requirements document, the ". . .inability to detect, designate, and attack targets at night, in adverse weather, and/or from outside enemy point defenses, reduces the aircraft's mission effectiveness and jeopardizes its survivability." AV-8B pilots needed to see a target to engage the aircraft's computerized bombing system. At night, AV-8B pilots were directed to a target by an airborne or ground forward air controller and used flares or marking rockets to see the targets. During the ground war, AV-8Bs generally operated at lower altitudes to get below bad weather, improve accuracy, and better support ground forces, but at a much greater risk to themselves from surface-to-air infrared (heat-seeking) missiles and antiaircraft guns. Three AV-8Bs were lost during the ground war, all to infrared missiles.

No AV-8B used in Desert Storm had an air-to-ground radar to improve target acquisition. A Marine Corps requirements document stated that a

radar ". . .will dramatically enhance the pilot's capability to locate and destroy targets under all conditions of marginal weather, limited visibility, and darkness." Also, ". . .without a radar to detect and attack airborne fixed/rotary wing targets or surface threats, the ability of the current AV-8B to contribute effectively to the defense of the force is limited."

AH-1W

None of the 50 Marine Corps AH-1W attack helicopters deployed in Desert Storm had FLIR systems or laser target illuminators to assist crews to more precisely locate, identify, and attack targets. According to a Department of Defense report on the war, the AH-1W's lack of a night targeting system ". . .severely restricted night and adverse weather operations and the use of the Hellfire missile's superior stand-off capability." Despite targeting limitations, AH-1Ws provided close-in fire support of ground forces by attacking enemy tanks, armored vehicles, and bunkers. Their crews fired about 150 Hellfire laser-guided missiles with the assistance of ground troops or other support helicopters that illuminated targets with their own laser designators.

Fighter Aircraft Could Not Identify Enemy Aircraft Beyond Visual Range

Navy fighter aircraft flew hundreds of miles inland from their ships, escorting and protecting attack aircraft from enemy aircraft threats in airspace crowded with many types of friendly and hostile aircraft. In the crowded Desert Storm airspace, strict rules of engagement required verifying the identity of aircraft beyond visual range to reduce the danger of shooting down friendly aircraft. Consequently, before firing a missile at a suspected enemy aircraft beyond visual range, pilots had to electronically query an unknown aircraft to determine whether it was emitting the proper friendly aircraft identification signal and, if not, whether it could be identified as a hostile aircraft. However, neither the F-14 nor F/A-18 had the electronic systems needed to completely and independently verify the identity of other aircraft as required by the rules. As a result, Navy and Marine Corps pilots had to coordinate with Navy or Air Force command and control aircraft to verify the identity of the unknown aircraft.

Only the Air Force F-15 had the capability to independently identify unknown aircraft, and it was credited with shooting down 33 of 38 Iraqi aircraft during Desert Storm. We did not determine, however, how many of the 33 F-15 "kills" were made beyond visual range using this capability. Navy F/A-18s shot down two Iraqi aircraft while an F-14 shot down one aircraft. Navy officials believed pilots lost several chances to shoot down

Iraqi aircraft because they lacked the independent verification capability. Moreover, they said that not having beyond visual range capability could place them within the lethal range of an enemy aircraft's missiles before positive identification was made.

Defensive Countermeasures Were a Concern

There were not enough defensive systems (which include radar warning receivers, radar jamming devices, expendable chaff, and flare decoys) to equip some Navy and Marine Corps attack and fighter aircraft, and some systems were unable to sufficiently detect some modern antiaircraft missiles. Consequently, early in the air war, aircraft without complete or adequate defensive systems were not assigned missions over hostile territory. Later, as the threat from the Iraqi air defense system diminished due to destruction of enemy weapons by Coalition air attacks, planes without electronic jammers flew in formation with aircraft that had the jammers. Air crews also relied on their knowledge of known antiaircraft sites and maneuvering skills to avoid and evade enemy missiles.

Navy and Marine Corps pilots told us that current aircraft defensive systems cannot detect and counter some modern radar-guided missile threats. The pilots added, however, that some degree of protection is better than no protection, and they preferred to have even the current systems on their planes. However, there were not enough assets available to outfit all aircraft in Desert Storm, and there are not enough today to meet operational, training, and support requirements. Generally, equipment is moved among squadrons: squadrons deployed or ready to deploy get the equipment, while those returning from active duty deployments or in earlier stages of training give up the equipment.

No U.S. fixed-wing tactical combat aircraft can currently detect heat-seeking (infrared) missiles such as hand-held, shoulder-fired versions. These missiles have passive sensors to detect and fly toward heat sources such as aircraft engine exhausts. They are difficult to see and cannot be detected by current warning receivers. Thus, low-flying aircraft run the risk of being destroyed because they are likely to come within the range of these missiles. Moreover, crew reaction time is limited when they spot an incoming missile. Three Marine Corps AV-8B Harrier close air support jets were shot down during the last 10 days of the war by these missiles, along with seven other Coalition aircraft. These aircraft were operating over Kuwait and flying at lower altitudes to get below bad weather and provide more accurate support.

Capability and Affordability Trade-Offs Contributed to Limitations

Historically, the expense, cost growth, and time it takes to develop, procure, and deliver new aircraft and systems result in trade-off decisions that affect affordability and capability. The results of these trade-offs included (1) not buying complete combat systems for all aircraft in an effort to hold down acquisition costs; (2) using funds planned for buying equipment, such as FLIR systems and electronic self-protection jammers, to pay for cost increases to the basic airframe, engines, and electronics; and (3) fielding and operating new aircraft without some systems because those systems were not developed in time to deliver them with the aircraft.

Affordability Trade-Offs

In some instances, the Navy chose not to buy a sufficient number of systems to equip all or most aircraft, even though these systems would improve combat capability or aircraft survivability. For example, in 1983, the Secretary of the Navy, citing affordability, directed that F/A-18 FLIR systems be bought on a ratio of one pod for every three aircraft, despite operational requirements of one pod for two aircraft. FLIR shortages reduced the ability of F/A-18 pilots to precisely locate, identify, and attack some targets, especially at night, in poor visibility and from high altitudes.

Electronic countermeasure systems to protect aircraft against radar-guided missiles were also not bought for every aircraft. For example, the Navy bought two ALQ-126B radar jamming units for every three A-6E, F-14, and F/A-18 aircraft and only 74 ALQ-164 radar jamming pods to equip over 200 AV-8Bs.[1] Equipment shortages necessitate sharing these assets for operations and training. Squadrons deployed aboard carriers have priority for getting equipment, while those ashore undergoing training have lower priority and get fewer assets.

We believe that the views of Navy and Marine Corps pilots we talked to were accurately reflected in a quotation from the March 1992 House Committee on Armed Services report, Defense for a New Era: Lessons of the Persian Gulf War. In that report, a Marine Corps pilot said that the Navy should buy completely equipped aircraft. He complained that the Navy bought airplanes equipped with unsatisfactory radar warning receivers, expendables (e.g., chaff and flares), and missile and bomb racks. He offered to give up 1 of the 12 aircraft in his squadron to fully equip the other 11.

[1]As noted previously, although these systems have limitations, they do provide some degree of protection and pilots preferred to have them installed in their aircraft. The Navy has initiated actions to improve the capabilities of defensive systems.

Planned Equipment Funds Used to Pay for Other Cost Increases

Historically, funds planned for buying ancillary equipment (which includes targeting and navigation FLIR pods, armament equipment, defensive countermeasure systems, and night vision devices), test equipment, publications, and other aircraft support items were used to pay for increases in the cost of airframes, engines, and electronics. Between fiscal years 1987 and 1992, for example, the Navy budgeted about $13.1 billion, including $4.28 billion for ancillary equipment and support items, to procure 450 F/A-18s. Congress actually appropriated about $12 billion to procure 414 F/A-18s. Navy expenditures for the ancillary equipment for this period, however, were about $3.53 billion while the amount budgeted was $4.28 billion, a decrease of about $750 million. While the average amount expended per aircraft for ancillary equipment declined by nearly $1 million from budget plans, the average unit cost for the airframe, electronics, and engines increased by about $700,000 and nonrecurring costs increased by about $600,000 per aircraft.

Similarly, AV-8B expenditures for ancillary equipment decreased from a budgeted amount of $183 million to $57 million. By eliminating some ancillary equipment, each aircraft's cost was reduced by about $900,000. However, this was more than offset by cost increases for the airframe, electronics, and engines of about $600,000 per airplane, plus nonrecurring cost increases of about $700,000 per aircraft.

System Development Not Concurrent With Aircraft Deliveries

In some instances, aircraft were delivered to the fleet without certain capabilities because the technology was not sufficiently advanced or, due to concurrency in the development and production of the aircraft, ancillary system development efforts were not completed in time to deliver the systems concurrent with fielding the aircraft. For example, initial F/A-18 deliveries began in late 1980, but the first FLIR systems were not delivered until fiscal year 1983. Subsequently, the Navy began efforts to incorporate a laser illumination capability into the FLIR system, and it initially projected these efforts would be completed in fiscal year 1985. As of November 1992, the laser capability for the F/A-18 FLIR system had still not reached the fleet.

In another example, fleet deliveries of Navy F-14D fighters began in March 1990, but the fighters did not have a defensive system to jam signals from radar-guided missiles homing in on the aircraft. The ALQ-165 Airborne Self-Protection Jammer (ASPJ), which was planned to provide this capability, has been terminated. The Navy is currently determining what system will replace ASPJ.

Combat Limitations Are Being Addressed

Navy aviation officials were aware of most aircraft limitations before the war and the Navy had begun to improve its offensive and defensive systems. Improvements include developing a laser for the F/A-18 targeting FLIR system, improving radar warning and countermeasure capabilities, developing an improved fighter identification system, and remanufacturing 72 AV-8B Harriers. Whether further progress is made to improve the capability of existing aircraft will depend on the priority that upgrades are given.

Offensive Systems

The Navy is continuing efforts to improve aircraft offensive systems. Improvements will enhance the ability of Navy and Marine Corps air crews to locate, identify, and conduct precision attacks at night and from higher altitudes.

F/A-18 Targeting FLIRs

The Navy is developing a laser targeting capability for the F/A-18's FLIR system that will enable pilots to drop laser-guided bombs without the assistance of another crew that has an external laser to mark targets. The Navy expected to begin delivering new laser FLIR pods, which cost about $2.9 million each, to the fleet in March 1993. It also plans to retrofit some older FLIR pods with a laser module, at a cost of about $340,000 each.

In May 1992, in response to Desert Storm lessons learned, the Navy increased the FLIR inventory requirement for the F/A-18 from one pod per three aircraft to two pods per three aircraft. A Navy official stated that the Navy's fiscal year 1994 aircraft procurement budget should reflect the increased procurement. Because the interval between contract award and delivery is about 18 to 24 months, actual deliveries will not begin until fiscal year 1996. Officials cautioned, however, that funding could be reduced or eliminated during the budget process, and if costs for the airframe, engines, and electronics rise, funds planned to buy FLIR systems and other ancillary equipment could be used to pay for those cost increases.

AV-8B

The Marine Corps plans to spend up to $1.6 billion to remanufacture 72 AV-8Bs, beginning in fiscal year 1996. The remanufacturing would include a more powerful engine, a radar, a better night combat capability, and structural and safety improvements.

AH-1W

The Marine Corps is developing a FLIR and laser targeting system that will improve the AH-1W's ability to perform close-in fire support at night. The system will enable AH-1W air crews to better locate and identify targets and independently fire laser-guided missiles like the Hellfire without relying on ground troops or another helicopter to mark targets. The Marine Corps plans to equip about 190 AH-1Ws with the system, which is expected to cost about $550 million, or about $2.9 million per aircraft. The system, being developed in conjunction with Israel, is expected to reach its initial operational capability in early 1994.

Fighter Positive Identification

An aircraft requirements officer in the Office of the Deputy Chief of Naval Operations (Air Warfare) said, with the exception of the Air Force F-15C, pilots could not positively identify enemy aircraft beyond visual range. This weakness is documented in Desert Storm lessons learned, and as a result, is getting greater emphasis. The official indicated that an initiative to develop positive identification capability for F-14 and F/A-18 pilots was approved in the Navy's fiscal year 1994 Program Objectives Memorandum and should be included in the fiscal year 1994 budget submitted to Congress. He said that this would probably be a joint program with the Air Force.

Defensive Systems

The Navy had begun efforts to improve the ability of aircraft defensive systems to detect and counter modern antiaircraft missiles prior to Desert Storm, and efforts are continuing. The Navy plans to improve the detection capability of the ALR-67 radar warning receiver used on A-6, AV-8, F-14, and F/A-18 aircraft by modifying existing systems and procuring new versions. The Navy has budgeted $257 million through fiscal year 1994 to buy and install about 420 upgrade kits at a unit cost of about $612,000. The upgrade, referred to as Engineering Change Proposal 510, is viewed by Navy officials as an interim improvement until a new radar warning receiver, the Advanced Special Receiver, is developed.

The Advanced Special Receiver is intended to improve radar detection sensitivity, operating frequency range, and processing time, and according to the Navy, it will meet future scenarios and threats well into the next century. The Navy plans to buy about 1,600 units at an estimated cost of $1.1 billion, about $700,000 per unit.

Planned upgrades for the A-6E will include the ALR-67 Advanced Special Receiver, the ALE-50 Advanced Airborne Expendable Decoy, and the

ALQ-156A Missile Approach Warning System to improve the aircraft's ability to detect and counter modern antiair threats.

Because Navy and Marine Corps fixed-wing aircraft cannot detect approaching infrared-guided missiles, a significant threat in Desert Storm that caused several combat losses, the Navy is considering several different missile warning systems. For example, the A-6E Intruder is supposed to be equipped with the ALQ-156A missile approach warning system. A variant of the AAR-47 system is being considered for the AV-8B, and other systems are being considered for F-14 and F/A-18 aircraft.

Observations

Although Navy and Marine Corps aircraft were able to perform the missions assigned, Desert Storm experiences revealed equipment limitations that made it more difficult for air crews to locate, identify, and attack targets with precision under some battle conditions; to identify unknown aircraft beyond visual range; and to defend against some antiaircraft threats. We believe that greater aircraft and crew losses could have arisen from these limitations but were avoided by operating at higher altitudes, increasing survivability but sacrificing bombing accuracy.

The equipment limitations were caused, in part, by trade-off decisions associated with the expense, cost growth, and time generally associated with developing, acquiring, and fielding new weapon systems. While performance was degraded in some instances, it did not have a major impact on overall operations. However, if the enemy antiair threat had been greater or if the number of aircraft had been limited, thus increasing the importance of individual aircraft capabilities, the end result could have been more costly. If enemy air defense systems had been more effective or if Iraqi offensive actions had been more determined, more effective U.S. defensive systems and greater bombing accuracy would have been critical to success.

Navy officials were aware of most limitations before the war and had initiatives to improve some capabilities, such as adding a laser designator to the F/A-18 targeting FLIR and improving radar warning and countermeasure capabilities. The Navy plans to address other limitations, including buying more F/A-18 FLIR systems, developing an improved fighter identification system, and upgrading AV-8B capabilities through a remanufacturing program.

The world situation and our national military strategy have shifted from a focus on global war to smaller but lethal regional conflicts similar to Desert Storm. If U.S. forces are committed to such a conflict, it is likely that U.S. combat aircraft will face modern antiaircraft weapons that are being spread throughout the world by aggressive arm sales competition. We believe that this changing environment, combined with the prospect of reduced U.S. defense spending, warrants a weighing of priorities between heavily investing in new aircraft development programs versus better equipping or upgrading aircraft already in the inventory.

Without the favorable factors of Desert Shield/Desert Storm, U.S. forces could face the prospect of fighting their way into the country, supported primarily by carrier-based aircraft, in order to build the supporting

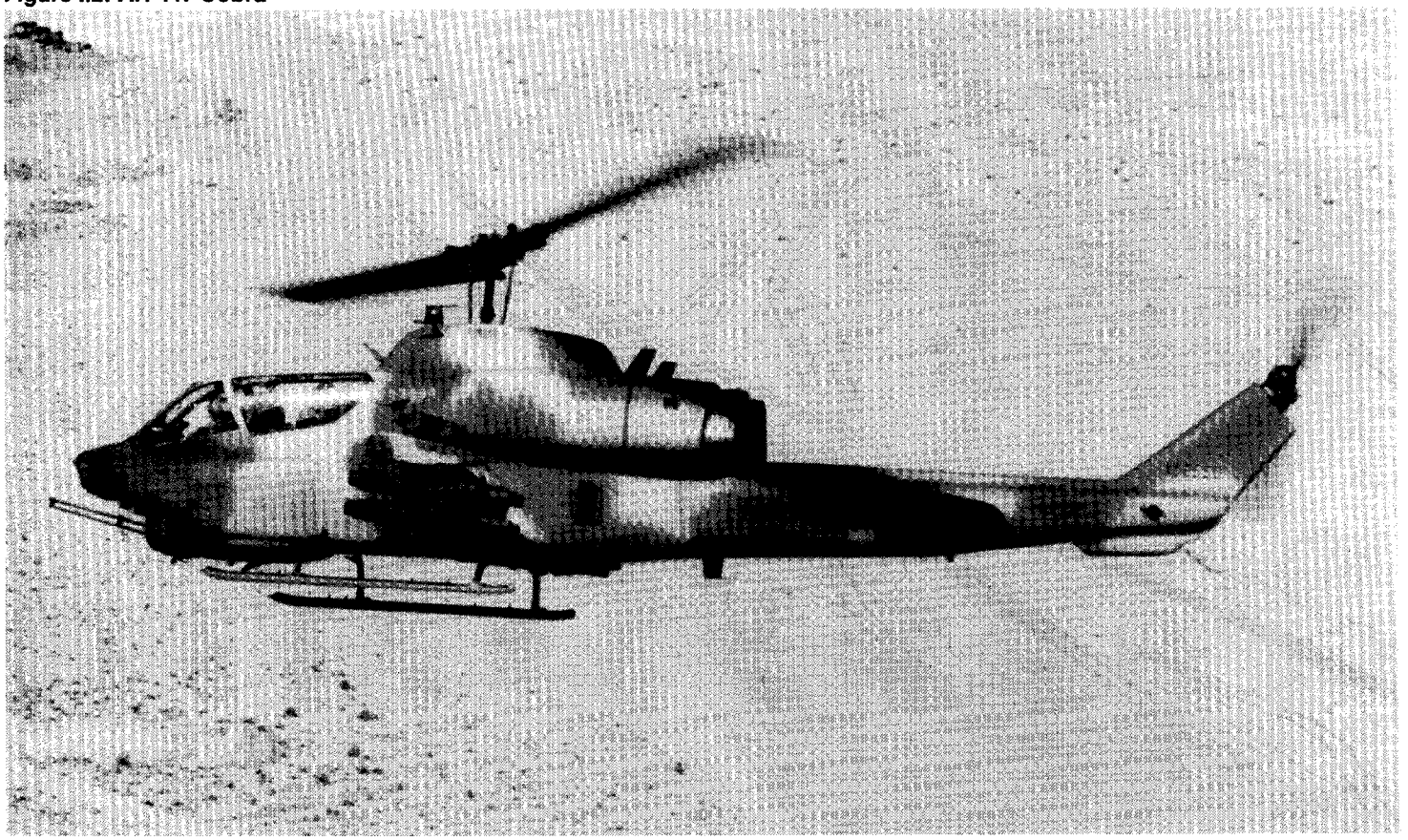
infrastructure that was immediately available in Saudi Arabia. Under these changed conditions, the United States would need to rely on a smaller number of attack aircraft and the sorties flown would have to score decisively. To be effective, the aircraft would require the necessary equipment to locate, identify, and attack targets both day and night and in poor visibility; to identify enemy aircraft beyond visual range; and to defend against modern antiaircraft threats. These capabilities were lacking in some instances during Desert Storm. The Navy and the Marines have begun some remedial actions. However, successfully upgrading their current aircraft depends in part on the continued priority and funding that the Navy and the Marines give upgrade initiatives as compared with competing and distracting priorities to develop new aircraft while reducing the defense budget.

Navy and Marine Corps Aircraft Discussed in This Report

Figure I.1: A-6E Intruder

The A-6E Intruder is a carrier-and land-based, all-weather attack aircraft that is operated by the Navy and the Marine Corps (see fig. I.1). The A-6E has an all-weather terrain following/ground mapping radar, a forward-looking infrared (FLIR) sensor for day/night target imaging, and a laser designator to mark targets and launch laser-guided weapons. Ordnance used by A-6Es in Desert Storm included 500-, 1,000-, and 2,000-lb laser-guided and unguided gravity bombs, cluster bombs, and the Stand-off Land Attack Missile. A-6Es were used for attacks on high value targets such as Scud missiles, Iraqi ground and naval forces, artillery, logistics sites, bridges, railroad yards, ammunition storage areas, and armor concentrations.

Figure I.2: AH-1W Cobra



The AH-1W Cobra is a Marine Corps twin-seat attack helicopter that provides fire support for ground forces in close proximity to the enemy (see fig. I.2). AH-1W weapons include a 20-mm gatling gun, Tube-launched, Optically-tracked, Wire-guided missile, and Hellfire laser-guided missile. AH-1Ws attacked tanks, armored personnel carriers and vehicles, bunkers, and antiaircraft artillery sites.

Figure I.3: AV-8B Harrier

The AV-8B Harrier is a Marine Corps single-seat, attack aircraft with vertical/short takeoff and landing capability that enables operation from small, austere airfields close to the battlefield and from ships (see fig. I.3). It can respond quickly to a ground commander's need for close air support when operating from sites close to the battlefield. Its weapons include a 25-mm gun, cluster bombs, and 500 and 1,000-lb bombs. AV-8Bs attacked Iraqi artillery, tanks, armored vehicles, ammunition storage sites, troop positions, airfields, and antiaircraft artillery/surface-to-air missile locations.

Figure I.4: F-14 Tomcat

The F-14 Tomcat is a Navy carrier-based, two-seat, variable-sweep wing supersonic fighter (see fig. I.4). It uses the long range AIM-54 Phoenix, AIM-7 Sparrow, and AIM-9 Sidewinder air-to-air missiles and a 20-mm gun. In Desert Storm, F-14s provided escort protection for attack aircraft, long-range air defense of ships and combat air patrol missions. Some F-14s also flew daylight photo intelligence missions using the Tactical Air Reconnaissance Pod System.

Figure I.5: F/A-18 Hornet

The F/A-18 Hornet is a Navy and Marine Corps, carrier-and land-based, supersonic, multimission aircraft that is used both as a fighter and attack aircraft (see fig. I.5). As fighters, F/A-18s use Sidewinder and Sparrow antiaircraft missiles and have a 20-mm gatling gun. As attack aircraft, F/A-18s carry various bombs, including 500-, 1,000- and 2,000-lb gravity bombs and cluster bombs, and air-to-ground missiles such as the Maverick antitank missile and the High-speed Anti-Radiation Missile. In Desert Storm, F/A-18 missions included escort, combat air patrol, fleet air defense, suppression of enemy air defenses, and attacks on airfields,

bridges, artillery, tanks, armored vehicles, and other Iraqi ground and naval forces.

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