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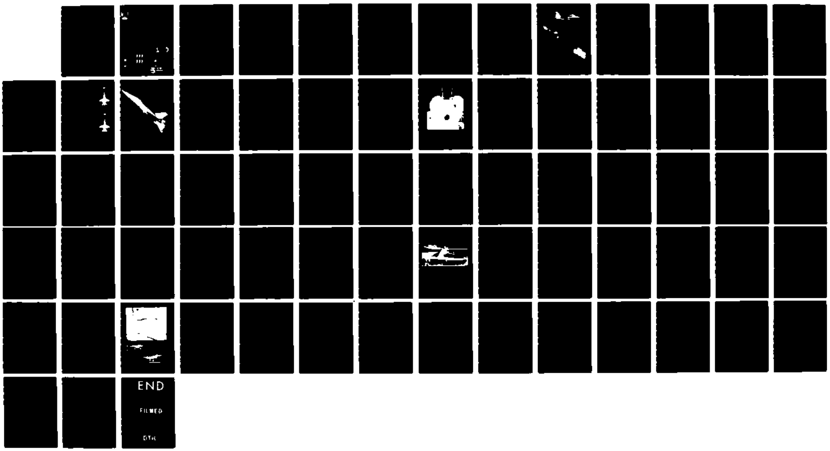

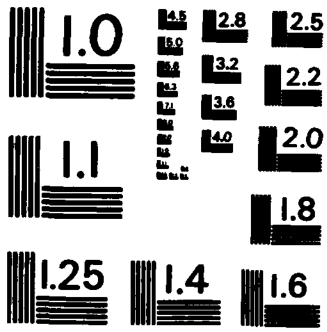

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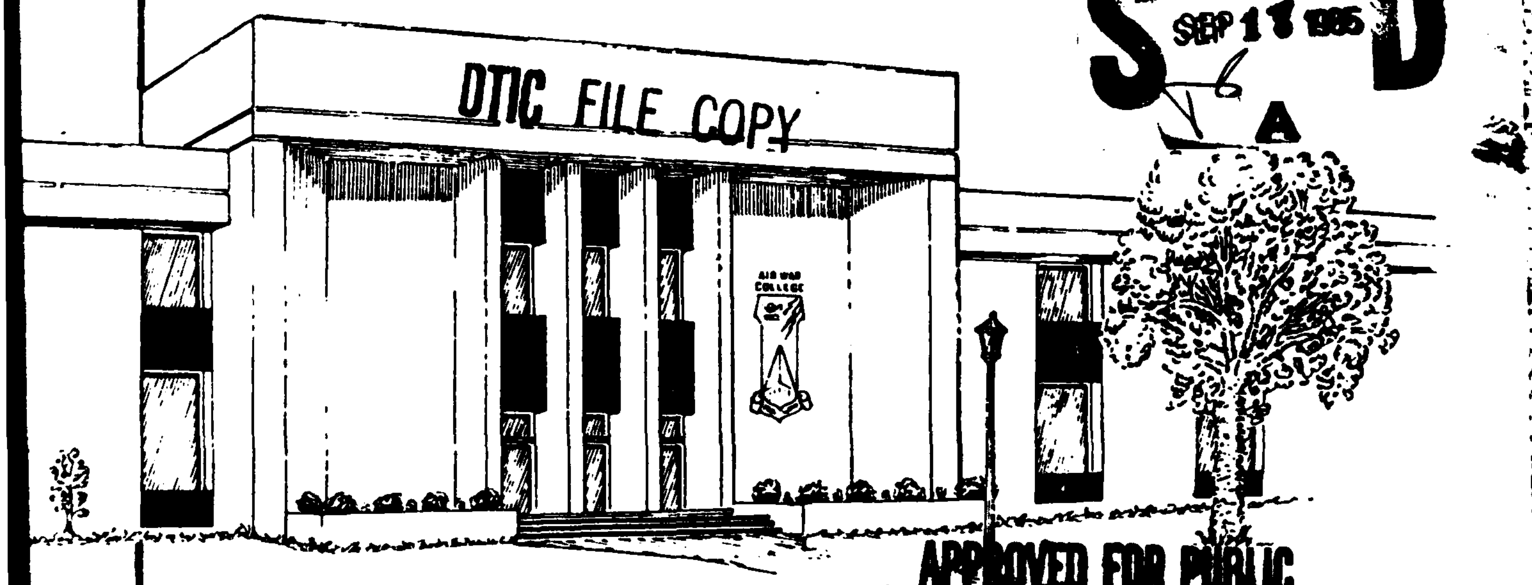
RESEARCH REPORT

No. AU-AWC-85-226

MARINE CORPS AVIATION; IS THE HORNET THE ANSWER?

By LIEUTENANT COLONEL GARY R. VANGYSEL, USMC



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MARINE CORPS AVIATION; IS THE HORNET THE ANSWER?

by

Gary R. VanGysel
Lieutenant Colonel, USMC

A RESEARCH REPORT SUBMITTED TO THE FACULTY

IN

FULFILLMENT OF THE RESEARCH

REQUIREMENT

Research Advisor: Colonel Richard L. Upchurch

MAXWELL AIR FORCE BASE, ALABAMA

May 1985

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AIR WAR COLLEGE RESEARCH REPORT ABSTRACT

TITLE: Marine Corps Aviation; Is the Hornet the Answer?

AUTHOR: Gary R. VanGysel, Lieutenant Colonel, USMC

By analyzing the performance of the F/A-18 Hornet, in accomplishing the tasks assigned to Marine Corps fighter/attack aviation, the author asserts that the F/A-18 satisfies Marine Corps requirements for the remainder of this century. A historical overview of the first 29 months of Marine Corps Hornet operations (1 August 1982 - 1 January 1985), and a general description of the aircraft's unique characteristics, serve to provide the reader sufficient background information to draw his own conclusion as to the performance of the F/A-18 Hornet.

BIOGRAPHICAL SKETCH

Lieutenant Colonel Gary VanGysel has been involved with Marine Corps fighter/attack aviation since his designation as a Naval Aviator in 1967. During his first 11 years flying experience he flew 2200 hours in the F-4 Phantom and completed one combat tour in Viet Nam. He was first introduced to the F/A-18 Hornet in 1978, when he became Assistant Project Officer and Operations Officer of the F/A-18 Fleet Introduction Team at Naval Air Station, Lemoore, California. In 1980 he assumed duties as Executive Officer of the first Navy F/A-18 squadron, VFA 125, and in September 1982 he assumed command of VMFA 323, the second Marine Corps squadron to transition to the Hornet. Lieutenant Colonel VanGysel is a graduate of the Armed Forces Staff College and a 1985 graduate of the Air War College.

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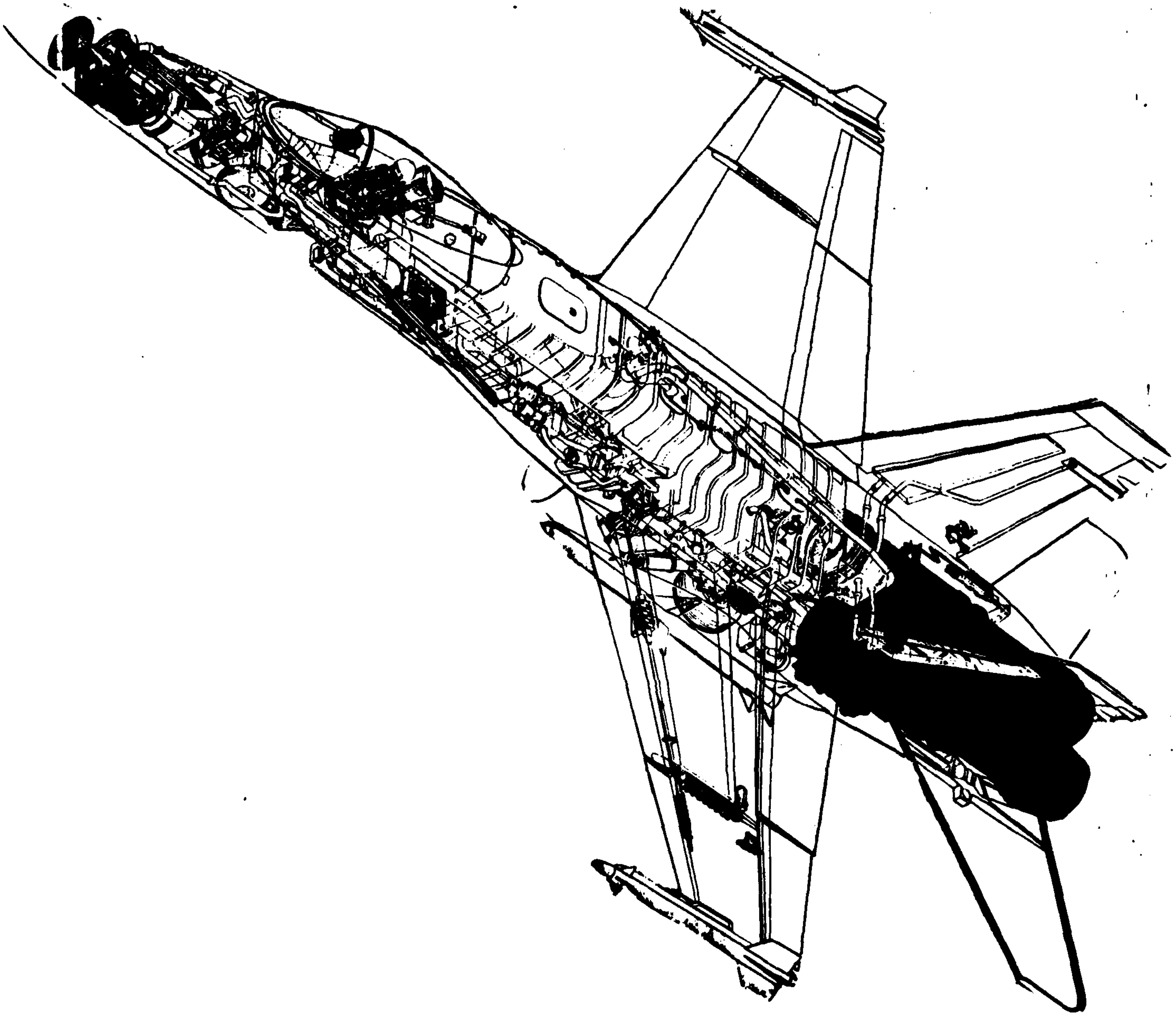

CHAPTER I

INTRODUCTION

On January 1, 1985, the Marine Corps completed its first 29 months of F/A-18 Hornet operations. Fleet Marine Force (FMF) transition to the Hornet began in the spring of 1982. Commanding Officers of fighter/attack squadrons (VMFA) at Marine Aircraft Group-11 (MAG-11), Marine Corps Air Station (MCAS) El Toro, California were directed to transfer their F-4N Phantom aircraft, and commence stabilizing squadron personnel. In August and October 1982, and January 1983, VMFA-314, VMFA-323, and VMFA-531 respectively, reported to the Fleet Readiness Squadron (FRS), Strike Fighter Squadron-125 (VFA-125), for F/A-18 transition training at Naval Air Station (NAS) Lemoore, California.

The pilots of VMFA-314 completed aircraft transition training in December 1982 and received their first aircraft the same month. Pilots of VMFA-323 and VMFA-531 followed in February and April 1983. Since reporting back to MCAS El Toro, the three squadrons have each received 12 F/A-18 aircraft, all required support equipment, and have participated in several training exercises leading to combat readiness. Training included: five AIM 7/9 missile exercises; numerous air to air gunnery periods; six Red Flag and two Maple Flag exercises; four day/night carrier qualification deployments; combined arms exercises at 29 Palms, California; numerous fighter weapons and air to ground deployments; and attendance at the Navy Fighter Weapons School at NAS Miramar, California, and the Marine Corps Weapons Tactics Instructor (WTI) Course at MCAS Yuma, Arizona. (1:7) Each squadron was tested for combat readiness in early 1984 using the Marine Corps Combat Readiness Evaluation System (MCCRES) criteria; the average score was 98 percent. This should be referenced to a 3rd Marine Aircraft Wing average of 90-92 percent. (2:9)

Marine Corps F/A-18 squadrons will soon fulfill defense commitments with the United States Navy. Two Marine Corps squadrons, VMFA 323 and VMFA 314, will deploy with Carrier Air Wing 13 (CVW-13) aboard USS Coral Sea (CV-43) in the Fall of 1985. Both squadrons are now participating with CVW-13 and CV-43 in a rigorous training schedule. (1:10)

Looking back at initial Marine Corps Hornet operations, and forward to Marine Corps commitment, it can be empirically assessed whether the Marine Corps has the best aircraft for the fighter/attack mission. I believe that the F/A-18 does satisfy Marine Corps requirements for fighter/attack aviation for the remainder of this century. Reliable data is now available that can educate an ignorant and probably confused public, correct misconceptions put forth in the media, and enlighten all Marines about the unique capabilities of the aircraft that will provide their close air and fighter support in combat--the F/A-18 Hornet.

The primary basis for this positive assessment is my experience as a Hornet squadron commander. But my knowledge of this fine aircraft is not limited to that rewarding 21 month period. During my first 11 years as a Naval Aviator, I was assigned to fighter/attack squadrons flying the F-4 Phantom. I was first introduced to the Hornet in 1978, when I served as Assistant Project Officer and Operations Officer of the F/A-18 Fleet Introduction Team at NAS Lemoore, California; the site chosen as the initial location for fleet introduction of the Hornet. In 1980 I assumed duties as Executive Officer of VFA-125, the first training squadron for future Navy and Marine Corps F/A-18 pilots and maintenance personnel. In September 1982 I assumed command of VMFA 323, the second Marine Corps squadron to transition to the Hornet. During my tenure in command, VMFA 323 trained to a combat ready status in the F/A-18.

I do not expect the reader to be convinced of my assessment without a critical analysis of how the Hornet performs the mission and tasks assigned to fighter/attack aviation. Before doing this, however, the reader needs a general knowledge of the Hornet's capabilities and an understanding of the unique requirements of Marine Corps aviation.

CHAPTER II

THE STRIKE FIGHTER

Aircraft

The F/A-18 Hornet is a true "strike fighter." A strike fighter is an aircraft which, with very little change in configuration and ordnance, can be a bomber or a fighter, or both; it is an aircraft that can go to the target unescorted, engage hostile air, and destroy a target without assistance from any other type of aircraft; it is an aircraft that on a single flight can excel both in the attack and fighter role, a rare characteristic in aviation weapon systems. (3:17) Previous aircraft have been capable of being both a fighter and a bomber, but none have excelled in both roles. The F/A-18 is the first aircraft designed to be a strike fighter.

The flexibility provided by a strike fighter is extremely advantageous for Marine Corps aviation. A Marine Air Ground Task Force (MAGTF)* in time of crisis could be deployed independently to any region in the world. The air combat element (ACE) commander of the MAGTF must, with limited aviation assets, be able to respond to both a ground and airborne threat. One aircraft, the F/A-18, can provide

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* The way Marines are employed in combat. A task force consisting of a ground combat element (GCE) and an air combat element (ACE), and a combat service support element (CSSE).

the ACE commander with a superb capability of responding to either threat, or both. It is truly a force multiplier.

The Hornet is a single-seat twin engine airplane designed for the U.S. Navy and the U.S. Marine Corps. It has been developed to replace the F-4 Phantom as an interceptor, fighter, and fighter escort and the A-7E as a light attack aircraft. Larger and heavier than the A-7 but smaller and lighter than the F-4, the Hornet has the following dimensions: length 56 feet; wing span 40 feet 5 inches; and height to the top of the vertical fin 15 feet 3 inches. (4:1-1) Its weight is 23,925 pounds empty, and 37,000 pounds when flying with full internal fuel, ammunition, and two AIM 7 and two AIM 9 missiles. (4:1-2) (See Figure 1)

The aircraft features a variable camber mid-wing with a leading edge extension (LEX) mounted on each side of the fuselage from the wing roots to just forward of the windshield. Twin vertical stabilizers are mounted well forward of the end of the aircraft and are canted outward 20 degrees from the vertical. The primary flight controls are the ailerons, twin rudders, differential leading edge flaps, differential trailing edge flaps, and differential stabilator. (See Figure 2) The hydraulically activated flight controls receive their input from two digital flight control computers through the control augmentation system (CAS).

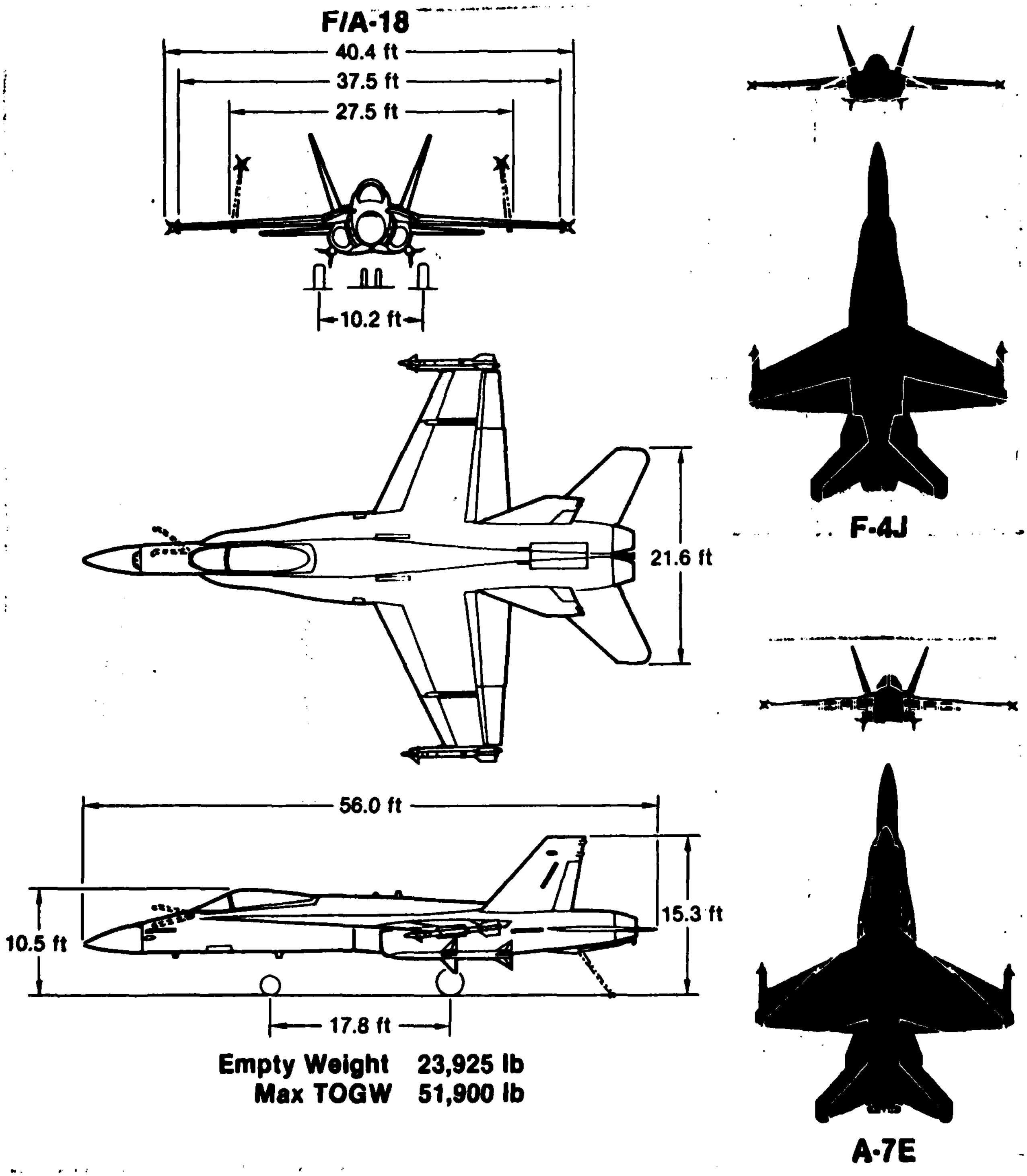


FIGURE 1. <u>HORNET PHYSICAL CHARACTERISTICS</u> (5:3)

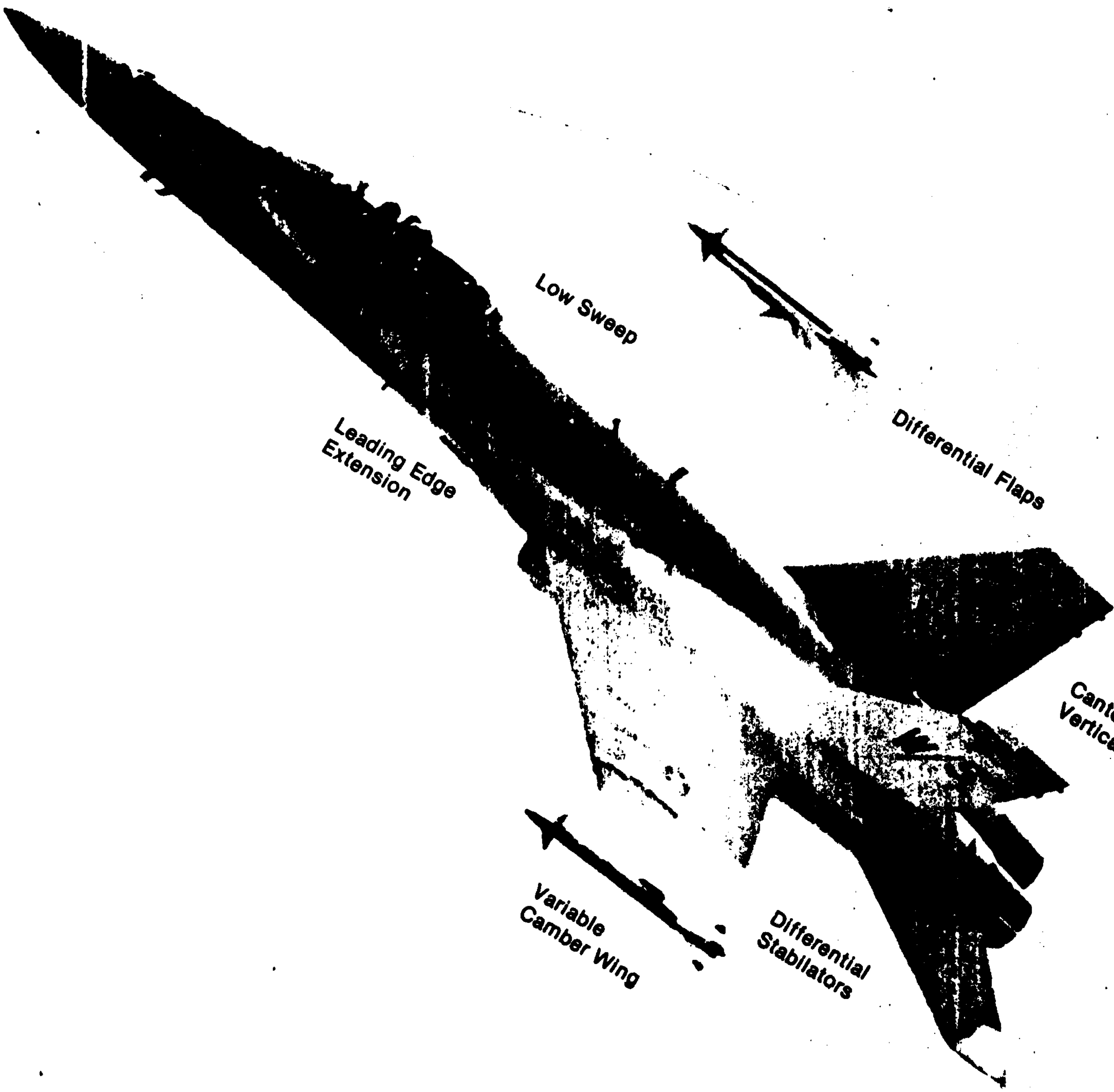


FIGURE 2. HORNET AERODYNAMIC FEATURES (5:10)

Approximately ten percent of all F/A-18s produced will be dual seat/controlled for training purposes. Rear cockpits include all tactical controls and displays, except for the head-up display (HUD).

The Hornet is powered by two F404-GE-400 turbofan engines; each produce 10,700 pounds of thrust at military power and 16,000 pounds of thrust in afterburner. (4:1-3) An aircraft mounted auxiliary power unit (APU) is used to start engines. On the ground, the APU may be used to supply air conditioning or electrical and hydraulic power to the aircraft systems.

When armed for air-to-air combat, the F/A-18 carries two AIM-9 Sidewinder missiles on its wing tips, two AIM-7 Sparrow missiles on the lower corner of its fuselage, and an M61A1 six barrel 20-millimeter gatling gun mounted in its nose. Sparrow or Sidewinder missiles may also be carried on the outboard wing stations. For the attack mission, the F/A-18 carries air-to-ground ordnance on center, inboard and outboard wing stations and Forward Looking Infrared Radar (FLIR) and Laser Designator Tracker (LDT)/Strike Camera (SCAM) pods in place of fuselage mounted Sparrows. Three external fuel tanks may be carried on the center and inboard wing stations.

Avionic Subsystem

The Avionic Subsystem is unique to the Hornet and combines the integration and automation needed for one-man operability with the redundancy required to ensure flight safety and mission success. Key features of the system include highly intergrated controls and displays; dual, redundant digital multiplex buses; a highly survivable quad-digital, control-by-wire primary flight control system; tactical sensors; inertial navigation set; and extensive built-in-test capability.

Two AN/AYK 14 mission computers are the heart of the avionic subsystem and store information from aircraft avionics equipment (e.g. flight control computers, air data computer, control converter, armament control processor set, inertial navigation set, radar set, FLIR, etc.) for display to the pilot upon request. Mission computer number one (MC1), the navigation computer, performs processing for navigation, controls/display management, aircraft built-in-test (BIT), status monitoring operations and backup for mission computer number two (MC2). MC2, the weapons computer, performs processing for air-to-air combat, air-to-ground attack, tactical controls/displays and backup for MC1. The two mission computers interconnect with primary avionics equipment via the avionic multiplex (MUX) buses. Each MUX bus channel functions asynchronously in a command/response mode, with peripheral avionic equipment responding to the mission computers upon command. (6:1-3)

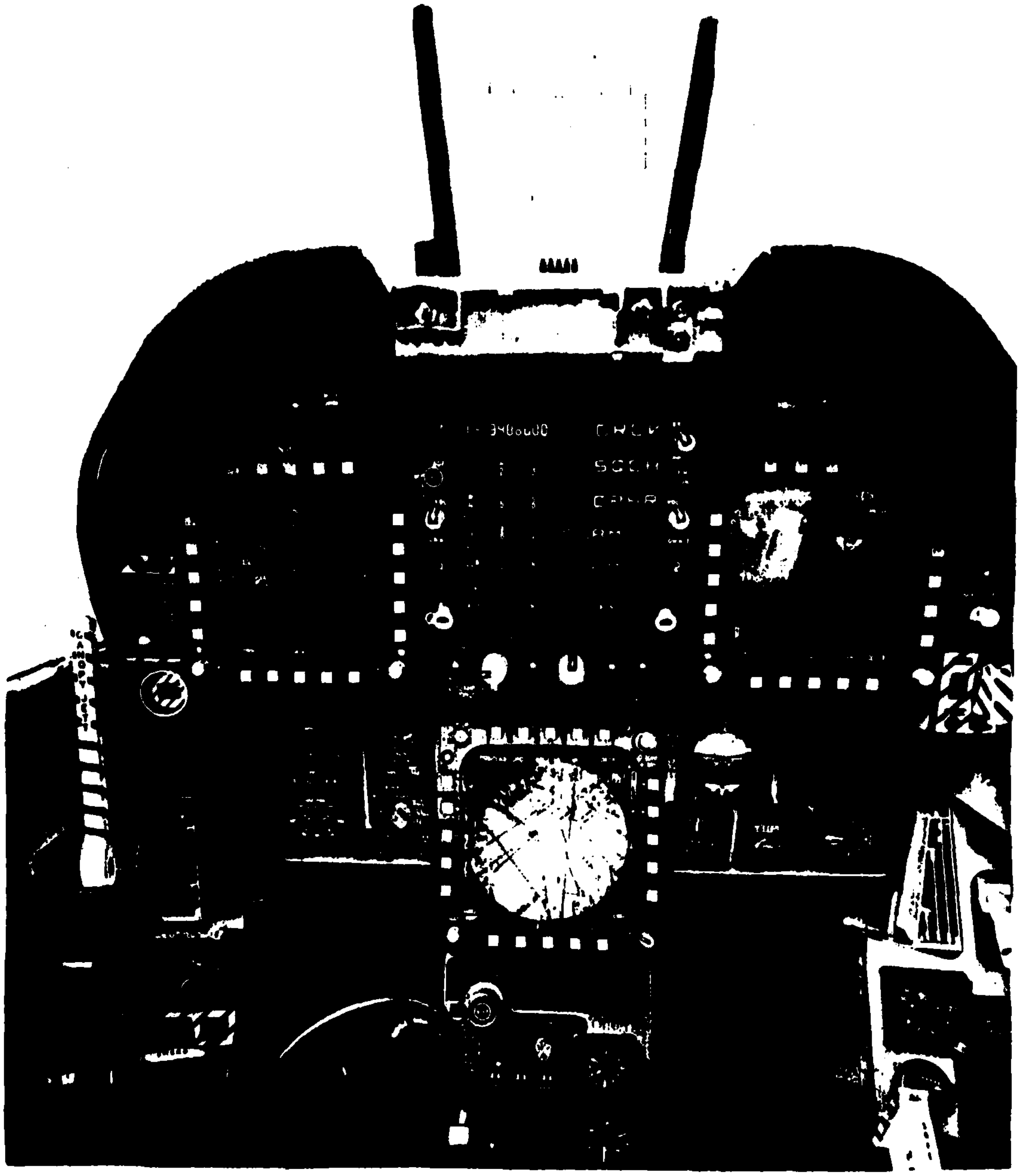
The F/A-18 controls and displays are highly integrated so that they can be controlled by a single crewman. The advanced cockpit makes use of computer controlled cathode ray tube (CRT) displays and Hands on Throttle and Stick (HOTAS) controls to reduce pilot workload and enhance multi-mission success. The HOTAS concept uses switches on the stick and throttle to allow the pilot to control the weapons, sensors, and displays during critical phases of the attack, while maintaining full control of the aircraft.

The primary displays on the main instrument panel are: the Head-up Display (HUD), left and right Digital Data Indicators (DDI's), and the Horizontal Indicator (HI). The Up-Front Control (UFC) is located in the center of the instrument panel above the HI. The HUD is the primary flight instrument and provides the pilot with flight, navigational steering, and weapons delivery information. The left and right DDI's are identical and interchangeable and each have a menu of functions which they can perform (e.g. sensor display [radar, FLIR], stores management display, advisory and BIT display, etc.). The HI combines an electronic horizontal situational display superimposed over a projected moving map display. The UFC is the pilot's means of communicating with the mission computers and provides controls for the ARC-182 radios, autopilot, IFF, tacan, instrument landing system, data link, radar beacon, and ADF (6:1-9). (See Figure 3)

The F/A-18 has three master modes of operation: *navigation*, air-to-air (A/A), and air-to-ground (A/G). The controls, displays, and avionic equipment operation are tailored as a function of the master mode which the pilot has selected. HOTAS switches, for example, can each perform different functions depending on the master mode selected.

The F/A-18 flight control set is a quad-digital control-by-wire electronic system. It has two flight control computers, each with two independent channels. Very simply put, the flight control system receives an input of pilot intentions from the control stick, and through the flight control computers, decides upon the optimum flight control(s) to provide the correct response. Through an air data computer interface, the flight control computer drives the leading edge and trailing edge flaps to provide a cambered wing that is efficient at all airspeeds, angle of attack, and G loading. It is this unique flight control system that gives the Hornet its superb pitch rate, turn performance and slow speed/high angle of attack handling qualities.

The F/A-18 tactical sensors include the radar set, the forward looking infrared (FLIR) set, and the laser



<u>HUD</u> - Transparent glass above glare shield. <u>Right DDI</u> - Right cathode ray tube. <u>Left DDI</u> - left cathode ray tube. <u>UFC</u> - Panel with keyboard between left and right DDI. <u>HI</u> - Cathode ray tube in the lower center of the cockpit.

FIGURE 3. <u>FLEXIBLE COCKPIT</u> (5:6)

designator tracker/strike camera (LDT/SCAM). The heart of the Hornet weapon control system is the multi-mission APG-65 radar set. A pulse doppler system, in the air-to-air master mode, it provides for initial contact, designation, and track of bogie aircraft, and continuous wave guidance for the AIM-7 Sparrow missile. In the air-to-ground master mode, it provides for reliable air-to-ground ranging for the multi-mode computerized bombing system, and real beam ground map to assist in navigation. High resolution surface mapping is provided, using doppler beam sharpening techniques, and is used for pinpointing and targeting radar significant targets. The radar also provides terrain avoidance to assist in penetrating heavily defended areas and a detection and tracking capability for moving surface targets.

The FLIR and LDT/SCAM are in various phases of operational testing and delivery to the fleet. Fleet Marine Force experience with these systems is, therefore, very limited. The FLIR and LDT/SCAM are conformally mounted pods, which during the attack mission, replaces the Sparrow missile in the fuselage corner stations. The FLIR will provide infrared imagery and target detection and track during day/night operations. The LDT provides detection and track of targets being illuminated by a laser designator from another aircraft or an observer in the target vicinity, allowing a first-pass target kill. The strike camera is installed at the rear of the LDT/SCAM pod and provides automatic photographic strike documentation as the aircraft overflies the target area following weapons release.

Essential for any computerized bombing platform is the requirement for the delivery vehicle to be able to pinpoint its exact position at all times. This capability is provided to the Hornet by a highly accurate inertial navigation system (INS). The INS is the primary navigation and attitude reference for the aircraft.

Unique to the Hornet is the degree to which monitoring and recording of aircraft systems and performance is accomplished. This information is invaluable for pilot and maintenance debrief following a flight. The recording and monitoring system has revolutionized organizational maintenance of the Hornet and has largely satisfied the requirement for improved maintainability with fewer personnel.

The Hornet is truly unique! I have addressed the exceptional capabilities of the F/A-18. But can it meet the unique requirements of Marine Corps aviation? An assessment of its initial performance in the Third Marine Aircraft Wing should answer the question.

CHAPTER III

MISSION AND TASKS

Marine Corps aviation is organized, trained, and equipped as a completely expeditionary air arm. This expeditionary aspect sets Marine Corps aviation apart from other aviation organizations. The mission of Marine Corps aviation is:

> To participate as the supporting air component of the FMF in the seizure and defense of advanced naval bases and for the conduct of such land operations as may be essential to the prosecution of a naval campaign. A collateral mission of Marine Corps aviation is to participate as an integral component of naval aviation in the execution of such other Navy functions as the fleet commander may direct. (7:5)

Doctrine envisions that Marine Corps aviation will support the landing forces throughout the assault landing and subsequent operations. Consequently, Marine Aviation must be prepared to provide tactical support by operating squadrons from aircraft carriers, or from airfields within striking distance of the amphibious objective area. Once the landing force is established ashore, Marine squadrons must provide support from existing airfields or expeditionary airfields constructed within the objective area. (7:2)

The capability to conduct successful tactical air operations is essential to the execution of an amphibious operation. To this end, the Marine Corps has established an effective aviation combat arms capable of meeting all the requirements of a landing force. (7:5) Fighter/attack aviation is an integral part of the Marine Corps aviation combat arm and has been assigned the following missions and tasks:

> Mission. The mission of the VMFA squadron is to intercept and destroy enemy aircraft under all-weather conditions, to attack and destroy surface targets, escort friendly aircraft, and conduct such other air operations as may be directed.
>
> Tasks. Intercept and destroy enemy aircraft in conjunction with ground and airborne fighter direction.
>
> Provide fighter escort of friendly aircraft.
>
> Maintain the capability to attack and destroy surface targets with those conventional weapons compatible with assigned aircraft.
>
> Conduct close air support operations within the capabilities of assigned aircraft.
>
> Perform visual reconnaissance.
>
> Maintain the capability of deployment or extended operations employing aerial refueling.
>
> Perform organizational maintenance on assigned aircraft.
>
> Maintain the capability of deploying and operating from aboard aircraft carriers, advanced bases and expeditionary airfields. (7:37)

I will prove that the performance of the F/A-18 Hornet satisfies the requirements of Marine Corps fighter/attack aviation by analyzing how it performs each task.

Tasks

Intercept and Destroy Enemy Aircraft In Conjunction With Ground and Airborne Fighter Direction (7:37)

Air superiority in the area of operation is a prerequisite for the success of an amphibious operation. (7:9) Air superiority as defined in JCS Pub 1, Department of Defense Dictionary for Military and Associated Terms, is:

> That degree of dominance in the air battle of one force over another which permits the conduct of operations by a former and its related land, sea, and air forces at a given time and place without prohibitive interference by the opposing force. (7:9)

Because of the vulnerability of the landing force during the ship to shore movement and during the initial buildup of combat power ashore, interference by opposing air forces would be disastrous. Marine Corps Hornets will be tasked with achieving and maintaining air superiority during an amphibious operation and subsequent operations ashore.

Intercepting an enemy aircraft involves positioning one's aircraft relative to an adversary so that an air-to-air weapon can be employed. I will discuss the Hornet's capability to conduct both all-weather intercepts and intercepts that require air combat maneuvering (ACM) to achieve a firing position.

A requirement for air intercept is a reliable, easily operable, high performance radar. The APG-65 radar meets this requirement. At MAG-11, the mean time between confirmed failure (MTBF) for the radar for the first 29 months of operations, has averaged 32.7 hours. (8:22) The F-4 Phantom has yet to attain an MTBF for the radar of one hour. Seldom does the radar degrade, let alone completely fail. Compared to the Phantom, this equates to greater pilot radar hands on time, fewer lost training sorties, and a greater level of pilot experience with the radar system.

Because the Hornet is single piloted, the radar has been designed for ease of operation. Some of the task reducing features include: automatic lock, automatic range decrement in track; automatic radar gain control; all radar controls located on the throttle, and all weapon select and launch controls on the control stick; and, digital readouts on the DDI of bogey altitude and mach, and on the HUD of range and closure rate. Optimum radar search parameters are automatically presented by the mission computer as a function of the selected weapon including azimuth scan width, elevation bar scan, pulse repetition frequency, range, and target history. Enough information is presented to the pilot by the radar system to make the most difficult all-weather intercept as simple as a formation rendezvous.

Heretofore, the most difficult single task to accomplish in completing a radar intercept was finding the bogey on radar. The pulse doppler radar and computer generated radar video display, completely eliminates the presence of ground clutter while in the air-to-air master mode, and significantly eases radar search techniques. In a recent MCCRES evaluation, squadron pilots received perfect scores for achieving radar contacts at ranges greater than 40 nautical miles. (9:A-19) Routinely, radar locks are achieved at ranges in excess of 35 nautical miles.

A variety of search modes are also available to the pilot: range while search (RWS) - target data is presented in range - azimuth format; velocity search (VS) - target data is presented in a velocity - azimuth format; and, track while scan (TWS) - the radar provides a multi-target detection and track capability. (6:4-3) The radar offers the pilot the flexibility of choosing a search mode that best meets the tactical situation (e.g. high speed threat, VS; multiple aircraft threat, TWS).

Designed for one-man operability, the F/A-18 radar electronic counter-countermeasure (ECCM) modes provide the aircraft with the capability to determine the presence and location of active electronic countermeasure (ECM) sources, and to automatically adapt the radar for search and acquisition performance against noise and deception type jammers. The pilot is alerted to the presence of a jamming environment by ECCM cues displayed on the radar and the HUD. During MCCRES evaluation, pilots were very successful in multi-bogey scenarios intercepting OA-4M aircraft carrying DLQ-3 ECM pods configured to jam the F/A-18 radar. (9:A-20).

To ensure good communications with ground and airborne fighter direction, the Hornet is configured with two ARC-182 radios, each with a complete UHF, VHF, FM and AM frequency span. Additionally, the Hornet's two-way data link system can receive and transmit tactical data to and from either the Naval Tactical Data System (NTDS) or the Airborne Tactical Data System (ATDS). Both data sources can provide multiple target information and specific information for each target. (6:4-5) The ARC-182 radio and data link are vulnerable to enemy communication jamming techniques. At this time, and for the foreseeable future, the Hornet will operate without a communication anti-jam capability. This can degrade the Hornet's effectiveness in all mission areas. The Joint Tactical Information Data System (JTIDS) will eventually provide for this capability, however, it will not be available until 1989. (10)

Should the rules of engagement require visual identification (VID) of a target prior to weapons employment, or should the Hornet start its intercept from a defensive position, then ACM may be required prior to reaching weapons launch parameters. After numerous fighter weapons deployments, many documented on tactical air combat training ranges, the F/A-18 has proven itself a fighter aircraft of the first order. A state of the art aircraft, it compares favorably with the Air Force F-15 and F-16. In performance comparisons with both of these aircraft, the

Hornet enjoys an advantage in pitch rate, lower corner velocity, and unrestricted angle of attack and engine performance. In both maximum instantaneous and sustained turn, it equals to the F-15 and enjoys a slight advantage over the F-16. (11:26)

Aircraft maneuvering performance is enhanced by such aerodynamic features as the leading edge wing extension (LEX), variable cambered wing, twin canted vertical tails, differential stabilator, and differential leading edge and trailing edge flaps. When interfaced with the digital flight control system, these features produce superior aircraft performance at all airspeeds and altitudes.

Particularly noteworthy is the Fornet's slow speed handling qualities; it own the upper left-hand corner of the maneuvering envelope. In this region, the LEX and variable cambered wing generate lift. The LEX and canted vertical tails provide directional stability and the differential stabilator and flaps augment the ailerons for roll performance. The flight control computers will not allow the pilot to inadvertently induce pro-spin controls at high angle of attack. The pilot, therefore, is allowed to maneuver with confidence at airspeeds well below 100 knots. The Hornet is a departure/spin resistant aircraft, and in my opinion the finest performing fighter below 300 knots in the U.S. today. A former U.S. Air Force F-15 commanding officer stated:

> The F/A-18 was quick, agile, and relatively small. I was particularly impressed by its slow speed nose positioning capability, endurance, avionics suite and engine reliability. Even up F-15/F-18 air combat is an excellent training experience for both USAF and USMC partipants. (12)

Many of today's fighter aircraft are severely restricted by engine performance. This is not the case with the Hornet. The F-404 turbofan engine is in the same thrust category as the J-79 engine that powers the heavier F-4. However, the F/A-18 engines are more reliable, more fuel efficient and have less moving parts. The Hornet's engines have no throttle movement, speed, or angle of attack restrictions. The engines are extremely responsive to the throttle (idle to maximum afterburner in three seconds); they yield superior acceleration and are totally smokeless. This important characteristic makes visual detection of the F/A-18 much more difficult. Because the engines are stall free over the entire operational envelope, at 45,000 feet and 40 degrees angle of attack both throttles can be retarded to idle and advanced to full afterburner with immediate response. (3:49) In numerous cases where pilots inadvertently maneuvered to zero airspeed (at any power setting) stalls or flameouts did not occur.

Visibility, both from an aircraft and of an aircraft, is an important fighter design consideration. From his position in the Hornet's cockpit, the pilot can look between the vertical tails and clear his deep six o'clock position. There is no restriction to visibiilty over the nose, and only a slight restriction to either side because of the LEX. The Hornet's gray on gray paint scheme, small airborne visual profile, and clean burning engines make it a difficult aircraft to see, especially nose on. The upper and lower plan form of the Hornet appears identical, making it difficult to discern aircraft attitude. Canadian Hornets are delivered with a canopy painted on the bottom of the fuselage to take advantage of this peculiarity.

The Hornet weapon system is designed well for one-man operability during ACM. With a radar contact, a 25 milliradian tactical designation box is displayed on the HUD and identifies the radar line of sight to the target. It circumscribes the position on the HUD where the target will appear when it comes within pilot visibility limits. This is a great aid in acquiring an adversary during the difficult transition from radar to visual contact. It is also useful in keeping sight during an aerial engagement (e.g. bogey disappears into the sun). Conversely, with a visual contact, the pilot can easily obtain a radar contact (to employ an air-to-air missile or gun) by using the ACM autoacquisition modes of the radar: boresight acquisition, HUD acquisition, and vertical acquisition. These modes will automatically acquire a target if it is within five miles and is positioned on the HUD or canopy within the specific physical parameters of the selected mode.

Having all radar controls and weapon select and launch switches at the pilot's fingertips (HOTAS) keeps the pilot from having to bring his eyes into the cockpit once engaged, possibly losing sight of his opponent. When a weapon is selected, digital information on the HUD reinforces the pilot of the weapon selected, tells how many are remaining, and gives a "SHOOT" command when all launch envelope requirements have been met.

The Hornet employs a variety of air-to-air weapons in accomplishing the second portion of this task, "destroy enemy aircraft." The AIM-7 Sparrow missile is an all aspect, long range, radar guided missile. The AIM-9L/M is a medium to close range infrared missile. F/A-18 missile firing exercise results in MAG-11 have been most gratifying. They revealed 83 percent success rate with the Sparrow (22 fired), and a 100 percent success rate with the Sidewinder (17 fired). Extremely high radar and weapon system reliability make successful missile firings routine. Of special note is the March 1984 flight of four Hornets (each carrying one missile) from MCAS El Toro to Barking Sands Missile Range, Hawaii and the successful firing of two AIM-7 and two AIM-9 missiles on arrival. Total flight time per aircraft was over eight hours. (2:5) This type reliablity is important when attempting to gain air superiority in the amphibious objective area. There may be a requirement to fly long distance from an advanced base or establish combat air patrols of long duration.

The M61A1 20 millimeter gun is available for use at close range, inside 1500 feet. The gun system can carry 578 rounds and will fire at a rate of 4000 and 6000 rounds per minute. Set at an angle two degrees above the aircraft waterline, it is optimized for air-to-air gunnery. An extremely accurate system, through a radar/mission computer interface, the pilot is provided with a digital reticle on the HUD that predicts the actual strike of the bullet relative to the target in radar contact. The gun system is easy to use and extremely reliable. It seldom jams. Pilots adapt to the gun system rapidly and become proficient at air-to-air gunnery in approximately six sorties. Although the MAG-11 squadrons have averaged between 12 and 15 percent hits on gunnery banners during MCCRES evaluations, individual pilots are now routinely scoring greater than 20 percent hits. (9:A-3)

<u>Provide Fighter Escort of Friendly Aircraft</u> (7:37)

It is extremely important that prior to, during, and after an amphibious operation, that deep ground targets (e.g. rear assembly areas, ammunition storage dumps) that could affect the success of the operation be destroyed. Because of the limited number of naval gunfire support ships available to support the landing force, and the limited range of their weapon systems, the destruction of these targets will depend mainly on Navy and Marine Corps air. Navy and Marine Corps attack aircraft typically have little capability to provide for their own defense if attacked by opposing air forces. Further, if attacked when part of a strike group and forced to jettison their ordnance to survive, important ground targets will not be engaged. An aircraft with a forward quarter air-to-air shoot down capability is required to provide fighter escort of friendly strike aircraft.

A fighter escort can be either attached to, or detached from, a strike group of friendly aircraft. If it is detached, the mission is to protect the strike group by intercepting and destroying enemy aircraft. All the previously discussed capabilities apply. The mission of an attached fighter escort is similar, except that the fighter escort is required to accompany (either in front or behind) the strike group during the ingress, attack, and egress, and not become heavily engaged with an enemy air threat. The challenge for the escort pilot is maintaining tactical situational awareness. He must decide which radar targets will pose a threat; destroy the target before it endangers the strike group and quickly resume his escort position so that the strike group does not become vulnerable. This must be accomplished at extremely low altitudes and high airspeeds.

To reduce pilot workload and help him maintain situational awareness, the F/A-18's radar modes include track while scan (TWS). This mode provides an automatic search and lock capability and will maintain a track file for up to ten targets and data on the eight highest priority targets. Using this mode, the pilot can concentrate on visual lookout; and the radar will automatically acquire targets within the range and azimuth scan selected. All TWS targets are displayed with a target aspect pointer, which continuously indicates the target's horizontal aspect angle. (6:4-40) The target aspect vector provides the pilot an assessment of each target's heading relative to the strike group, converging or opening. He can quickly determine which target poses the greatest threat and designate that target as priority for either the Sparrow or Sidewinder missile. Both of these all aspect air-to-air weapons can be launched while in the TWS mode without requiring that the escort aircraft leave the escort position.

Maintain the Capability to Attack and Destroy Surface Targets With Those Conventional Weapons Compatible With Assigned Aircraft (7:37)

One of the greatest advantages of the F/A-18 is that it is a true strike fighter; i.e., it can attack and destroy a target without the requirement for escort. Simply by pushing a button, the F/A-18's radar changes from an air-to-air radar to an air-to-ground radar, and visa versa. The aircraft can carry two Sidewinder and two Sparrow missiles without affecting its total carriage capability for conventional ordnance. Eliminating the requirement for escort means that more aircraft are available to attack the target. This is particularly important if the ACE commander's aviat'on assets are limited. In assessing how the Hornet accomplishes this task, we will look at its performance in two areas; the ingress and egress, and the target area.

An important factor in planning the ingress and egress, and one of the more controversial issues during the introduction of the Hornet, is range. To be able to plan for and address this issue intelligently, MAG 11, early in the transition, conducted an operational assessment of the aircraft's range. Long range interdiction and strike missions were flown without refueling beyond radii of 500 nautical miles. They reached from MCAS El Toro to targets at Fallon, Nevada. Aircraft configuration was three external fuel tanks (retained), two air-to-air missiles, and a bomb load consisting of either four 500 pound or two 2000 pound general purpose bombs. Twenty high low low high*

*Profile flight that starts in the high altitude structure, a low altitude ingress, low altitude egress and high altitude return.

profile missions, which included 100 nautical miles of high speed, low altitude ingress and egress, were flown. Despite some air traffic control delays, fuel on landing averaged 3300 pounds, enough for a minimum combat package or a weather divert. The conclusion of this operational assessment was that the Hornet meets Marine Corps range requirements. (2:3)

As the enemy's air and electronic order of battle becomes more sophisticated, the reliance on low altitude high speed tactics, and electronic countermeasure will increase. The Hornet demonstrates superb flying qualities in the low altitude environment. Its sea level military power performance with one external fuel tank, four 1000 pound bombs, two Sidewinder missiles, a FLIR, and 578 rounds of 20 millimeter ammunition, is 581 knots. With three external fuel tanks and the same configuration, it is 562 knots. (13) Because the flight control system automatically induces flight control inputs to reduce convective turbulence, it is an extremely comfortable aircraft at low altitude. Superior aircraft pitch and turn rates ensure good maneuverability for low altitude transit through treacherous terrain. Unrestricted visibility and a heads-up presentation of flight, navigation and attack related data, allows the pilot to do more tasks without having to look down into the cockpit.

Precise navigation is required in transiting the electronic battlefield in order to avoid known enemy air defenses. Low level navigation is greatly simplified and made much more precise using the Hornet's primary navigation system, the ASN-130A inertial navigation set (INS). The pilot can input into the mission computer the coordinates of nine navigation waypoints to be used during the ingress, attack, and egress. The navigation system will continually update the pilot on his present position, and give the magnetic bearing, distance, and "time to go" at present ground speed to reach a selected waypoint. All horizontal indicator (navigation display) navigation symbology is superimposed over a moving map display that has selectable scales: 500,000: 1 and 2,000,000:1. (6:3-12) The map moves to reflect the aircraft transit over the ground and digital waypoint symbology is continually repositioned to reflect the actual waypoint location. To further reduce pilot workload, a steering cursor and a digital readout of range to the selected waypoint are displayed on the HUD and automatic cruise throttles can used to enable the flight control computers to modulate engine thrust and maintain a constant airspeed. The precise timing and navigation required of modern stream raid tactics can be better accomplished in the Hornet.

To better ensure survival in transiting today's electronic battlefield, the Hornet is configured with a state of the art electronic warfare (EW) suite consisiting of: the ALR-67 radar warning receiver, ALQ-126B countermeasures set, and the ALE-39 flare/chaff dispenser. The ALR-67 and ALQ-126B are presently undergoing operational test and evaluation and are scheduled for delivery to deploying Navy units in early 1985. (10) Fleet and FMF units have had no training with this equipment and little will be written on its capabilities until operational testing is complete. The ALE-39 flare/chaff dispenser, however, has been operational for some time and has proven extremely reliable. A programmable system, both flares and chaff can be deployed in either single bursts, or in multiple bursts programmed to defeat a specific threat or cover a known period of exposure (e.g. pop-up delivery).

Once the strike group arrives in the target area, pinpointing the exact target location is a challenge. If the target can be illuminated by a laser designator, the aircraft mounted laser designator tracker (LDT) will receive the reflected laser energy. With this signal, the mission computer will display on the HUD steering cues and a space stabilized aiming diamond over the target. This attack symbology will assist the pilot in either obtaining the target visually or in deploying a smart weapon. Similar attack symbology will be displayed, if the target coordinates have been entered as an INS waypoint and the waypoint has been designated as the target. If the target is radar significant, by using the doppler beam sharpening mode of the radar, the pilot can paint a radar snapshot of the target area and designate the exact point to be attacked. Similarly, the FLIR can paint an infrared snapshot for use in target designation. Using either the FLIR or the radar, once the target is designated, attack symbology will be displayed on the HUD to lead the pilot to the target. The radar and the FLIR are particularly useful in finding and attacking targets at night or in all-weather conditions.

Once the target is located, the Hornet's computer assisted bombing system can be used to assure its destruction. The F/A-18 is an extremely accurate bomber; if you can see it you can kill it. From my experience instructing in the Hornet at VFA-125, an average pilot with prior bombing experience, but no F/A-18 bombing experience, using a 30 degree bombing pattern, normally obtains a circular error probable* (CEP) of 50-60 feet. Normally five sorties are required to tighten the circle from 50-60 feet to 35 feet. After this initial training, my squadron pilots could routinely obtain a 35-50 foot CEP with no refresher training. In comparison, an equally talented F-4 crew, after two weeks of concentrated weapons deployment practice,

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* CEP - an imaginary circle drawn on the ground inside which 50 percent of all bombs dropped have landed.

can generally obtain an average CEP of 150 feet. (3:33) This average CEP will increase over time if continual refresher training is not provided. The F/A-18 squadron can devote the majority of its valuable training time to the ingress, target acquisition, and egress, instead of continually working to maintain minimum standards of accuracy.

The Hornet has a five to seven mil bombing system.* (3:33) A five mil system will put 50 percent of all ordnance delivered from an altitude of 1000 feet, in a five foot diameter circle. In the high threat scenario, when flying close to the ground and distracted by an enemy air threat and anti-aircraft defenses, the Hornet pilot can depend upon his bombing system to deliver five to seven mil accuracy. High speed computers consider all aircraft flight and ordnance delivery parameters and constantly computes the ordnance impact point on the ground. The pilot has merely to fly the constant computed impact (CCIP) cross, displayed on the HUD, over the target and release his ordnance. Unlike pilots, computers are not distracted by the pressures of combat. When the pilot acts as a computer (manual bombing system), he will experience an adverse impact on his

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* A mil is an angular measure, one unit in a thousand. A one mil system is one that would consistently place 50 percent of all bombs dropped at a target, from an altitude of 1000 feet, within a one foot diameter circle on the ground. (3:33)

accuracy as his concentration on the exact delivery window becomes interrupted.

The reliability of the radar and the INS ensures that the pilot seldom has to revert to bombing in a degraded mode (BARO or manual). Air to ground radar ranging (AGR) is always available and the INS seldom becomes so unreliable that a computerized bombing mode cannot be used. Unlike the A-7E, if the system does start to degrade, the F/A-18 pilot does not have to accomplish cumbersome diagnostic checks to determine the nature of the problem, prior to reverting to a backup mode (e.g. BARO ranging). The system in the F/A-18 continually monitors itself and will automatically revert to an alternate mode without any action by the pilot. The Hornet bombing system is easy to manage and use.

The F/A-18 is mechanized for delivery of the following weapons: conventional and laser-guided bombs, rockets, mines, nuclear bombs, walleye glide bombs, AGM-65E Maverick, AGM-88A HARM and M61A1 internal gun. (6:5-9) Not all weapons have been cleared for carriage and release. This has adversely impacted F/A-18 ordnance training. The majority of FMF training to date has been with only practice ordnance or low drag MK-80 series general purpose bombs. High drag bombs (Snakeye) have not been cleared for release because the Snakeye fin retaining band has damaged the aircraft differential stabilator. (14:1) During exercises, pilots have been forced to use a 20 or 30 degree pop-up delivery, instead of the preferred and less vulnerable ten degree to level delivery. A modified Snakeye fin (MK15, MOD5) will be available in early 1985. Slow production rates, however, will require that they be initially reserved for deploying contingency units. A shortage of live, high drag ordnance will impact future ordnance training and will have an adverse affect on combat readiness.

Conduct Close Air Support Operations Within the Capabilities of Assigned Aircraft. (7:37)

Because of its expeditionary nature, the Marine Corps is organized lightly for combat as compared to the U.S. Army. Accordingly, the GCE commander must depend upon Marine Corps aviation to supplement his organic fire support. This is particularly important during the vulnerable period when the landing force is first put ashore. The GCE commander will initially have no organic fire support available. He will have to depend upon close air support and naval gunfire to support his advance. Once established ashore, the GCE commander will continue to depend on close air support to serve as his heavy artillery.

To conduct close air support (CAS) and survive in today's electronic battlefield, the pilot must enter the target area at high speed, low altitude, and attack using a minimum exposure pop-up type delivery. The attacking aircraft must enter the target area through navigational checkpoints that will provide deconfliction with the trajectory of other supporting arms. Timing is extremely important. Supporting arms used to suppress enemy air defenses will be secured for only a minimum time to allow attacking aircraft to ingress, attack, and egress the target. The F/A-18's INS allows the pilot to easily accomplish the precise navigation and timing required for this type of attack.

When bombing close to friendly forces, using a pop-up type delivery, acquiring the target and keeping it in sight is a challenge; hitting it is not. Flight and attack related data displayed on the HUD allow the pilot to concentrate on finding the target during the pop-up climb instead of having to repeatedly go head down to check cockpit instruments. The LDT can additionally be used as an aid in finding the target, if the target can be illuminated by laser energy. Once acquired, the pilot can use the attack symbology displayed on the HUD to accurately deliver his ordnance. He does not have to use cockpit instruments to achieve exact delivery parameters.

The Hornet has repeatedly demonstrated its ability to provide effective CAS during Combined Arms Exercises (CAX) at the Marine Corps Air Ground Combat Center (MCAGCC), 29 Palms, California. During a CAX, a Marine battalion trains in the use of supporting arms, while maneuvering through a modern high threat battlefield. To be a realistic exercise, all combined arms support provided is performed with live ordnance. As commander of an aviation combat element (ACE) for a CAX conducted during March 1984, I had the opportunity to observe the Hornet's performance from the ground and witness the genuine enthusiasm displayed by the Commanding Officer of the First Battalion Fifth Marines and his Marines about the Hornet's performance. One commander stated that: "When it's time to go to war for real, I want the Hornet for support." Another commented: "It is the best supporting arm we have." The Commanding General, MCAGCC, post exercise report further applauded the Hornet's performance: "Deployed for the first time in an expeditionary environment, the responsiveness, timeliness, and accuracy of bombing demonstrated by the F/A-18's were noteworthy." (15:1) I agree with all the ground observers that the F/A-18 is the best close air support aircraft in Naval Aviation today.

Good close air support requires flawless communications. A target brief must be provided to, and acknowledged by the pilot, prior to commencement of an attack. Before a weapon can be released, clearance to drop must be transmitted by a terminal controller best able to ensure the safety of friendly forces. Communication is both a strength and a limitation for the Hornet. Two ARC-182 radios, both with a complete UHF, VHF, FM and AM capability, will provide the F/A-18 pilot with both redundant and flexible communications. However, no anti-jam radio protection is a significant limitation and could preclude the successful accomplishment of close air support on the modern battlefield.

Perform Visual Reconnaissance (7:37)

After an amphibious assault the GCE commander will have little combat intelligence available from organic intelligence sources. His best source of intelligence on activity immediately to his front and deeper, is friendly aircraft.

Visual reconnaissance is a secondary mission of every combat sortie. At the conclusion of each mission, intelligence personnel debrief the pilot on any unusual activites he observed. Of course, excellent visibility will allow the F/A-18 pilot to see more, but the INS will allow him to record the exact coordinates of what he sees. This information can be communicated immediately to controlling agencies as real time targeting information or used after the flight for the intelligence debrief. If tasked with reconnaissance of a specific area the Hornet pilot can be certain that he is, in fact, reconnoitering the correct location.

In addition to visual reconnaissance the F/A-18 has a signficant capability for reconnaissance using its infrared sensor. The FLIR is particularly useful in pinpointing the location of targets during periods of reduced visibility (night, all-weather). It can also be used to find targets hidden by natural or man made camouflage.

Maintain the Capability of Deployment or Extended Operations Employing Aerial Refueling. (7:37)

The F/A-18 has an excellent in flight refueling system that will allow it to deploy anywhere in the world quickly. The retractable refueling probe is located on the right forward fuselage within the pilot's field of view. The pilot can easily see probe to drogue closure all the way to engagement. The Hornet's superb slow speed handling qualities allow the pilot to aerial refuel with ease while in the heaviest configuration and from the slowest tanker.

The pilot can use the INS to facilitate tanker rendezvous by providing the pilot magnetic bearing and range to the aerial refueling control point. The air-to-air radar can be used to find the tanker and conduct a stern intercept to the refueling position. During instrument metereological conditions (IMC), with a radar lock, HUD air-to-air symbology can be used to effect an all-weather tanker rendezvous if required.

During aerial refueling the pilot must ᴀ are of the location of the right angle of attack probe. Because it is below and slightly aft of the refueling probe, the angle of attack probe can become entangled in the drogue and has been known to separate from the aircraft. (See Figure 4)

FIGURE 4. Angle of Attack Probe/Refueling Probe Location (3:55)

This has resulted in the angle of attack probe being ingested into the right intake and causing foreign object damage (FOD) to the right engine. Besides engine damage, the flight control system will degrade because of the lack of accurate angle of attack input to the air data computer. Fortunately only minimal damage has occurred from this problem, but in my opinion, the potential exists for a major aircraft mishap.

Perform Organizational Maintenance on Assigned Aircraft (7:37)

The organizational maintenance concept for the Hornet requires that squadron personnel perform the following functions: launch and recover aircraft, provide all aircraft servicing; fault isolate all aircraft discrepancies to a malfunctioning weapons repairable assembly (WRA, black box, actuator, etc.); remove and replace faulty WRA's; and perform scheduled maintenance. The Hornet is designed with many unique reliability and maintainability features that facilitate this maintenance concept and the expeditionary nature of Marine aviation. After Marine aviation is phased ashore, minimum numbers of personnel, equipment, and spare parts should be forward deployed to support combat operations. The intermediate level maintenance activity (IMA), which contains the bulk of the assets required to maintain the Hornet, can be positioned in a benign environment outside the amphibious objective area.

The most important and effective maintainability feature is the aircraft recording and monitoring system. Recording and monitoring functions are provided by the built-in test (BIT) mechanization (both avionic and non-avionic) in the individual equipment, the software BIT module in the navigation computer (MC1), and by the ASM-612 signal data recording set. The ASM-612 records aircraft fatigue/strain data (G), engine parameters when out of tolerance conditions occur, and aircraft and target parameters when targets are designated and weapons are delivered. (6:1-17) BIT caution and advisory displays are presented to the pilot on the left DDI. In addition, BIT fail indicators are stored in the non-volatile memory of the maintenance monitor panel (MMP) located in the nose wheel well. Merely by pushing on a button, this information can be recalled after a flight and used to locate faults in aircraft systems, including those systems not used by the pilot. The MMP tells what servicing is required for aircraft consumables, such as hydraulic fluid, engine oil, radar coolant and fire extinguishing agent. The monitoring and recording system is extremely reliable; there is a high degree of certainty that the WRA identified as faulty is in fact bad. The maintenance manhours saved by this system in troubleshooting and servicing are considerable.

Unlike the F-4 and the A-7E, the Hornet allows maintenance personnel excellent accessibility to their aircraft. The forward windscreen is hinged for easy removal and access to cockpit instrumentation. The F/A-18 has 268 access doors, of which only 30 require workstands. Fifty three percent of all doors have quick release latches. (3:50) Most highly used access doors are chest high and located on either side of the aircraft fuselage. In most instances, avionic WRA's in these panels can be removed and replaced without tools. The human hand is adequate to lock and unlock screw-type positive lock devices which secure the WRA to the aircraft.

The engines are reliable, FOD resistant, and rarely require maintenance. When maintenance is required, however, engine and aircraft design allow it to be accomplished in a fraction of the time required by other aircraft. An engine change would keep an F-4 in a non-operating status for at least 24 hours (assuming the availability of around the clock maintenance). Four people can change an F/A-18 engine in just 1.5 hours. (3:48) After the engine change, the F-4 engine requires trimming and high powered ground preflight checks; the Hornet engine change requires no such tests. Additionally, unlike the Phantom, there is no peculiar left or right engine for the Hornet; both engines are completely interchangeable. Therefore, the requirement for spare engines is reduced.

A life cycle analysis of the number of maintenance manhours to produce one hour of flight time (MMH/FH) for fleet aircraft is shown below:

	F/A-18	F-4J/s	F-14A	A-6E	A-7E	
MMH/FH	26.0	51.6	60.2	50.9	46.1	(5:28)

The Hornet requires roughly half the maintenance of other fleet aircraft. A similar analysis with U.S. Air Force fighters is shown below.

	F/A-18	F-15	F-16	
MMH/FM	26.0	49.9	35.0	(16:C-58, 59)

The Hornet is clearly the most maintainable aircraft of the three newest fighters listed.

The Hornet's inherent reliability does most to facilitate organizational maintenance. As a Squadron Commander, it was a pleasure coming to work each morning knowing that enough fully mission capable aircraft would be available to complete the daily flight schedule. During 1984, MAG-11 F/A-18 squadrons averaged 43.3 flight hours per aircraft per month. During the same period, MAG-11 Hornets were fully mission capable (FMC) a startling 81.8 percent of the time. (17:1-1D) It is not uncommon for squadrons to have all of the aircraft in an "up" status or to have all their aircraft airborne at the same time. During a recent MCCRES evaluation, one Hornet squadron, during surge operations, flew 80 sorties in a 9.5 hour period. At the end of the period, all 12 airframes were mission capable with the only avionic discrepancies being a "down" radar and a "down" radar altimeter. (18:A-15) Only an extremely reliable aircraft can achieve such performance.

The production F/A-18 (Navy and Marine Corps) currently enjoys reliability that is three times better than other fleet aircraft. A measure of aircraft reliability is mean flight hours between failure (MFHBF). A MFHBF comparison between the F/A-18 and other fleet aircraft is shown below:

	F/A-18	F-4J/s	F-14A	A-6E	A-7E	
MFHBF	2.2	.7	.6	.6	.7	(15:28)

A comparison with the F-15 and F-16 is not available because the U.S. Air Force computes MFHBF only for aircraft subsystems.

Design simplicity contributes to Hornet reliability. For example, the F-404 engine and the APG-65 radar have 8000 and 7700 fewer parts respectively, than the F-4J engine and radar. Obviously fewer parts means fewer failures. Hornet avionic reliability is improved by a deliberate de-rating of the power levels at which these electronic components operate to as low as 50 percent of their designed power levels. Avionic components that operate at lower power last longer. (3:50)

I personally can attest to Hornet reliability after flying 600 hours in the aircraft. I have never had a radio, tacan, generator, mission computer, hydraulic, engine, gun or weapons release failure. I can only recall a few occasions when my radar failed during a flight. I only had half a dozen ground or airborne aborts.

The largest consumer of manhours in maintaining the Hornet is the fuel system. To increase aircraft survivability, much of the fuel system plumbing is located inside the fuel cells. This resulted in an extremely complex fuel system design. The fuel system is hard to troubleshoot and repair. For example, the number four fuel cell has over 100 penetrations where fuel lines enter and exit the cell. To perform maintenance in this cell, or remove and replace it, is an extremely difficult task.

Maintain the Capability of Deploying and Operating From Aboard Carriers, Advanced Bases, and Expeditionary Airfields (7:37)

The expeditionary nature of Marine Aviation requires that squadrons be capable of operating from a variety of operating bases: aircraft carriers, expeditionary airfields, and advance bases. Therefore, deployability is an important consideration when procuring Marine Aircraft. Deployability, as used in the context of this paper, is the ability during a crisis to deploy to any location and begin operating immediately. Fixed wing elements of the ACE must be able to deploy quickly to support the GCE, which may already be afloat in the objective area as part of an amphibious task force. Because of limited airlift and sealift assets, this may require a squadron commander to operate for a period of time with minimal personnel, equipment, and spare parts. The Hornet has the ability to deploy quicker, and operate longer with less than any other aircraft in the fleet today. It can deploy to any trouble spot in the world using aerial refueling. Upon arrival, minimum ground support equipment is required to begin combat operations. The APU and battery are not only used for engine start, but to power aircraft systems for maintenance troubleshooting. Because of low maintenance manhours per flight hour, fewer maintenance personnel are required to support initial operations. Inherent aircraft reliability allows a squadron to operate with fewer spares and less support equipment. Obviously, if the mean time between failure (MTBF) on the radar is 32 hours (F/A-18), that system can be sustained with fewer assets, than if the MTBF is one hour (F-4).

MAG-11 squadrons routinely deploy, and conduct high tempo operations for a two or three week period, using a small maintenance detachment, a supply packup, and minimal support equipment. The assets required to support these deployments are considerably less than those required to support a similar F-4 deployment.

During 1985, two MAG 11 F/A-18 squadrons will deploy aboard the aircraft carrier U.S.S. Coral Sea. (1:10) The Hornet is highly suitable for carrier operations in several ways. The addition of an APU and built-in-ladder requires less ground support equipment on an already crowded carrier deck. Aerodynamically the aircraft "flies itself" off the carrier deck. Because of the sensitivity of the flight controls, Hornet pilots do not touch the control stick until about 4-5 seconds after catapult launch. The flight control system automatically flies the aircraft to a 12 degree nose high altitude off the catapult. (See Figure 5). In contrast, the F-4 is not a forgiving aircraft off the catapult. Many Phantoms have been lost because of overrotation. The Hornet's superb slow speed handling qualities makes it a very comfortable aircraft to land aboard a carrier. Having all flight related data displayed on the HUD allows the pilot to stay heads up throughout the approach to landing. Therefore, he has more time to concentrate on the carrier optical landing system and aircraft to carrier lineup. A reliable instrument landing system (needles for azimuth and glide slope corrections) and automatic throttles can be used by the pilot to assist during his landing. All of these qualities add up to a safe aircraft around the "ship."

During MAG-11's first F/A-18 day and night carrier qualification detachment, Marine first tour pilots had a

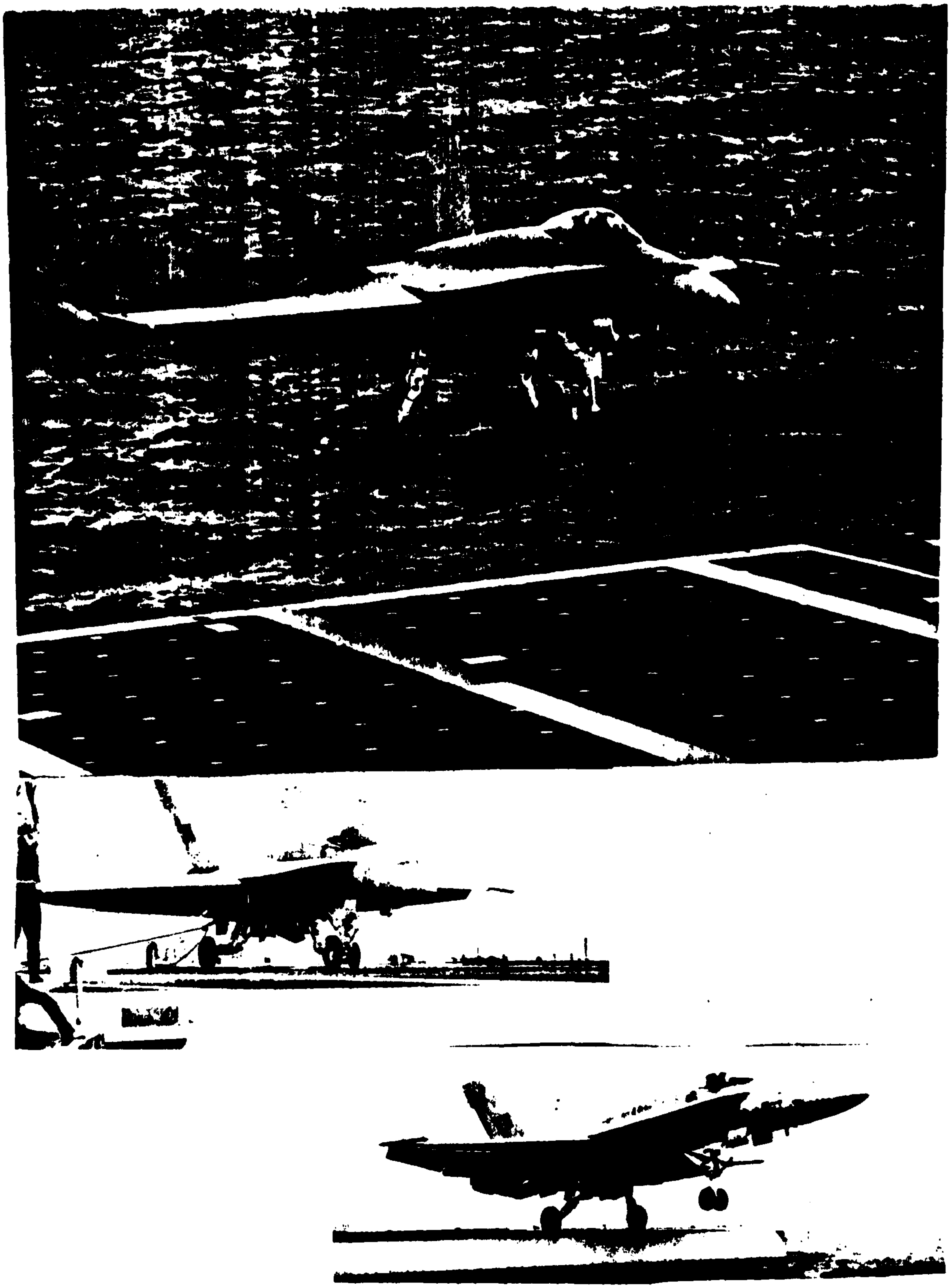

FIGURE 5. Hornet Carrier Operations (3:30)

boarding rate* of 94 percent day and 83 percent night. (19:2) These pilots had never night qualified in any aircraft prior to this detachment. More experienced Navy carrier pilots are achieving boarding rates of 97 percent day and 95.3 percent night. These percentages are approximately 3.5 percent higher than all other type aircraft in the carrier air wing. (20:B-3)

MAG-11 first deployed to the expeditionary airfield at 29 Palms, California in March 1984 as part of an Aviation Combat Element (ACE) for a Combined Arms Exercise (CAX). As Commanding Officer of this element, I gained a firsthand appreciation for the Hornet's capabilities. Superior afterburner thrust to weight performance, slow approach/landing speeds, massive landing gear, large tires and an excellent antiskid brake system, allow the Hornet to operate safely from a 4000 foot runway. When operating from a crowded expeditionary parking apron, which may be shared with helicopters and AV-8 Harriers, foreign object damage (FOD) to jet engines is an extreme hazard. The F/A-18 engines produce minimal intake suction at low power settings, making it a FOD resistant aircraft. In fact, upward canted engines and low idle thrust prevent the Hornet from creating a foreign object problem. The wingfold

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* Percentage of approaches to landing that terminate with an arrested landing (trap).

system allows for tighter parking and the self start capability means less ground support equipment on crowded parking aprons.

While deployed in the demanding expeditionary environment at MCAGCC, the Hornet flew 199 sorties without incident. Many of these sorties were flown at the maximum landing and takeoff crosswind conditions which were exacerbated by blowing dust, sand, and rocks. The F/A-18 proved extremely capable, able to operate in adverse conditions from an austere airfield.

I have completed my analysis of how the F/A-18 performs the tasks assigned to Marine Corps fighter/attack aviation. Modern technology has produced an aircraft that allows one pilot to become proficient in performing all the assigned fighter/attack tasks. But can it perform these tasks safely? I will now turn to the Hornet's safety record, a most important aspect of mission performance.

CHAPTER IV

SAFETY/SURVIVABILITY

An aircraft, even though extremely capable in performing all its assigned tasks, if not safe to fly, has little value. If aircraft are continually lost during routine training, the losses during the increased tempo of combat will certainly be unacceptable. Although not a "stated" task for Marine Corps fighter/attack aviation, safety and survivability is a requirement for any U.S. aircraft. During the first two years of operational flying, the F/A-18 has proven itself an extremely safe aircraft, possibly the safest U.S. fighter introduced to date. A safety comparison of the first two years of operational flying and 1984 for the F/A-18, F-14A, F-15, and F-16, is shown in Figure 6. The chart depicts by aircraft, a yearly accumulation of aircraft mishaps, mishap rates*, and the number of hours flown. These statistics clearly show that the F/A-18 introduction was the safest in recent experience. As with other aircraft the Hornet's mishap rate will continue to improve with time. During 1984, MAG-11 flew 23,932 hours in the Hornet with a zero mishap rate, a very noteworthy achievement. (23)

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* The number of major aircraft mishaps in each 100,000 flying hours for each type aircraft. (21)

FIRST OPERATIONAL YEAR

	F/A-18 1983	F-14A 1976	F-15 1976	F-16 1979
Mishaps	2	7	0	2
Mishap Rate	7.90	18.53	0	30.6
Hours Flown	25,326	37,768	17,803	6,527

SECOND OPERATIONAL YEAR

	F/A-18 1984	F-14A 1977	F-15 1977	F-16 1980
Mishap	1	11	6	5
Mishap Rate	2.01	22.73	14.1	18.6
Hours Flown	49,728	48,390	42,369	26,803

1984

	F/A-18	F-14A	F-15	F-16
Mishap	1	4	3	10
Mishap Rate	2.01	3.61	1.7	5.0
Hours Flown	49,728	110,000	173,530	198,876

FIGURE 6. SAFETY STATISTICS (21,22)

Many Hornet survivability features have already justified their extra cost. Redundancy is designed into every flight critical system. With a single failure, a second system is available to carry the load. Two engines provide not only a redundant power plant, but a redundant electrical, hydraulic, and fuel transfer system. The flight control system has two flight control computers and four channel redundancy. A mechanically driven differential stabilator (capable of providing pitch and roll) is available in the event of a complete electrical failure. Although all systems are extremely reliable and rarely fail, redundancy has prevented minor incidents from becoming major accidents.

The Hornet fuel system was designed for survivability. No fuel above the engines, and a fire wall between the engines and the fuel tanks, have greatly reduced the potential danger of fuel leaks or engine cavity fires. The majority of fuel system plumbing is contained within the fuel cells. In the event of a plumbing leak, fuel will leak into the fuel cell instead of the aircraft. On several occasions fuel transfer manifolds have ruptured. The only indication to the pilot was a center of gravity shift. Had this manifold been external to the cell, these aircraft could have been lost due to fuel starvation or fire. Self sealing fuel tanks and fuel feed lines, and wing tank foam for explosion suppression, are provided to reduce battle damage.

The Hornet incorporates an engine fire extinguishing system. In the event of an engine fire, the pilot can secure fuel to the affected engine at the engine fire wall. The pilot can then discharge an extinguishing agent into the engine cavity. This system can be credited with saving two MAG-11 aircraft.

The aircraft monitoring and recording system has been effective in identifying potential system failures.

For example, many hydraulic actuators have been replaced before failure. Subsequent inspections of these actuators revealed defects which would have caused failure within a few flights. Out of tolerence engine conditions, which normally would go unnoticed by the pilot, are now recorded in the ASM 612 signal data recorder set. The cause of these conditions will now be immediately corrected, therefore extending engine life.

Modern technology has indeed made the Hornet a safe survivable aircraft. The safety record it now enjoys (established during the most vulnerable period in the life cylcle of an aircraft) is better than the overall 1984 Department of the Navy aviation safety record. (24)

CHAPTER V

SUMMARY

The tasks assigned to Marine Corps fighter/attack aviation in effect define an operational requirement for a "Strike Fighter"; an aircraft that with little change in configuration and ordnance load can be a bomber or a fighter. A review of the Hornet's performance and capabilities clearly shows that the F/A-18 can support the landing force throughout the assault, landing, and subsequent operations. The F/A-18 meets the requirements of Marine Corps fighter/attack aviation for the remainder of this century.

In time of crisis, the Marine Corps can deploy the Hornet anywhere in the world. Because of its versatility the Hornet will operate equally well whether deployed to an advance base, an expeditionary airfield or onboard an aircraft carrier. This reliable, maintainable and supportable aircraft, can deploy longer with less, than any of its contemporaries.

Once deployed, a commander has the flexibility to configure his Hornets to meet the threat. If tasked with providing air superiority, the Hornet is superb. In the intercept role, the extremely reliable air to air radar is mechanized so as to make the most difficult intercept as easy as a formation rendezvous. The pilot can choose a radar mode and an air-to-air weapon that best meets the tactical situation.

As a fighter, the Hornet's performance compares to other state of the art aircraft. Below 300 knots the Hornet is the finest fighter in the world today. A spin resistant aircraft with stall free engine, the Hornet pilot can maneuver with confidence to the edges of the performance envelope. Excellent visibility, small airborne silhouette, and smokeless engines, allow the pilot to see, but not be seen. The efficient radar ACM autoacquisition modes allow the pilot to interface with the Hornet's weapon system even when heavily task loaded. All aspect missiles and an air-to-air gun allow the pilot to achieve a kill from all quadrants and all ranges.

If tasked to destroy a ground target, the Hornet is superb. It has the range, speed, and electronic warfare suite available to penetrate the modern electronic battlefield. It's inertial navigation system can ensure the precise navigation and timing required of today's modern stream raid tactics. Once in the target area, Hornet sensors can assist the pilot in pinpointing the target and the five to seven mil bombing system will assure its destruction. In this mission the Hornet is a true force multiplier. It can go to the target unescorted, engage hostile air, and destroy the target without assistance from any other type of aircraft.

If a strike group requires fighter escort, the Hornet's weapon system will allow the pilot to maintain the situational awareness required to make difficult tactical decisions required of this mission. All aspect air-to-air missiles provide the capability to protect the strike group without having to leave the escort position.

When tasked with providing close air support (CAS) the Hornet is again superb. The INS will provide the precise navigation and timing required in high threat CAS. The extremely accurate bombing system will ensure excellent support for friendly forces, and allow the pilot to bomb with confidence close to friendly positions.

For the first time in Marine Corps aviation, a pilot will be able to become proficient in all the tasks assigned to fighter/attack aviation. A Hornet pilot is not more talented than other Marine Corps fighter/attack pilots. Instead, he flies an aircraft that was designed to perform the fighter/attack mission, not forced to perform a mission for which it was not designed. It is the right aircraft for the Marine Corps.

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