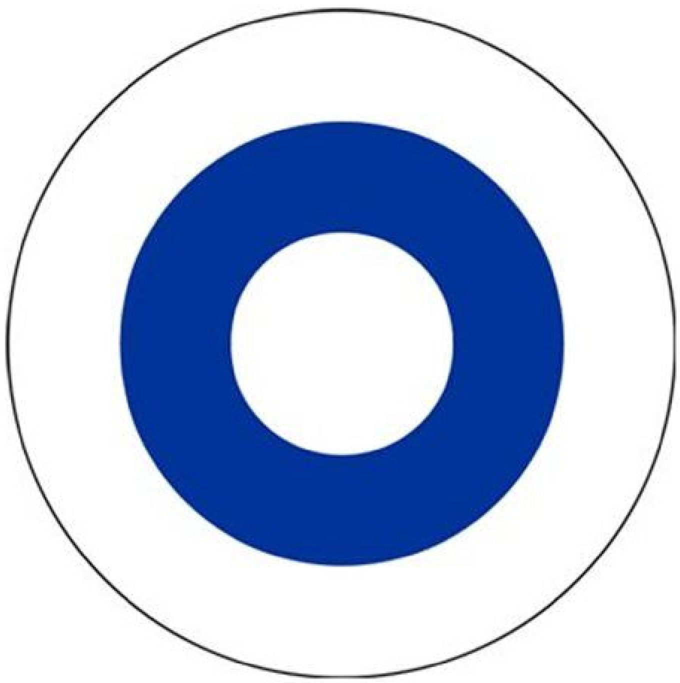
THE

HORNET

IN

FINLAND



BY NICK ZEDLAR

THE HORNET IN FINLAND

Section 1: History and Background

A. Prototype to Production

1) Early Development and Competition

The story of the Hornet starts with its predecessors, for it is a derivative of two other aircraft. The first, the Northrop P-530 Cobra—with roots in the N-156 design—was already on the drawing board in 1966 and regarded as a potential successor to the popular F-5 family of low-cost lightweight fighters (LWF). This “grandfather” of the F/A-18, a twin-engine multi-mission fighter designed for the export market, was never built in this form.

In 1971, the USAF requested proposals for an LWF prototype program for its Tactical Air Command. Northrop responded with its Cobra-derived design. One of two victors in the first-round cut in the Air Force competition, Northrop won a contract in April, 1972 for two YF-17 prototypes powered by dual GE YJ101 engines. The other winner, General Dynamics, contracted for two single-engine YF-16s.

The YF-17, the “father” of today's Hornets, flew for the first time in June 1974. Promising flight test results of these YF-17 and YF-16 archetypes convinced then-Defense Secretary James Schlesinger to proceed with the Air Combat Fighter (ACF) Program, despite upper echelon Air Force resistance. This move circumvented the original LWF schedule, which called for a year of non-competitive trials. ACF would last but six months.

About this time, the Navy and Marine Corps embarked on VFAX (Carrier-borne Fighter/Attack Experimental Airplane), their own R&D/procurement program designed to find a replacement strike-fighter for the F-4 Phantom II, A-7 Corsair II and A-4 Skyhawk. Interest in a low-cost alternative to the troubled and expensive Grumman F-14 Tomcat (which, it was readily apparent, would not be purchased in the quantity originally envisioned) was also a key consideration.

The USN requested proposals from six companies. Among the responses, Grumman proposed the F-14X, a stripped version of the Tomcat to meet the VFAX requirement. However, this was summarily rejected by the Deputy Defense Secretary. Other discarded suggestions included a navalized F-15 and an improved F-4.

On May 10, 1974 the House Armed Services Committee also renounced the F-14X and dictated that VFAX focus on a completely new aircraft. Apparently having forgotten the F-111 debacle, the Committee wanted the Air Force and the Navy to purchase essentially the same plane as a cost-cutting measure. This meant cooperating with the USAF and its ACF project. Congress directed the Navy to pattern VFAX on either the YF-16 or YF-17, essentially calling for a navalized LWF/ACF. However, in contrast to the USAF, the USN clearly desired a single air-to-air and air-to-ground-capable platform. While politicians wrangled over the details, R&D surged ahead. Only weeks after the F-14X proposal went down in flames, the first YF-17 took off on its maiden flight.

Yet in another procurement shell-game maneuver, Congress decided by August 1974 to cancel VFAX on budgetary grounds and divert its funds into a new program called the Navy Air Combat Fighter (NACF). Despite lingering staunch F-14 support by naval aviators who saw no merit in either VFAX or NACF, the USN announced the following month that it would select a single contractor to begin NACF engineering development. The winner of this competition would reap an order for some 800 aircraft.

Meanwhile, Northrop's hopes for the ACF contract dissipated in the final round of the USAF competition. On January 13, 1975, Air Force Secretary John McLucas announced that the YF-16 had been chosen due to its slight speed advantage and by virtue of what was considered the more reliable F100 engine (already operating with the F-15, but twice as costly as the YJ101). Despite some initial inherent instabilities associated with the YF-16 airframe, the Tactical Air Command chose to fly and fight in them. Northrop had lost.

Undeterred, however, the company realized that it still had a shot at the “back-up” NACF contest. To this end, Northrop vigorously touted the twin-engine format and growth potential of the YF-17 to its naval audience. It maintained that its aircraft was an especially well-suited air combat attack-fighter for the Navy's carrier air wings. To develop a navalized YF-17, Northrop decided to team up with McDonnell. There was good reason for this collaboration, for McDonnell had extensive experience with Navy fighter design and USN contacts, both of which Northrop lacked.

On the YF-16 side, General Dynamics paired with Ling-Temco-Vought (also located in Dallas/Fort Worth) for the same reasons. If both the Air Force and the Navy picked the YF16, General Dynamics would be the prime USAF contractor and L-T-V the prime USN contractor. However, in political retrospect, since both of these contractors were located in the same state, there was little likelihood of receiving a contract. This team entered Models 1600, 1601 and 1602.

Northrop's navalized YF-17, called P-630, was to have BVR radar, which was not part of the original planning for the USAF F-16. To meet Navy requirements, considerable improvements in combat radius, radar capability and carrier suitability were incorporated. The resulting redesign was extensive. These features, joined with developments from McDonnell's NACF experience, produced Model 267.

On May 2, 1975, the Navy announced that it had opted for the Northrop/McDonnell proposal, particularly because of its twin-engine format, superior suitability to maritime operations and more promising multi-mission capability. The aircraft was re-designated F18A and its augmented YJ101 engines dubbed F404s. According to the original procurement plan, the Northrop/McDonnell aircraft would focus on three closely related models:

- the F-18 single-seat fighter would replace the USN and USMC's F-4 Phantom II;
- the A-18 single-seat striker would replace the USN's A-7 Corsair II and the USMC's A-6 Intruder; and
- the tandem-seater TF-18 would serve as combat trainer.

The F-18 and the TFA-18 were to share the same basic airframe and engine arrangement, but differ in stores attachments and avionics. The TF-18A was to retain the full mission capability and armament suite of the F-18A but was to have slightly reduced fuel capacity. On March 1, 1977, Secretary of the Navy W. Graham Claytor announced that the F-18 would be called “Hornet”.

Under the terms of the agreement worked out between the two corporations, McDonnell would market the aircraft to the Navy, while Northrop, as prime subcontractor, would secure rights to market a land-based version to various foreign air forces.

2) The Doomed F-18L

While the carrier-based F-18A Hornet design got underway, a land-based version known as the F-18L was also planned. Since it did not have to carry any equipment for carrier-based operations, the F-18L was expected to be significantly lighter and better-performing than its carrier-borne brother. It was to have lighter landing gear and would scrap the wing-folding mechanism. Although, as yet, there were no orders, Northrop anticipated a flood of interest from foreign air forces wishing to purchase a more capable aircraft than the F-5 (for example, Iran expressed interest in purchasing 250 such aircraft in 1976, though this deal ultimately did not materialize).

However, major disagreements soon arose over sales. It seemed that whenever potential customers would express interest, McDonnell would often mount an active sales effort and put the McDonnell F-18A in direct competition with the Northrop F-18L! As a result, Northrop roused little buyer enthusiasm in the F-18L, whereas, despite its “liability” of 7,700lbs (3,500 kg) of extra weight, the F-18A excelled. In retrospect, this is often attributed to the trend that few foreign military sales (FMS) successes include aircraft with no history of demonstrated U.S. military service. There have been some exceptions to this rule, but not many. Perhaps the most notable deviation was the Northrop F-5 LWF series, which sold over 2,700 aircraft to 30 countries. Evidently, Northrop was optimistic about duplicating itsF-5 triumph with the F-18L.

Northrop management, angered by what it perceived to be consistent violations of the agreement terms by McDonnell, launched a series of lawsuits in October 1979, claiming that McDonnell was unfairly using F-18L technology to sell its own F-18A abroad. Northrop alleged that McDonnell was sabotaging a potential Israeli deal by placing its version in direct competition. Northrop asked the courts to restrain McDonnell from selling to a foreign government any F-18 version implementing Northrop technology at Northrop's expense. The case languished in the courts for years and was not settled until April 1985. At that time, it was agreed that McDonnell would be prime contractor for all existing and future versions of the Hornet.

As part of a later McDonnell-Northrop agreement, it was decided that fabrication of the baseline F-18 would be split roughly 60/40 between them respectively. In the event of orders being received for the F-18L, these proportions would be reversed. Northrop was to build the center and aft fuselage sections of the F-18 as well as both vertical fins. These major sub-assemblies were to be shipped to McDonnell at St. Louis, Missouri and joined with the McDonnell contribution, consisting of the wings, horizontal tail and forward fuselage, including the cockpit.

Northrop ultimately terminated all work on the F-18L. This move permanently relegated the bones of a land-based Hornet variant to the graveyard of cancelled aircraft. Even so, Northrop's labor hadn't been totally in vain. Despite the demise of F-18L scheme, careful redesign of the original F-18 made possible the merging of the two single-seat fighter and attack versions. This aircraft was initially referred to as “F/A-18A” in DoD press releases, though the designation did not become official until April 1984. At this time, the combat capable tandem trainer was redesignated TF/A-18A (later F/A-18B).

Creating a single multi-role aircraft centered on the two stores pylons (Stations 4 and 6) located on the lower corners of the air intakes. In the fighter role, these pylons would carry AIM-7 Sparrow air-to-air missiles. In the attack role, they would carry a port side-mounted forward-looking infrared (FLIR) scanner and a starboard-mounted laser spot tracker (LST).

In anticipation of the appearance of the F-18, the second YF-17 was turned over the Navy for test duties with the Pacific Missile Test Center at Point Mugu, California, the Naval Air Test Center (NATC) at Patuxent River, Maryland and the Naval Weapons Center (NWC) at China Lake, California.

3) Full-Scale Development and Production

The F-18 program went ahead with the award of letter contracts in November of 1975 to General Electric for the development of the F404 turbofans and on January 22, 1976 to McDonnell for nine single-seat and two dual-seat full-scale development (FSD) aircraft. On September 13, 1978, the first FSD F-18A (BuNo 160775) rolled out in St. Louis. Piloted by test aviator Jack E. Krings, the F-18 prototype's official maiden flight took place in St. Louis, not far behind schedule, on November 18, 1978.

Beginning in January 1979, most flight development took place at the Naval Air Test Center, Patuxent River, Maryland. Nine F-18A and two TF-18A two-seat FSD aircraft (Bu Nos 160781 and 160784) entered an intense flight test program. During this period, Navy pilots commented favorably on the aircraft's stability, particularly during landing approaches. Carrier qualifications began with the third FSD aircraft (BuNo 160777) aboard the USS AMERICA (CV-66) on October 30, 1979. These tests went extremely well.

At this time (1979-81) costs started to rise and Congress began to exhibit some concern. The Navy/Marine Corps order was now up from the original figure of 780 to 1,366 aircraft (this was later reduced to 1,157). The Hornet, having originated from a supposedly low-cost project (a cheaper alternative to the F-14 and A-6), ultimately emerged as more expensive than the Tomcat. Also, instead of a light-weight fighter, the USN/USMC was getting a “middle-weight fighter-bomber.”

Nonetheless, thanks in part to President Ronald Reagan's resurrection of the F-18 project with his infusion of defense funding, the first production aircraft in the series (an A model) undertook its maiden flight in April 1980. Production was delineated into Lot numbers, each subdivided into three Blocks. The number of aircraft per block varied but peaked at 33.

There were 371 production Hornet-As in Blocks 4 through 22 and 39 production F/A-18Bs in Blocks 4 to 21. Initially designated TF/A-18As, they were essentially intended as trainers, but, as mentioned, retained full combat capability. It's been said that the Hornet-A/B has the ignominious distinction as the shortest-lived U.S. carrier aircraft of all time (from 1983 to 1994) and that the C/D model is responsible for saving it. C/D-models emerged as a result of a 1987 block upgrade, which incorporated provisions for employing updated missiles and jamming devices against enemy ordnance. Such aircraft delivered since 1989 also include improved night attack capabilities.

The F/A-18C prototype flew in September 1986, with the first in the series (BuNo 163427) flown on September 3, 1987. The C-model (introduced with Block 23) is the current production model of the original single-seat Hornet, now sold exclusively to foreign air forces. Other than the appearance of different antenna fairings, the differences between the F/A-18A and C were entirely internal.

The F/A-18C featured a Martin-Baker NACES (Navy Aircrew Common Ejection Seat), an improved mission and stores management computer, an ALQ-165 airborne self-protection jammer and a flight incident recording and monitoring system. “Charlie” Hornets, with their updated APG-65s, could now employee the AIM-120 AMRAAM air-to-air missile and imaging infrared (IIR) AGM-65F Maverick air-to-surface missile. Read more about the cockpit and electronics or about problems with the ejection seat.

Partly in anticipation of the Hornet-C/Ds impending Fleet arrival, Naval Air Reserve squadrons began integrating Hornet-A/Bs in September 1985. The first of these was VFA-303 “Golden Hawks” (ND), based at NAS Lemoore, California. A year later, the first F/A18C was delivered to the Naval Weapons Center at China Lake. Active squadrons would not transition to F/A-18Cs until 1989, however, the first being VFA-25 “Fist of the Fleet” (NK)and VFA-113 “Stingers” (NK).

Hornet-Ds were introduced to the USMC in October 1989, when the Marine Corps replaced its 108 OA-4M, RF-4B Phantoms and A-6E Intruder aircraft. Whereas virtually all the 40 B models produced have been used for training purposes, the USMC's F/A-18D is a true combat aircraft (as demonstrated, for example, in the FAC role in Desert Storm). Today,72 D-models, are deployed to six active squadrons.

On May 15, 1987, the 500th Hornet entered service with VMFA-145 at MCAS Beaufort, South Carolina. Almost five years later (April 22, 1992), USMC squadron VMFA(AW)-242 “Bats” (DT) at MCAS El Toro received the 1,000th Hornet (F/A-18D BuNo 164237)

4. Hornets in USN And USMC Service

1) Hornets Join the Fleet

Before carrier qualifications got under way, the Navy decided to forego distinct attack and fighter versions of the Hornet. The aircraft was deemed sturdy and versatile enough to carry out both tasks. Plans for separate F-18s in fighter (VF) squadrons and A-18s in attack(VA) squadrons were abandoned. The Navy introduced a new type of unit, the strike-fighter squadron (VFA), to carry out both fighter and attack missions. It was to be the USN equivalent of the Marine VMFA squadron.

The first production F/A-18 was delivered to the Navy in May 1980. It had NAVY painted on one side and MARINES on the other, indicating that both services would be flying the aircraft. The Hornet was first issued to training and fleet replacement squadrons (FRS), starting with VFA-125 “Rough Riders” (NJ) commissioned as a FRS at NAS Lemoore, California on November 13, 1980. The first Hornets joined this squadron three months later.

VFA-125 initially provided conversion training for pilots transitioning from Marine VMFA squadrons and from Navy VA and VF squadrons. Later, VFA-125 concentrated on training new pilots with no fleet experience. In this role, they were later joined by an Atlantic Fleet FRS, VFA-106 “Gladiators” (AD) based at NAS Cecil Field, Florida and by a Marine Training Squadron, VMFAT-101 “Sharpshooters” (SH) at MCAS El Toro, California. These three replacement training units train pilots from both the Marine Corps and the Navy.

The USMC beat the Navy in breaking the Hornet into active service. The first operational units to convert to the Hornet were VMFA-314 “Black Knights” (VW) and VMFA-323 “Death Rattlers” (WS), both based at El Toro, California, in January and March 1983 respectively.

Onboard for the USS CORAL SEA's 1983 Mediterranean cruise, they saw action against Libya (described in detail below).

The Marines were pleased with their F-4 Phantom replacements. During the early days of Marine Corps service, a VFMA-314 Hornet pilot got into an air-to-air furball with a MiG-23 operated by the USAF 4470 Test Group at Tonopah, Nevada, and supposedly “waxed the MiG all over the sky”.

The Navy received its first operational Hornets later the same year. USN squadronsVA-113 (redesignated VFA-113 “Stingers” (NK)) and VA-25 (redesignated VFA-25 “Fist of the Fleet” (NK)) at NAS Lemoore converted from A-7Es to Hornets that fall. The first operational cruise by Navy Hornet squadrons were western Pacific and Indian Ocean deployments with VFA-25 and VFA-113 aboard the USS CONSTELLATION (CV-64) in February-August 1985.

These cruises established the Hornet as an extremely reliable aircraft, requiring much less maintenance than the F-14A and the A-6E. See also this paper’s comparison of combat aircraft. Mission capable rates were 89 percent. USN squadrons VFA-131 “Wildcats” (AG)and VFA-132 “Privateers” (AE) and USMC squadrons VMFA-314 and VMFA-323 made up the next Hornet cruise as part of CVW-13 aboard the USS CORAL SEA (CV-43). This would prove to be a truly non-routine deployment to the Atlantic and the Mediterranean.

2) The Hornet's First Sting: Libya

As fate would have it, in 1986 the United States government increasingly came to associate Libya’s Colonel Khaddafi with European anti-US terrorist activity. In addition, Khaddafi claimed the Gulf of Sidra as Libyan territorial waters. He declared a “Line of Death” at the mouth of the gulf and denied international maritime traffic entrance.

President Ronald Reagan demonstrated American resolve to operate freely in what it saw as international waters. In response to Khaddafi's ultimatum, Reagan ordered the Sixth Fleet to begin “Freedom of Navigation” maneuvers in the Gulf of Sidra. Consequently, F/A-18As with squadrons VFA-131/132 and VMFA-314/323 onboard USS CORAL SEA (CV-43) flew CAP missions to protect the CBG from Libyan aircraft. They were frequently called upon to intercept and challenge numerous MiG-23s, MiG-25s, Su-22s and Mirages sent out to harass the fleet. The Hornets often flew prepared to fire only a few feet from their adversaries.

Following the terrorist bombing in a Berlin disco that was traced to Khaddafi, Operation Prairie Fire (March 24-April 15) saw Sixth Fleet Hornets fly several ship-to-shore air strikes against Libyan shore installations. During this action, the Hornets attacked the SA-5 missile site at Sirte which had been radar-painting U.S. aircraft. This was the official battle debut for the Hornet and incidentally marked the first combat firing of the AGM-88A HARM anti-radiation missile. The Hornets attacked the SAM sites in bad weather and at wavetop heights. See photo of four-HARM load.

All Hornets returned to their carriers without mishap. On April 15, 1986, Operation Eldorado Canyon was staged, which was a combined USAF/Navy attack on targets in and around Tripoli and Benghazi. The Hornets teamed up with A-7E Corsairs from other carriers to HARM-strike Libyan SAM sites. Numerous SA-2 missiles were fired at, but missed, these F/A-18s. Again, the Hornets acquitted themselves without incident.

3) Other Operational Notes

F/A-18 Hornets are currently operating in 37 tactical squadrons from air stations worldwide and from 10 aircraft carriers. Some noteworthy high-profile Hornet missions have occupied the spotlight in recent years. F/A-18s supported NATO operations over Bosnia Herzegovina. These were 18 Navy Hornet-Cs (off the aircraft carrier USS AMERICA) and 18 USMC Hornet-As (VMFA-251 “Thunderbolts” (DW)) and Hornet-Ds (VMFA(AW)-533 “Hawks” (ED) 8 and VMFA(AW)-224), 12 Hornet-Ds and eight Spanish EF-18As from Aviano Air Base, Italy.

Following the Gulf War, as part of Operation Southern Watch in January 1993, VFA-27“Chargers” (NL) and VFA-97 “Warhawks” (NL), both Hornet-A squadrons aboard the USS KITTY HAWK (CV-63), delivered HARMs and bombs against Iraqi targets in support of the United Nations no-fly zone over southern Iraq.

Seventeen F/A-18s served at the “Top Gun” U.S. Navy Fighter Weapons School at Miramar. They were typically flown by instructors as “enemy bandits”. VFC-13 demonstrated the blue-gray Su-27 Flanker paint scheme and VFC-13 the Middle Eastern desert brown MiG-29 Fulcrum camouflage paint schemes, complete with red stars (during the Soviet period). These sported paint tricks to simulate vents, large annular intakes and clipped vertical tails [see left].

Elsewhere, eight F/A-18As and one F/A-18B replaced the F-104 Starfighters at NASA’s Ames-Dryden Flight Research Facility for chase and proficiency flying. NASA has also used its Hornets for a variety of research projects, most focusing on high alpha issues. Read more on Hornets at NASA or view a picture of the Hornet-A known as NASA 840.

Hornets are also flown by the U.S. Navy's Blue Angels Flight Demonstration Squadron. The team converted from Douglas A-4Fs to F/A-18As in the winter of 1986. The team operates nine Hornets, one of which is a two-seater F/A-18B, with two in reserve. The single seat aircraft are early F/A-18As which are no longer considered capable of carrier operation. They sport a new flight-control system software optimized for aerobatics. The gun is removed and new seat harnesses are fitted to help the pilot handle the weightlessness of some maneuvers. In addition, civilian ILS and navigation equipment is installed, as well as a smoke-generation system fitted for use during aerial displays.

4) Consolidation

Due to the decommissioning of NAS Cecil Field (Jacksonville, Florida) by the 1995 Base Realignment and Closure Commission, the Navy's East Coast F/A-18 squadrons will relocate to NAS, Virginia Beach (Virginia Beach, Virginia) and MCAS, Beaufort (Beaufort, South Carolina). This move, encompassing eleven fleet squadrons and the fleet replacement squadron (FRS) will begin in the fall of 1998 and last until late 1999. NAS Oceana will receive nine operational squadrons and the FRS, totaling 156 aircraft. The remaining two squadrons (24 Hornets) will transfer to NAS Beaufort. The U.S. Navy announced these plans on May 18, 1998.

9C. Operation Desert Storm

1) Prelude to War

In August 1990, Iraqi dictator Saddam Hussein invaded and annexed neighboring Kuwait, threatening Middle Eastern peace and oil. Hussein defied UN resolutions demanding his unconditional withdrawal by January 15, 1991. Within 24 hours of the deadline, Iraqi occupying forces were assaulted by massed Coalition military assets 500,000 combatants strong. This U.S.-led offensive to drive Iraqi forces out of Kuwait was known as Operation Desert Storm. It began with a vast air campaign, in which Coalition forces quickly established air superiority, crippled Iraq's C3I and mercilessly pounded enemy troops, armor and positions in the field. Literally from Day One, F/A-18 Hornets played a major role in making it happen.

2) The Air War

Operation Desert Storm, due to the sheer scale of the air war, was the operational proving ground for America's air arsenal, including the F/A-18. Air Force commanding general McPeak estimated some 88,500 tons of bombs were delivered in over 109,000 sorties flown by a total of 2,800 fixed-wing aircraft. Of these sorties, the U.S. Air Force accounted for over half (some 1,300 aircraft), the U.S. Navy 16 percent (with its six aircraft carriers and some 400 aircraft) and the U.S. Marine Corps nine percent (some 240 aircraft). The remaining aircraft were contributed by various non-U.S. Coalition forces.

Just over half of sorties were actual bombing raids, while the remainder involved refueling, bomber escort, surveillance and so forth. Of the actual bombing missions, about 20,000 sorties were flown against a select list of 300 strategic targets in Iraq and Kuwait. Of these, 5,000 were directed against SCUD missile launchers. Some 30,000 - 50,000 sorties were directed against Iraqi forces in southern Iraq and Kuwait.

In all, more than 3,000 bombs (including sea-launched cruise missiles) were dropped on metropolitan Baghdad. The total number of bombs dropped by allied forces in the war comes to about 250,000. Of these only 22,000 were so-called “smart bombs”, or guided bombs. About 10,000 of these were laser-guided bombs (LGB) and about 10,000 were guided anti-tank bombs. The remaining 2,000 were radiation-guided munitions fired against communications and radar installations.

Estimates vary, but a good general picture of air-delivered munitions is as follows:

- over 2,000 HARM missiles;
- over 200 Walleye missiles;
- over 5,000 IR/EO Maverick missiles;
- over 57,000 unguided cluster bombs;
- over 136,000 conventional bombs; and
- over 9,000 laser-guided bombs.

Altogether, LGBs in the Gulf War accounted for only 3.4 percent of all delivered ordnance (unlike NATO's 98 percent figure in the Bosnian conflict). Nonetheless, they are thought to have inflicted some 75 percent of the serious damage to all Iraqi strategic and operational targets.

3) The Navy and Marine Corps

During the Gulf War, as many as 190 U.S. Navy and Marine Corps Hornets were used inaction: 106 on aircraft carriers and 84 with land-based Marine Corps units. These operated from nine USN Hornet-A/C squadrons and seven USMC Hornet-A/C/D squadrons.

The Marine Corps through MAG-11 and MAG-31 (forming MAG-70) deployed F/A-18As with VMFA-314 “Black Knights” (VW), VMFA-333 “Shamrocks” (DN) and VMFA-451 “Warlords” (VM). USMC F/A-18Cs, all from MAG-24, flew with VMFA-212 “Lancers” (WD), VMFA-232“Red Devils (WT) and VMFA-235 “Death Angels” (DB). Marine F/A-18Ds from MAG-11 operated with VMFA(AW)-121 “Green Knights” (VK).

When Hornets with VFA-25 “Fist of the Fleet” (NK) and VFA-113 “Stingers” (NK) on the USS INDEPENDENCE (CV-62) and VFA-131 “Wildcats” (AG) and VFA-136 “Knight Hawks” (AG)on the USS EISENHOWER (CVN-69) rotated home, they were replaced by F/A-18s aboard:

- USS MIDWAY (CV-41), with three F/A-18A squadrons, VFA-151 “Vigilantes” (NM), VFA-192 “Golden Dragons” (NF) and VFA-195 “Dam Busters” (NF) ;
- USS SARATOGA (CV-60), with two F/A-18C squadrons, VFA-81 “Sunliners” (AA) and VFA-83 “Rampagers” (AA); and
- USS THEODORE ROOSEVELT (CV-71), with two F/A-18A squadrons, VFA-15 “Valions” (AJ) and VFA-87 “Golden Warriors” (AJ).

Other non-Hornet air assets onboard USS JOHN F. KENNEDY (CV-67) and USS RANGER(CV-61) were part of this battle group. USS AMERICA (CV-66), with her two F/A-18C squadrons—VFA-82 “Marauders” (AB) and VFA-86 “Sidewinders” (AB)—later joined the force.

American Hornets in Desert Storm					
Crew	**Total**	**USN**	**USMC**	**Inventory**	**Deployed**
1	162	90 A	72 A/C (36/36)	526 aircraft	31 percent
2	12	0	12 D	29 aircraft	41 percent

The F/A-18 proved its versatility by shooting down enemy fighters and subsequently bombing enemy targets with the same aircraft on the same mission. Additionally, the Hornet broke all records for tactical aircraft availability, reliability and maintainability.

According to Jane's, Gulf War Hornet availability rates averaged 90 percent and peaked at 95 percent (although, it should be noted, this figure reflects “all the US Navy's resources devoted to sustaining only half the Hornet force”). The aircraft's survivability was impressive, for even those suffering direct SAM hits were recovered, repaired quickly and airborne again the next day.

There was a clear division of labor between USN and USMC Hornet tasking during the Gulf War. Navy missions fell into three rather uniform categories—strike missions (36 percent), fleet defense (30 percent) and support (34 percent)—whereas Marine flights were predominately direct combat sorties (84 percent), augmented by support (16 percent). The F/A-18 workhorse in both services demonstrated a wide range of operational applications.

F/A-18s flew some 4,551 strikes with ten casualties, equating to a casualty rate per strike of0.22 percent. Altogether, two were lost in combat and three to non-combat accidents. Two of the latter were Marine

Hornet-Cs involved in a mid-air collision over Saudi Arabia on March 9th. Both pilots ejected and parachuted to safety.

4) Hornet Mission Overview

Hornets completed 95 percent of scheduled sorties and missed none for maintenance reasons. These sorties numbered over 11,000, totaling some 30,000 flight-hours. F/A-18s delivered 18,000,000 lbs of ordnance and used 15 different types of weapons to attack over 6,000 targets, including 24 main bases, 30 dispersal bases, command and control facilities and surface-to-surface missile sites. Along with F-16s and A-6Es, F/A-18s attacked targets in 11 of 12 (92 percent) strategic target categories. However, Navy Hornets were the only multirole aircraft actually employed in both air-to-ground strikes and air-to-air engagements, day and night.

A large number of early F/A-18 missions took place in conjunction with EA-6Bs and A- 6Es escorting large strike packages into southern Iraq. Also, with USAF F-15s and Navy F-14s, USN/USMC F/A-18s provided CAP and sweeps for attack packages, establishing air supremacy quickly. As Iraqi threats against Navy aircraft carriers decreased, the number of F/A-18 combat air patrol (CAP) sorties switched to interdiction. F/A-18s attacked a wide range of their own ground and naval targets, focusing primarily on command, control and communication (C3); so-called kill-boxes (KBXs, dug-in Republican Guard positions); offensive counter-air (OCA)and defensive counter-air (DCA) missions. Of the approximately 18,120 sorties flown by carrier-based aircraft during Operation Desert Storm, about 21 percent were devoted to these DCA missions.

In general, Hornets flew six types of missions:

- fleet air defense and CAP, including HVU (high-value unit) and HARM CAP;
- SEAD (Suppression of Enemy Air Defenses) (typically with two drop tanks, two Harms, two AIM-7s and two AIM-9s);
- interdiction (typically with three Mk 20 Rockeye CBUs, two drop tanks, two AIM-7s and two AIM-9s);
- self-escort;
- offensive and defensive counter-air (OCA/DCA); and
- close air support (CAS).

The six single-seat F/A-18A/C squadrons deployed to Southwest Asia (SWA) flew over 4,600sorties (totaling 8,864 flight-hours) with no combat losses. They were joined by twelve F/A18Ds used solely in the Tactical Air Coordinator (Airborne)/Forward Air Controller(Airborne), or “Fast FAC” role, proven successful by other aircraft in Southeast Asia (SEA).

These “Deltas” proved to be superior TAC(A)/FAC(A) platforms as they augmented the venerable OV-10 Bronco (two of which were lost early in the war). They flew into target areas ahead of strike aircraft to locate and identify high-value targets for USMC, USAF, USN and Kuwait Air Force TACAIR missions.

In this role, they often used “Willie Pete” white phosphorus 2.75-inch and 5-inch rockets for target-marking. When rockets were unavailable or exhausted, these F/A-18Ds radio-directed airborne strike units to enemy positions and vehicles. By providing target location and identification, threat updates and the overall battlefield situation, they controlled as many as 20 strike-fighters in a single 30-minute period. With their contributions, total USMC Desert Storm sorties came to 5,047.

In attacks on Silkworm anti-ship missile sites (some 50 missiles and seven launchers at the beginning of the war), the Hornets used AGM-142 Walleyes, SLAM (Standoff Land Attack Missile, a ground attack version of the AGM-84 Harpoon anti-ship missile) and Mk 80 series iron bombs. USMC F/A-18s dropped "snake"-retarded versions of these Mk 80s on Iraqi troop positions in Kuwait. Later low-angle "snake and nape" strikes against Iraqi bunkers packed the fiery Vietnam-era double punch of retarded bombs with napalm canisters. Rockeye cluster bombs were dropped on revetted vehicles, troop concentrations and parked aircraft.

Carriers in the Gulf provided A-6s, A-7s and F/A-18s for strikes beyond the fire support coordination line (FSCL). F/A-18s and A-6s from Bahrain and forward-based AV-8B Harriers attacked targets and responded to close air support (CAS) requests for troops on the ground in Kuwait. As the war progressed, the number of large strike packages diminished progressively with the neutralization of enemy air defenses and the decrease in the number of large juicy targets, both fixed and mobile. At this time, USMC Hornets frequently roved over kill-boxes as split two-ships, hunting for something to bomb or shoot. Later in the war, they routinely dove low (typically no lower than 500 feet or so, yet down where F-16s, Navy F/A-18s and F-14s dared not venture) to employ their Vulcan cannons.

In conjunction with A-6s, F/A-18s were also used in a limited number of armed surface reconnaissance (ASR) missions to search for and engage Iraqi surface vessels. F/A-18s, along with A-6s and AV-8Bs, attacked and destroyed armored vehicles, tanks, trucks, artillery and free rocket over ground (FROG) batteries throughout southern and central Kuwait. Hornets were part of an elaborately orchestrated series of high-tech strikes composed of USAF F-117As, F-16s, B-52s, A-10s and F-4Gs and USN/USMC A-6Es and USMC AV-8Bs and Navy A-7s. Along with A-10s, F-16s and AV-8s, Hornets fired AGM-65 Maverick missiles against tanks.

There were a number of recurring problems in the theatre. Ancient Mk 80 bombs—many from the 1950s—had to be double-fused (electrical and contact) in an attempt to decrease the frequency of "dud" drops. A shortage of munitions (most notably Mk 83 1,000-lb bombs), FLIR pods and LDT/R pods degraded overall Hornet effectiveness. Many a mission was scrapped due to poor visibility. Post-strike battle damage assessment (BDA) feedback was chronically minimal. The overwhelming number of Air Force, Marine and Navy aircraft overtaxed the Direct Air Support Center (DASC) and Tactical Air Operations Center (TAOC)mission-tasking resources and caused delays. Interservice communication and intelligence was severely deficient.

5) Enemy Air Defenses

The Iraqi integrated air defense system (IADS) was a synthesis of European/Soviet search and acquisition radars and Soviet/European SAM and AAA systems, all integrated by a French-built Kari C3 (Command/Control/Communications) network. The IADS was characterized by a high density of SAM and AAA systems, with redundant communications and reinforced C3 facilities. Its three principal elements were manned by the:

- AIR FORCE, fixed sites with fighters and SA-2/SA-3 systems covering key airfields and strategic air defense sites;
- REPUBLICAN GUARD, SAM and AAA systems covering key nuclear, biological and chemical warfare facilities; and

- IRAQI ARMY, mobile radar, SAM and AAA systems protecting both fixed sites and field units.

When the war broke, Iraq's air power consisted of some 860 combat aircraft and attack helicopters. More than 100 of these fled to Iran during the course of the conflict. Although Iraqi aircraft offered but negligible resistance (the Iraqi Air Force lost only 39 aircraft, 14 of them in air-to-air combat), Coalition aircrews suffered immediately from surprisingly capable infrared surface-to-air missiles (IR-SAMs). There were no Hornet losses to IR-SAMs, but more F/A-18s were disproportionately damaged than any other Coalition aircraft type, accounting for almost half of all reported IR-SAM damage. However, the F/A-18A piloted by LT Robert

J. Dwyer (lost 40 nm east of Kuwait City on January 5th) holds the ignominious distinction of being the only Coalition loss, of any aircraft type, not verifiably SAM/AAA-inflicted. All told, it appears that at least 15 Coalition aircraft were lost to AAA or IR SAMs, with the Soviet-made SA-16 SAM responsible for downing more of them than any other single air defense system.

For the F/A-18 in particular, according to one General Accounting Office (GAO) post-war report, nearly 88 percent of ground-based AA damage was attributed to SAMs, the rest to AAA. It is known that three USN Hornet squadrons and two USMC units suffered SAM-inflicted damage (comprising seven aircraft). The latter—Marine F/A-18Ds—were able to make it back to their launch points, where they were repaired and used again within two days, demonstrating the essential robustness of the airframe. Incredibly, one of these was hit in both engines and still flew 125 miles to recover at its home base.

During Hornet SEAD missions to deal with this threat, HARMs (numbering some 250) and other munitions were employed in operational conjunction with F-16s, the USAF's dual-role operational counterpart of the Hornet. However, this supplemented rather than eliminated the role played by other aircraft. Specialized USAF F-4Gs, or "Wild Weasels," and EF-111s along with USMC A-6s, A-7s and EA-6Bs were all used extensively in SEAD and jamming.

Of those flown by naval platforms, F-14 Tomcats accounted for 67 percent and Hornets the remaining 33 percent. Marine Corps F/A-18s fired half of the first 200 HARMs used in initial suppression strikes, but ultimately “Weasels” delivered the bulk of them. Other HARM platforms or aircraft otherwise involved in SEAD were the A-10, F-15E, F-117, B-52 and Tornado GR.1 (nine of the latter flew 24 missions and fired the RAF's ALARM, a more advanced anti-radiation missile than the American HARM). All in all, the Navy accounted for 60 percent of SEAD missions and fired 80 percent of all HARMs.

In conjunction with USAF BQM-74 drones, Navy and USMC F/A-18s (along with A-6Es, A-7sand S-3s) employed tactical air launched decoys (TALD) as well, with the purpose of causing Iraqi defenders to energize their radars and thus reveal themselves to Coalition SEAD aircraft. The success of these initial attacks on Iraqi air defense nodes largely neutralized SAM coverage, enabling medium- and high-altitude engagements. Ten-thousand feet above the low altitude lethal zone of AAA and infrared (IR) SAMs, Coalition aircraft freely applied medium-altitude delivery tactics in relative safety. However, some aircraft were damaged and lost to AAA and IR missiles as deteriorating weather conditions forced aircraft to fly at lower, more vulnerable altitudes.

This was particularly true of Marine F/A-18s that routinely attacked trucks, armored vehicles, troops and artillery at low altitude later in the war. After diving to target and delivering their ordnance, many of these pilots chose to afterburn their way back to speed and altitude to clear the area as quickly as possible. It did this, of course, but at a cost. It depleted fuel more quickly, but, more importantly, it rendered flare countermeasures useless (by making the engine exhaust much juicier to an IR-seeking missile). It also made the aircraft highly visible to the enemy, particularly at night or against the black smoke billowing from numerous arson-sparked oil fires.

For example, both aircraft in a two-ship strike under lead MAJ Bob "Boomer" Knutzen and wingman Scott "Coma" Quinlan of VMFA-314 were hit by handheld SAMs. During their mid-morning strike against rocket positions near Kuwait City, smoke and clouds limited visibility to under three miles. Overcast conditions reached down to 8,000 feet. Soon after releasing their three bombs, it happened. As Knutzen explains, a few classic pilot errors are probably directly responsible:

> The weather had driven us low. We were carrying a lot of weight and drag and so had gotten slow while junking to avoid the AAA. We had attacked from the same direction several times, and both of us were out of flares. On top of that, we were easy targets highlighted against the low overcast.

Bottom line: according to GAO figures, with the exception of the A-10, F/A-18s were more likely to be damaged on a per sortie basis than any other ground-attack aircraft. Most aircraft hit by SAMs were unaware they were even targeted and, hence, did not drop flares or take evasive maneuvers. One explanation, dating back to Vietnam, deals with routine flights in high-threat areas.

Enduring the constant whine of their radar warning receivers reporting enemy radar "paints," many pilots simply turn down the volume and disregard the droning tone altogether. A constant warning is useless and only serves to distract. For Hornet drivers, most missile evasions were from visual sightings, radio calls from other aircraft or through rehearsed "blind" countermeasure deployment, usually on the way out of the hot zone after weapons delivery.

6) Hornets and Laser-Guided Munitions

F/A-18s delivered 5,513 tons of ordnance and averaged 1.2 daily sorties (about the same as the A-6E). However, with a daily average of 0.74 tons of munitions, the Hornet fared the lowest of any aircraft (the A-6E, for example, averaged some 1.16 tons of munitions per day). The Hornet's lack of an autonomous laser for LGB-delivery was considered a serious shortcoming, one which contributed to some degree to the aforementioned unflattering tonnage figure. This was also true of U.S. Air Force F-15E Strike Eagles, which lacked LANTIRN targeting pods (only 12 aircraft were so equipped, some 75 percent of them were not).

This considered, it is not surprising that the Hornet's guided/unguided munitions ratio was 1:30 (368 guided, 11,179 unguided), compared to the F-15E's ratio of 1:8 (1,669 guided, 14,089 unguided). In the Gulf War, although Hornets did deliver cluster bombs and precision-guided munitions (PGMs), the U.S. Navy relied predominantly on the nightcapableA-6E for LGB delivery and left iron bombs to the F/A-18 (mostly in the form of 1,000-lb Mk 83s, usually carried in fives). In fact, the 115 A-6Es deployed constituted over half of all U.S. LGB-capable aircraft on the first day of Desert Storm.

7) "Bandit On Your Nose, 15 Miles!"

Although nearly 85 percent of downed Iraqi aircraft were attacked by F-15Cs, the Naval F/A-18 stands as the only multi-role aircraft credited with a defensive air-to-air capability that actually had an opportunity to use it in Desert Storm. USAF F-15s and F-16s, for instance, never performed escort or air-to-air missions. The F-15C/D's primary mission is considered to be air superiority.

Although the two “incidental” air-to-air kills scored by F/A-18Cs accounted for but six percent of total U.S. A/A kills in the Gulf War, the story is a dramatic one. These kills represented the first (and, at present, only) air-to-air victories in Hornet history.

As the story goes, four Navy Hornets from VFA-81 “Sunliners” off the USS SARATOGA were on their way to a target on January 17th (the first day of the war) when two of them were engaged by Iraqi MiG Fishbed fighters. Directed by an E-2C Hawkeye (159107/AA600), LCDR Mark Fox in F/A-18C (BuNo 163508/AA-401) and LT Nick Mongillo in F/A18C (BuNo 163502/AA-410) got a MiG apiece with AIM-9 Sidewinder shots without having to dump their 16,000 lbs of bombs. Having dispatched their foes, they continued their mission through a hail of SAM and AAA fire on to their original target (an airfield in western Iraq), dropped their bomb-loads and eventually made it home in one piece.

According to Mark Johnson, a USN Hornet pilot formerly of the “Sunliners”, LT Mongillo's MiG kill was done with a single AIM-9M Sidewinder shot, whereas LCDR Fox fired both a Sidewinder and a Sparrow, believing that the first missile with a smokeless motor had failed. In addition, although some sources maintain that the engaged aircraft were F-7As (Chinese-built MiG-21s), they were almost certainly Russian-built MiGs.

The story is best told by one of the men who were there. From his Unit Mission Report, here is Fox's account of the encounter:

> We crossed the Iraqi border in an offset battle box formation to maintain the best lookout possible. As the strike developed, the volume and intensity of communications over the strike frequency increased. Bandit calls from the E-2 to our other strike group crowded in to my mind as I plotted where those bandits should be relative to our position. A call from the E-2 clearly intended for the Hornet strikers finally registered: 'Bandits on your nose,15 miles!' I immediately selected Sidewinder and obtained a radar lock on a head-on, supersonic Iraqi MiG-21.
>
> I fired a Sidewinder and lost sight of it while concentrating on watching the MiG. Thinking the Sidewinder wasn’t tracking, I selected Sparrow and fired. A few seconds after the Sparrow left the rail, the Sidewinder impacted the MiG-21 with a bright flash and puff of black smoke. Trailing flame, the MiG was hit seconds later by the Sparrow and began a pronounced deceleration and descent. As the flaming MiG passed below me, I rocked upon my left wing to watch him go by. Another F/A-18 pilot killed the MiG's wingman with a Sparrow shot only seconds after my missiles impacted the lead MiG... After the tactical activity associated with bagging a MiG while entering a high threat target area, the dive bombing run on our primary target was effortless. Visible below me were numerous muzzle flashes, dust and smoke from gun emplacements, a light carpet of AAA bursts and several corkscrew streaks of handheld SAMs being fired. I glanced back at the target just in time to see my four 2,000-pound bombs explode on the hangar. Our division quickly reformed off target without incident and beat a hasty retreat south of the border. Our relief in having successfully completed the strike without loss to ourselves was overwhelming.

The AIM-9M variant was responsible for all ten Sidewinder kills scored during the Gulf conflict. Most kills, however, are attributed to six-o'clock Sparrow shots at greater range, due the Iraqis' reluctance to dogfight.

8) He Who Hesitates

Not all Hornet missions were “hitchless” and not every flight came home. In at least one case (discussed below), the inability to positively and quickly identify enemy BVR targets had fatal consequences. Under the established rules of engagement (RoE) in the Gulf, F-14, F/A-18 and F-16 pilots often found their hands tied. Only the Air Force F-15 had the RoE required capabilities to employ BVR AAMs.

Sadly, for instance, on the first night of the war, LCDR Michael “Spike” Speicher, also of VFA-81 (in F/A-18C BuNo 163484/AA-403), was shot down 29 nm southeast of Baghdad. Although some initial sources attributed his loss to ground fire (specifically a Soviet-made self-propelled SA-6 SAM), the most credible accounts attribute the downing to an Iraqi MiG25PD Foxbat interceptor (perhaps even by a collision with the MiG) that was in the area.

Ironically, Spike had originally been scheduled only as an alternate, or backup, pilot. He was later added to the roster by special request because he wanted to fly on the first strike mission.

Pieced together from several reports, it appears that Spike was part of a SAM suppression mission ahead of a group of bombers. Spike and some other Hornets—piloted by CMDR Mike “Spock” Anderson and LCDR Tony Albano—were tasked with firing HARMs against specific targets, such as the Al Taqaddum airfield near the Euphrates River. Not long after 4 am, still some 50 miles from Baghdad, they came across an Iraqi Foxbat-A which had managed to take off. To CMDR Anderson, through IFF and other cues, this was obviously an enemy aircraft. It was climbing quickly with afterburner at Mach 1.4, spouting its telltale fingers of yellow flame. They Hornets dispersed at about this time and headed out toward their individual targets, spread out over some 50 to 60 miles.

Meanwhile, Anderson continued to tangle with the Foxbat, which responded to his radar lock by turning. The two of them circled each other several times, just outside range of the Hornet's weapons envelope. Meanwhile, Anderson requested firing authorization from the nearest E-3 AWACS controller. Although several Coalition jets had also achieved radar lock at this time, Anderson's controller could not see the aircraft on its instruments and thus could not allow him to fire under the established RoE. Incidentally, Anderson later would learn that other AWACS in the area had identified the MiG but were operating on a different frequency. This would cost the life of one 33-year-old naval aviator.

Attempts at visual tracking failed when the Iraqi switched off his afterburners and was lost in the dark. While Anderson's E-3 above attempted to identify the fast-closing bogey, it continued to deny permission to fire. In the resulting confusion, the MiG got a missile off (presumably a AA-6 Acrid, one of the largest AAMs in the world). This Soviet-made missile hit Speicher's Hornet and probably killing him instantly.

Spike's absence only became apparent during the in-flight roll call, as the others regrouped and exited the area. Later, many reported a flash and a definite aircraft explosion over Spike's target area.

The Fox and Mongillo kills represented the Navy's only fixed-wing victories in the Iraqi campaign. They were also the first air-to-air kills in the Hornet's service tenure. Likewise, although the jury is still out on the LT Dwyer downing, LCDR Speicher's loss was the first Navy combat loss of the conflict. Also, as of this writing, it represents the only known F/A18 air-to-air combat casualty of all time.

9) Canadian CF-18s

America was fortunate to have many allies contribute to U.S. air power during the conflict.

However, only Canada also flew the Hornet strike-fighter (designated CF-18). All told, Canadian Hornet assets totaled 34 aircraft. First on the scene, Canada's 18 CF-18s with No 409 Tactical Fighter Squadron were transferred from Baden-Söllingen, Germany to Qatar on October 7, 1990 during the pre-war Coalition build-up. From this base at Doha, dubbed “Canada Dry,” Canadian Hornet drivers flew over 1,110 CAP and training sorties in the months leading up to the Gulf War.

No 409 Squadron was replaced in mid-December by 26 Hornets from No 439 Squadron “Tigers” and No 416 Squadron “Lynxes”. A new squadron composed of both—part of Canadian Air Task Group Middle East (CATGME)—continued CAP missions in Saudi Arabia and in the Gulf, performed “MiG sweeps” and escorted strike packages consisting of British Buccaneers and Tornados and U.S. F-16s. They were deployed to the region accompanied by a Boeing 707 airborne refueling platform.

The CF-18s had the difficult task of sorting through the constant flow of southbound aircraft exiting the Iraqi battlefield. Later in the conflict, they also carried out some limited A/G delivery of their own with 500-lb “dumb” ordnance and even fired their nose cannons. This came only after the Canadian Minister of National Defense cleared such action on February 20th.

For example, on the day before the Battle of Bubiyan, an A-6E on ASR (having already successfully expended its own two 500-lb LGBs on two Iraqi patrol boats) “buddy-lased” a third to help guide a Hornet's 500-lb LGB to target. At 2 a.m. the E-2C TAC, which directed the F/A-18 to aid the A-6, then called for two newly tanker-refueled Canadian CF-18s—piloted by MAJ David “DW” Kendall and CAPT Steve “Hillbilly” Hill—to finish the job.

Though pulled off CAP duty and not configured with A/G ordnance, they attacked and severely damaged the last of the four patrol boats (an AAG- and Exocet-equipped TCN-45) with strafing fire. A weak heat signature thwarted several attempts to gain A/G Sidewinder locks, but on a subsequent pass Kendell achieved a Sparrow lock in A/A mode and fired. The missile impacted the water near the boat. This was the first time Canadian forces had fired on an enemy in declared combat since the Korean War.

However, the primary mission of the CF-18s was to protect Canadian warships against Iraqi Mirage F1EQs carrying AM 39 Exocet anti-ship missiles (which demonstrated their effectiveness against the British in the Falklands conflict). In total, the Canadians flew 5,730 hours (the 707 refueler flew 306 hours) with no combat losses or damage. Following its participation in Desert Storm, No. 409 Squadron was disbanded in 1991 and turned over some of its aircraft to Nos 421 and 439 Squadrons. Subsequently, in June 1992, No. 421 Squadron disbanded. No 439 Squadron stood down in December 1992. Canada's operations in the Gulf War were known as Operation Friction.

D. International Hornets

1) Introduction

Northrop could illicit minimal interest in its F-18L version, for the export market seemed to prefer the relatively heavy Hornet as it was. In fact, a sturdy construction and increased internal fuel capacity in the Navy versions were viewed as benefits which compensated for the aircraft's "liability" of 3,500 kg of extra weight. Partly because of its all-round capability, with a bigger radar than the F-16 and Sparrow AAMs, the Hornet was selected by Canada as the CF-18 and by Australia and Spain, and later by Finland as the FN-18. None of these countries required carrier equipment, but Finland, for example, purchased arrestor gear.

All Foreign Military Sales (FMS) versions of the F/A-18 are physically identical to the US versions (unlike the F-16, which finds itself occasionally fitted with a drag-chute fairing on the tail or some other minor mod). However, the Operational Flight Program (OFP), the basic software driving the avionics and displays, is customized for the customer country. No other country gets the US version of the software. The F/A-18's wide operational climate profile (temperatures of - 51 degrees to 51.7 degrees centigrade) makes it attractive to a varied international market.

F/A-18 Foreign Military Sales					
	A-models	**B-models**	**C-models**	**D-models**	**Total**
Australia	60	12	0	0	72
Canada	98	40	0	0	138
Finland	0	0	57	7	64
Kuwait	0	0	32	8	40
Malaysia	0	0	0	8	8
Spain	57	18	0	0	72
Switzerland	0	0	26	8	34
Total	**215**	**70**	**115**	**31**	**428**

2) Canada

Canada's desire for new combat aircraft was made public in April 1980. In searching for a replacement for its Lockheed CF-104 Starfighter air superiority fighters and CF-101B Voodoo fighter-interceptors and CF-5 Freedom Fighters, Canada became the F/A-18's first foreign customer. In this respect, the F-16 was also considered, but the Hornet was clearly the better all-weather fighter for the Canadian climate. The determining factor in acquisition became the dual engine feature. Northrop attempted to push its F-18L Hornet derivative, but this was ruled out on technical legal grounds. Canadian pilots were nonetheless enthusiastic about the YF-17 when evaluated while it served as the F-18L demonstrator.

The decision to purchase the Hornet was first published on April 10, 1980. The initial order encompassed 113 single-seaters and 24 tandems, with the option for 20 more. Canada had planned to order 11 of the aircraft on which it had options but allowed this option to lapse on April 1, 1985. At the same time, the original contract was modified to 98 single seaters and 40 two-seaters, for a total of 138.

Canada's version, though essentially identical to the U.S. Navy version, underwent some significant modifications such as a 600,000-candlepower spotlight fitted on the port side of the forward fuselage (just under the very tip of the LEX) to enable night identification of other aircraft. The maritime rescue package was exchanged for cold-weather equipment, and the Automatic Carrier Landing System (ACLS) exchanged for Instrument Landing System (ILS). In addition, it has provision for LAU-5003 rocket pods (containing 19 Bristol Aerospace CRV-7 2.75-inch unguided rockets) and BL-755 cluster bombs. Also, these Hornets have provision for three 480-gallon (1,817-liter) drop tanks.

The aircraft is designated CF-18 (single seat) and CF-18B (two seat) in Canadian Armed Forces service. The two-seater was initially designated CF-18D, the “D” meaning “Dual”, following previous Canadian practice. However, this was eventually changed to CF-18B, lest the aircraft be confused with the D-model of the F/A-18. So, today they are known as the CF-18 (single-seat) and the CF-18B (two-seat). In the beginning the name “Hornet” was deliberately not used in Canadian service, presumably because the French translation is “Frelon,” which already referred to a French-built Aerospatiale helicopter. According to retired Canadian Air Force aviator CAPT Bruce W. Beswick, a nearly six-year, 2,000-hour veteran Hornet pilot, today:

> even the French pilots call it the F-18 or the Hornet. That the Hornet name was banned several years ago was somewhat true. A French member of parliament objected to the name. However, now... true Hornet drivers have reverted to using the appropriate name. Even official publications are now calling it the F-18 ‘Hornet’.

The first production CF-18 aircraft for Canada took off on its first flight at St. Louis on July 29, 1982 and was delivered on October 27. All CF-18s were built by McDonnell in production blocks 9 to 23, the last of 98 examples being delivered in September of 1988. They were assigned Canadian military serials 188701 through 188798. The 40 two-seat CF-18Bs were built in Blocks 8 to 25 and were assigned Canadian military serials 188901 through 188940. The first Canadian Armed Forces unit to be equipped with the CF-18 was the No 410 “Cougar” Operational Training Squadron based at Cold Lake, Alberta, which received its first planes on October 30, 1982. Deliveries were completed in 1988.

The first year of service was spent training instructors on the new aircraft in preparation for the conversion of other squadrons to the type. The CF-18 has served with 416 “Lynxes “and 441 “Silver Foxes” Squadrons based at Cold Lake, Alberta, with 425 “Alouettes” and 433 “Porcupines” Squadrons based at Bagotville, Quebec, and with No 409 “Nighthawks”,421 “Red Indians” and 439 “Tigers” Squadrons stationed at Baden-Sollingen in Germany.

Following the end of the Cold War, Baden-Sollingen closed down in 1994 and all the Hornets based there were returned to Canada. Once the European-based aircraft returned home, the CF-18 force was now down from seven to four active duty squadrons—416, 441, 425, and 433 Squadrons—plus the 410 training squadron at Cold Lake. Two of these squadrons will be on notice for a quick return to Europe if an emergency breaks out, and the other two will be assigned to the support of maritime operations. The primary role of all four squadrons, however, will be Canadian aerial defense.

Following the disestablishment of the European-based CF-18 squadrons, some of their planes were redistributed to the surviving four Canadian-based squadrons, whereas others were placed in storage.

By the end of 1994, out of the 125 CF-18s originally in the Canadian inventory, only about 72 remained in operational squadrons, with the remainder serving with the training unit at Cold Lake or else being placed in storage.

In 1995, The Canadian Forces Air Command announced that a further 12 CF-18s would be withdrawn from active service and placed into ready reserve storage. This now leaves only 60 of the CF-18 fighters in four operational squadrons, each with 15 rather than 18 CF-18s.

Some 23 additional CF-18s serve with 410 Squadron at Cold Lake, with another 23 being either already in storage or under repair. The reduced utilization should extend the lifetime of the CF-18 until 2014. In the meantime, an upgrade program is being planned which will include APG-65 radar improvements, modification of the ALR-67 radar warning receiver and expanded capability for the mission computer and stores management system.

The Canadian Forces are currently planning a service life extension program, which would significantly upgrade the avionics of their CF-18s. The country's fleet of 138 Hornets is the largest outside the United States.

3) Australia

At roughly the same time as Canada, Australia sought a successor to its ageing Dassault Mirage IIIO aircraft. After a six-year evaluation period, on October 20, 1981 the Royal Australian Air Force (RAAF) announced it too had chosen the two-engine F/A-18 over the competing General Dynamics F-16 Fighting Falcon. The decision was based largely on the Hornet's ground-attack avionics, BVR missile capability and twin-engine safety, even before the aircraft had achieved IOC with any U.S. service. The acquisition decision of 75 Hornets (57 single seaters and 18 two-seaters) was printed in October 1981, with ensuing delivery lasting from May 1981 to May 1990.

The single-seater is sometimes listed as AF/A-18A, the two-seater as AF/A-18B, with the A standing for "Australia", although these designations are not official DoD designations. A part of the Australian Hornet deal, a complex offset arrangement was arranged, with as much as 40 percent of the components being manufactured in Australia. McDonnell was to be responsible for the manufacture of the first few examples. Afterwards, the Government Aircraft Factory (later renamed Aerospace Technologies of Australia, or ASTA) at Avalon, Victoria would be responsible for the subsequent assemblies from parts supplied by both U.S. and Australian factories.

There was to be extensive local input, with ASTA being responsible for final assembly, as well as the manufacture of forward fuselage installations, trailing edge flaps and shroud assemblies, radome assemblies and all transparencies. Dunlop Aviation Australia was to make the wheel and brake assemblies as well as the airspeed indicator. Software was to be done by Computer Sciences Australia. Electronic components were provided by Morris Productions, Philips, Thorn EMI Electronics Australia, and Standard Telephones and Cables.

The F404 turbofans were to be built under license by the Commonwealth Aircraft Corporation, with the radar and other avionics built by British Aerospace Australia, Ltd.

In May of 1984 McDonnell shipped components for the first two AF/A-18As to Avalon. The first two fully-assembled Hornets for Australia (both B-models) were manufactured by McDonnell in St. Louis and were handed over on October 29, 1984. They were retained at St. Louis for training until May 17, 1985 and were thereafter transferred to RAAF Williamtown. The remaining planes on order were all assembled in Australia. The first Australian-assembled Hornet was flown on February 26, 1985 and was delivered on May 4. The first completely all-Australian Hornet took off on its maiden flight on June 3, 1985.

The Australian Hornet deleted the catapult launch equipment, has a conventional ILS/VOR and landing lights and is equipped with a fatigue recorder. It also sports an added high frequency radio for long-range communications. Otherwise it is identical to the U.S. Navy/Marine Corps version. Australian Hornets are fully compatible with the AGM-65 Maverick and AGM-84 Harpoon. In addition, they may optionally carry a reconnaissance pod in place of the internal cannon.

The 57 single-seat AF/A-18As (Blocks 14 to 28) and were assigned RAAF serials A21-1 through A21-57. These were outfitted with the Litton ALR-67(V) RWR, the Sanders ALQ126B deception radar jammer and the Northrop ALQ-162 continuous-wave radar jammer.

The 18 two-seat AF/A-18Bs were assigned RAAF serials A21-101 through A21-118. Production shifted to the F/A-18C/D standard in FY1986, with the use of a modified Flight Incident Recorder and Monitor System, provision for AIM-120 AMRAAM, improved fuel system and an Airborne Self-Protection Jammer (ASPJ). The last was delivered by ASTA on May 16, 1990.

First to receive the Hornet was No. 2 Operational Conversion Unit based at RAAF Williamtown in New South Wales, which began training Hornet pilots in the summer of 1985. F/A-18s currently serve with No 3 and No 77 Squadrons at RAAF Williamtown and with No 75 Squadron at RAAF Tindal in the Northern Territory near Darwin. Almost immediately after the delivery of the last Australian Hornet, ASTA began to upgrade the Hornet fleet to operational equivalency with the F/A-18C/D. This included AIM-120 AMRAAM provisions.

Other incorporations include new mission computers, armament control processors, stick-top controls to enhance HOTAS capabilities, data storage and data transfer equipment, revised flight management systems, improved electronic countermeasures equipment and target designation capability. RAAF Hornets have added integration with the Northrop ALQ-162 radar jammer and the LoralAAS-38 Nite Hawk targeting FLIR pod equipped with Laser Target Designator/Ranging equipment (they do not use the AAS-50 NAVFLIR). This affords the Hornet the ability mark targets on its own for precision delivery of laser-guided weapons.

Twenty-three examples had provision for reconnaissance systems, as the nose-mounted gun would be interchangeable with a sensor pallet. Available sensor systems are KA-56 3-inch panoramic cameras, KS-87 6-inch side oblique cameras, KA-93 24-inch sector panoramic cameras and KS-87 12-inch split vertical cameras. Some of the two-seat Australian Hornets were provided with night attack capability, with a configuration quite similar to that of the USMC Night Attack aircraft. These include night vision goggles, modified cockpit lighting and HUD changes for displaying FLIR information, and digital color map displays for both cockpits. Future plans are to upgrade the APG-65 radar to APG-73 standards and to upgrade the F-404-GE-400 turbofans to -402s.

Two A-models and two B-models have been lost in crashes. A21-104 was lost in November 1987, and A21-41 was lost in a midair collision with A21-29 (A21-29 landed at Tindal) in August 1990. A21-41 was lost in June 1991, and A21-106 was lost in May 1992. Currently, the program is in the post-production phase, consisting of sustaining engineering and logistics support.

4) Spain

The first European customer for the Hornet was the Spanish Air Force, the Ejercito del Aire Espanol. The US government initially offered Spain an interim loan of 42 ex-USAF F4E Phantoms, followed by the sale of 72 F-16s. However, the F-18 entered the competition in 1980, offering the benefit of a twin-engine safety margin. In a bid to replace its F-4C Phantoms, Spain broke the news of its decision to purchase the Hornet in December of 1982. Spain originally announced acquisition plans for 72 single-seaters and 12 two-seat versions, but this proved to be beyond the country's financial means.

The order was then reduced to 72 aircraft of both types on May 31, 1983 for a cost of about$4.2 billion. In addition, as part of an offset agreement reached with Spain, Construcciones Aeronauticas SA (CASA) at Gefale is responsible for the maintenance of EdA Hornets. CASA is also responsible for major overhauls of Canadian F/A-18s based in Europe, as well as the Hornets of the US 6th Fleet in the Mediterranean.

The Spanish Hornets are sometimes referred to as EF-18A and EF-18B, the “E” standing for “España” (Spain) rather than for “Electronic” as would normally be the case for an official DoD designation. They have local EdA designations, C.15 and CE.15 respectively. Serial numbers are C.15-13 thru C.15-71 and CE.15-1 thru CE.15-12, respectively. The first EdA Hornet (EF-18B CE.15-01) was presented in a formal ceremony at St. Louis on November 22, 1985. It made its initial flight in December.

The first few two-seaters were sent to Whiteman AFB in Missouri, where McDonnell Douglas personnel assisted in the training of the first few Spanish instructors. The first two-seater was flown to Spain on July 10, 1986. By early 1987, all 12 two-seaters had been delivered to Spain, after which the single-seaters were delivered. A total of 60 EF-18As and 12 EF18Bs have been delivered, the last in July 1990. The Hornet serves with Escuadron 151 and Escuadron 152 of Ala de Caza 15 at Zaragoza-Valenzuela and with Escuadron 121 and Escuadron 122 of Ala de Caza 12 at Torrejon de Ardoz. The SAF has developed depot level maintenance capability organized along the lines of U.S. Navy depots but delivered to highly specialized sites.

Spain has ordered 80 Texas Instruments AGM-88 HARM anti-radiation missiles and 20 McDonnell Douglas AGM-84 Harpoon anti-shipping missiles. They are also fully capable of delivering laser-guided munitions and Mavericks, having demonstrated their effectiveness, for example, during Operation Deliberate Force over Bosnia in 1995.

The first 36 (both versions) Spanish F/A-18s carry the Sanders ALQ-126B deception jammer and on the last 36 aircraft the Northrop ALQ-162(V) systems. In 1993, plans were announced for the EdA's fleet of EF-18A/B Hornets to be upgraded to F/A-18C/D standards.

McDonnell Douglas will rework 46 of these ex-USN planes, with the remainder being upgraded by CASA. Most of the changes involve a new mission computer (with increased FC memory) and software improvements, an upgraded data bus, increased data-storage set, and wiring and pylon upgrades. Following this rework, the planes will be redesignated EF-18A+ and EF-18B+.

Worried about a “fighter gap” opening up early in the next century because of delays in the Eurofighter 2000 program, Spain has gone in search of additional fighter aircraft. Spain has acquired some additional Mirage F1s from Qatar and France. The USAF has offered Spain50 surplus F-16A/B Fighting Falcons and the U.S. Navy has offered about 30 F/A-18As.

In September 1995, the SAF signed a letter of offer and acceptance to procure an additional 24 F/A-18As from the U.S. Navy inventory. These aircraft were delivered to Spain over four years at a rate of six per year. They joined the new squadron based at Moran, taking the place of F-5s, which had been provisionally replaced by CASA C-101s.

5) Switzerland

The Swiss rejected the Dassault Mirage 2000, the Israel Aircraft Industries Lavi, the Northrop F-20, the Saab JAS-39 Gripen and the F-16 Fighting Falcon as fighter possibilities in favor of McDonnell Douglas’ offer. In October of 1988, the government announced its selection of the Hornet as the next fighter of the Schweizerische Flugwaffe/Troupe d‘Aviation Suisse (Swiss Air Force). The decision was for 26 single-seater C-models and eight dual-seater Ds. These 34 aircraft, powered by F404-402 turbofans, were deployed to three squadrons of the Swiss Air Force beginning in 1993. They replaced the Mirage IIIS and fly alongside Northrop F-5E Tigers acquired during the early 1980s.

In 1991, the competition was reopened so that the MiG-29 and the Dassault Mirage 2000-5could be considered. However, even a personal appeal on the part of French President Francois Mitterand could not overturn the original plan to buy 26 F/A-18Cs and 8 F/A-18Ds.

The formal contract was expected to be signed in 1992. However, the Hornet order remained controversial and was even the subject of a popular referendum held on June 6,1993, which finally approved the program.

The first Swiss Hornet-D flew on Jan. 20, 1996, with the ceremonial rollout in St. Louis on January 25, 1996. After weapons system testing, this and a sister aircraft were delivered in December 1996 and early 1997. The rest of Switzerland's 32 F/A-18s underwent final assembly and ramp operations at the Swiss Aircraft and Systems Co. in Emmen, near Lucerne. Swiss industry manufactured selected components.

Delivery delays allowed Switzerland to specify the APG-73 radar for its Hornets, which were delivered between 1996 and 1999. Three squadrons at Payerne, Sion, and Meiringen operate the Hornets in the air defense role, allowing some of the F-5E/F Tiger IIs to be transferred to ground attack roles.

The first F/A-18 assembled in Switzerland flew in December 1996 and was delivered to the Swiss Air Force in January 1997. Altogether, Switzerland is procuring two complete F/A18s, 32 F/A-18 kits, support equipment and services.

6) Kuwait

General regional instability, exacerbated by the tangible military threat of powerful nearby aggressor-states, usually is sufficient motivation to purchase new, more sophisticated weapons systems. Foreign Hornet acquisitions have been no exception to this axiom.

Kuwait, for instance, ordered the F/A-18 in response to Saddam Hussein (however, the Iraqi invasion occurred before the Hornet was in-country for domestic deployment).

Actually, the order for 40 Hornets by the Al Quwwat al Jawwiya al Kuwaitiya (Kuwait Air Force) had taken place in August 1988 with the signing of the letter of acceptance. These aircraft were to be built to F/A-18C/D standards and equipped with the more powerful F404402 turbofans—making them, in fact, the very first Hornets outfitted with this engine upgrade. Delivery had originally been scheduled to commence in August of 1991, but the occupation of Kuwait by Iraq and the ensuing Gulf War delayed delivery. However, even during the time of the Iraqi occupation of Kuwait, the manufacture of the Kuwaiti Hornets continued.

Kuwaiti Hornets are sometimes referred to as KAF-18C/Ds, although not official DoD designations. Following the ejection of Iraqi occupation forces from Kuwait, the delivery program went forward. The first KAF-18D (serial number 441), flown on September 19,1991, was officially presented to the KAF on October 8th. The early KAF aircraft were Block35 aircraft but were fitted with the -402 powerplant in a production line which otherwise used the -400.

The first three Hornets were flown to Kuwait on January 25, 1992 and the last of the initial batch (from Block 40) arrived in Kuwait on August 21, 1993, completing the initial order for32 KAF-18Cs and eight KAF-18Ds. The Hornets first received were given to No 25 Squadron operating from Kuwait International Airport, but they are ultimately destined for Ali Al Salem military air base. Later planes went to No 4 Squadron. Both of these squadrons previously operated the A-4KU Skyhawk.

7) Malaysia, Thailand, Korea and Others

The most recent customer has been Malaysia, prompted by the sale of Russian Su-27 Flankers to China. Malaysia is so shaken by the perceived Chinese threat that, in addition to the F/A-18 purchase, it announced on June 7, 1994 the decision to buy 18 MiG-29R Fulcrums in a $660-million deal with Moscow. All of this happened after months of debate on re-equipment of the Tentara Udara Diraja Malaysia (TUDM, or Royal Malaysian Air Force), after which the Malaysian Defense Minister confirmed on July 1, 1993 that they would order both MiG-29s and F/A-18s.

On December 9, 1993, Malaysia signed the Hornet letter of offer and acceptance for eight units. The first F/A-18 for Malaysia was rolled out in a ceremony in St. Louis March 19,1997. The first four Malaysian F/A-18s were delivered in May 1997 to the TUDM. The remaining four were in arrived in Butterworth, piloted by USN and USMC aviators, via Hawaii and Guam.

Thailand signed a letter of offer and acceptance in May 1996 for eight aircraft (four C-models and four D-models). Deliveries will start in February 1999 and conclude in October 1999. The country is also expected to receive AIM-120s when Russian R-77 (AA-12 Adder) active-radar-guided AAMs are introduced into the region.

In the late 1980s, the Republic of Korea held a competition for its next fighter aircraft. The F/A-18C Hornet was announced as the winner of the Korean Fighter Program contest in December of 1989. The Hornet had experienced stiff competition from the F-16, a type which was already in service with the Republic of Korea Air Force. Among the attractive features of the Hornet was its twin-engine assurance and its ability to carry out maritime anti-shipping missions. In addition, the South Korean government regarded the adverse weather interception performance of the F/A-18 as superior to that of the F-16.

Also, since at that time the F/A-18 was able to carry a forward-looking infrared pod but the F-16 was not, it was thought that the Hornet would be more effective than the F-16 against North Korea's fleet of Antonov An-2 fabric-covered biplanes, which have a very small radar cross section, but are discernible via infrared. Finally, the Koreans felt that the F/A-18 would be more capable than the F-16 against North Korean MiG-29s in air-to-air combat.

Ordered were 120 Hornets. According to the original plan, the first 12 Hornets for the Republic of Korea were to be manufactured by McDonnell, with 36 Hornets then being assembled by Samsung Aerospace Industries at Sachon from kits supplied by McDonnell.

The final 72 were to be manufactured from scratch under license at Samsung. Twenty-seven F404-402 turbofans were be supplied by General Electric, with Samsung building ten engines from General Electric-supplied components and 144 being wholly manufactured in Korea. However, the 120 Hornets planned for Korea suffered a series of cost increases and by early 1991 they were 50 percent more expensive than when initially ordered.

By March 1991 the South Korean government was so unhappy about the whole F/A-18 deal that it decided to switch to the competing General Dynamics F-16C. The revised contract duplicated the original Hornet contract in many respects, but with an initial delivery of 12 F16s provided from the USA. This was followed by 36 kits for assembly by Samsung and 72more to be exclusively Samsung-built. One advantage of the change in contract discontinuity: 40 F-16C/Ds are already in RoK AF service.

Today, the Hornet is being evaluated by Hungary, Poland, Austria, Chile and the Philippines for future procurements. Reportedly, the Czech Republic is also interested in the Hornet.

The government of Singapore has announced that it might be interested in acquiring 18F/A-18C/Ds. Singapore has also expressed interest in buying 18 F-16s but is delaying a purchase decision until it completes an evaluation of the Hornet. Thailand ordered eight two-seater Deltas, which were subsequently delivered in good faith. However, the country reneged on the deal and American aviators were dispatched to bring the strike-fighters back to the U.S. These aircraft have since joined their brethren in American service.

E. Hornets in NASA

1) High Angle of Attack Research Vehicle

In the mid- to late 1980s, the Navy transferred eight F/A-18As and one F/A-18B to NASA tube used by the Ames-Dryden Flight Research Facility for chase and proficiency flying. They eventually replaced all of the F-104 Starfighters that had previously been operated by NASA. NASA has also used its Hornets for a variety of research projects, the first of these being the High Alpha program begun in 1987 to study airflow surrounding the aircraft in high angle-of-attack attitudes.

NASA's High Angle of Attack Research Vehicle (HARV) program involved the use of a modified Hornet to explore the use of thrust vectoring in the high angle of attack regime. The goal was to achieve better maneuverability in conventional non-V/STOL aircraft in the hope of giving aircraft designers a better understanding of aerodynamics, flight controls and airflow under such conditions. See more on Hornet aerodynamics.

The HARV program was a joint effort between NASA's Dryden, Ames, Langley and Lewis research centers. The Navy loaned a YF-18A (BuNo 160780) to NASA for the tests. It had been serving with the Naval Air Test Center at Patuxent River, Maryland and in storage pending further use. It arrived at NASA's Dryden Flight Research Facility in September 1985 and was assigned the NASA number of 840.

NASA 840 required 18 months of refurbishment work. The HARV program began in 1987 with an unmodified aircraft. NASA 840 was finally fit with thrust vectoring equipment in 1991. This consisted of a set of three spoon-shaped paddlelike vanes fitted around each engine's exhaust to provide pitch and yaw forces in those flight regimes where the conventional flight controls tend to lose their effectiveness. In order to shorten the distance that the vanes must be cantilevered, the external exhaust nozzles were removed. This makes supersonic flight impossible but does affect subsonic performance. The flight control computers were modified to accommodate the vanes.

The aircraft was equipped with wingtip camera pods in lieu of Sidewinder missiles. These cameras view streams of white smoke emitted from the forward fuselage for airflow pattern analysis. To make the smoke trails contrast sharply with the fuselage, the upper surfaces of the aircraft were painted matte black. Similarly, in order to provide details about on surface flow patterns, a special red liquid can be emitted from dozens of tiny holes in the aircraft’s nose and filmed as it streams out over the fuselage surface.

With the thrust-vectoring vanes, the F-18 HARV has achieved stable flight at angles of attack as high as 70 degrees (previous maximum for conventional Hornet was 55 degrees). High roll rates can be achieved at 65-degree AOA, whereas controlled rolling was impossible above 40 degrees for normal F/A-18s. This research data has been incorporated into the next generation of fighter aircraft, including the Hornet-E/Fs.

F. The F/A-18E/F Super Hornet

1) Origin

McDonnell Douglas' advanced version of the F/A-18 in the 1980s, known as the Hornet 2000, promised a larger wing and horizontal tail, two fuselage plugs for more internal fuel, more powerful engines and an improved cockpit. In 1987, a Pentagon delegation was dispatched to Europe in an attempt to interest the French in a Hornet 2000 co-development scheme.

Although no solid customers appeared at that time, the project became the basis for the F/A-18E/F proposal. The F/A-18E/F grew out of a 1987 study requested by then-Defense Secretary Caspar Weinberger. The joint Naval Air Systems Command, McDonnell Douglas and Northrop study focused on potential Hornet upgrade considerations. The Super Hornet reflects the USN's improvement preferences from this report.

On January 7, 1991, the troubled General Dynamics/McDonnell Douglas A-12 Avenger II advanced stealthy attack program, intended to replace the A-6, was cancelled. The new program, originally designated A-X, was later renamed A/F-X when it fused with two other programs: the NATF (Naval Advanced Tactical Fighter)—intended to produce an F-14 alternative—and the USAF's F-111 replacement program. At this time, the leading contender was the Lockheed/Boeing AFX-653, which suggested an essentially navalized USAF F-22 Advanced Tactical Fighter (ATF) tandem-seater with a Tomcat-like swept-wing configuration.

However, when the A/F-X (Attack/Fighter Experimental) project was cancelled late in 1993, McDonnell Douglas immediately proposed an alternative: a stretched version of the F/A-18 optimized for the attack role. Although it was essentially a new aircraft, it was assigned the designation F/A-18E (single-seater) and F/A-18F (two-seater), implying that the proposal was merely a modified version of an already tried and true design. The definitive E/F development contract was signed on December 7, 1992, calling for three static test airframes, five F/A-18Es and three F/A-18Fs.

McDonnell Douglas procured the $3.7 billion - $4.88 billion contract for the aircraft’s engineering and manufacturing development in June 1992 (this included a separate contract with GE to develop the derivative F414 engine). Production of the center/aft fuselage began in May 1994 at Northrop Grumman in Hawthorne, California. McDonnell Douglas opened the St. Louis F/A-18E/F Super Hornet assembly line on September 23, 1994.

The first F/A-18E/F Super Hornet undertook its maiden flight on November 29, 1995. On September 18, 1995, almost 12 years after the first F/A-18 entered operational Navy service, the USN received its newest tactical combat aircraft at a St. Louis ceremony.

Secretary of the Navy John H. Dalton said, “the development process for the F/A-18E/F is one of the first, and by far the foremost example of our success in Acquisition Reform in the Navy.” Dalton called the aircraft a “remarkable achievement,” adding that “in all respects this aircraft has been on target: it is on schedule, on budget and underweight”.

2) The Improved Hornet-C/D Debate

In January 1996, a three-year flight test program began at the Naval Air Warfare Center at Patuxent River, Md. Ironically, the same year, just as the Hornet-E/F project was quite literally getting off the ground, the GAO suggested that the DoD cancel the program. The recommendation was that F/A-18C/D purchases continue until the Joint Strike-fighter (JSF)became available sometime between 2008-2010 (more on this below).

In the GAO's estimation, with “minor” upgrades and “minimal changes”, the Hornet-C/D could carry more than 10,000 lbs (4,546 kg) with stronger landing gear and larger (480-gallon) external fuel tanks. To the GAO, the Hornet-E/F's estimated $11.1 million additional flyaway price tag per unit over the projected $32.5 million for the Navy's JSF was at the crux of the discussion. The GAO clearly considered the Super Hornet only a “marginal improvement” over its F/A-18C/D predecessors. The idea, then, was to keep current strike-fighters viable until its eventual replacement entered service.

The U.S. Navy disagreed. Expecting minor upgrades to perform miracles on an ageing aircraft design was thought to be an ultimately naive and futile effort. As the Navy saw it, the GAO's further recommendation of increasing landing weight to boost recovery payload was simply untenable considering current Hornet-C/D design limitations and margins dictated by existing safety regulations.

However, in response to these considerations, the USN introduced landing weight increases of 990 lbs (450 kg) to a total of 33,800 lbs (15,400 kg) during F/A-18 patrols over Bosnia. The intent was to allow recovery of unexpended munitions. However, according to Flight International magazine (15-21 January 1997):

At the unrestricted carrier-landing weight of 15,000 kg [33,000 lbs], the typical Bosnian stores load of some 1,500 kg [3,300 lbs] would have reduced the fuel available to an unacceptably low 900 kg [1,980 lbs], so the landing weight was raised to increase the “first pass” fuel allowance to almost 1,400 kg [3,080 lbs]. This is still less than would normally be required for safe operations... [C]arrier air wings usually set first-pass fuel at 1,800kg [3,960 lbs] for day operations and almost 2,300 kg [5,060 lbs] for night operations. As pilots become more experienced, these allowances are reduced to 1,600 kg [3,520 lbs] day/2,000 kg [4,400 lbs] night.

This increase reflected F/A-18C/D payloads of 7,166 lbs (3,257 kg) in Bosnia, an increase of 866 lbs (394 kg) over standard operating weight. The Navy felt that beyond this, nothing more realistic could be done.

Performance limits were stretched as far as they would go with the current F/A-18. Any further recovery payload increases would require strengthening the internal structure of the Hornet to accommodate them.

Engineers and pilots were well aware of the spiral that would follow. Reinforcing the airframe inevitably means adding weight. Added weight makes the approach speed for the heavier aircraft too fast. Compensating with a corresponding increase in wing area increases drag. By the time all the emerging flight dynamic challenges were worked out, an altogether new aircraft was taking shape.

Low-rate initial production of the F/A-18E/F began in fiscal year 1997 with 12 aircraft. The first production F/A-18E/F Super Hornets will enter service with the U.S. Navy in 1999, with the first operational squadron of Super Hornets ready for deployment in 2001. Their service life is expected to extend beyond 2020. The U.S. Navy began purchasing in 1997 at an average 1990-dollar cost of $36.4 million each. The Navy plans to procure 548 Super Hornets, though the original figure was some 1,000 (660 Navy and 340 Marine Corps).

Twelve aircraft were funded in FY1997. Procurement numbers increased to 20 in FY1998and 30 in FY1999. It will reach a final maximum rate of 48 per year in FY2001.

These numbers could vary depending on the progress of the Joint Strike-fighter Program, as the Navy may purchase some 300 JSF strike-fighters. According to the U.S. Department of Defense 1997 Quadrennial Defense Review, if JSF deployment is delayed beyond 20082010, the Navy may purchase as many as 785 Super Hornets.

The F/A-18E/F is designed to perform some of the duties originally planned for the F-14D and the cancelled A-12. It is expected to replace Grumman's F-14 Tomcat in the air defense role and the retired A-6 Intruder. The F-18F command-and-control warfare variant(C2W) is expected to take the place of current EA-6Bs. E/Fs in “buddy tanker” and precision-strike aircraft roles are also of great interest to the USN. As Flight International magazine (15-21 January 1997) tells:

Off-loading 2,900 kg [6,380 lbs] of fuel to another E/F at 610 km [381 mi] would enable the refueled aircraft to reach a radius of almost 1,600 km [1,000 mi]. The new SLAM ER stand-off missile would extend the aircraft's reach to 1,850 km [1,156 mi], the Navy calculates The "tanker" aircraft, meanwhile, would remain on combat air patrol to defend the carrier.

Procurement remains a point of contention with the GAO, especially as it estimates that F/A-18E/F acquisition will consume the greatest amount of resources in fiscal years 19962001 at a cost of about $21 billion. One 1997 government report, found that the Super Hornet may cost only 13 percent more than the F/A-18C/D based on production figures of 1,000 aircraft per program. This puts the aircraft at $36.5 million and $41.6 million, respectively.

Other estimates place the cost of E/Fs over upgraded C/Ds at some 39 percent higher or more. The GAO maintains that the next-generation Joint Strike-fighter (JSF) could cost $21million less per aircraft (with greater capability, to add insult to injury). With the F/A-18E/F costing at least $9.6 million more per aircraft than originally estimated, the GAO says the Navy would save $17 billion in recurring flyaway costs if it procured F/A-18C/D aircraft instead. Others maintain that buying Super Hornets saves one-third to one-half the cost of a "new start" airplane.

3) Not Stealth, But Lower Visibility

The Super Hornet was designed specifically to extend the Hornet's long-term viability for U.S. aircraft carrier operations. Admiral Mike Boorda, Chief of Naval Operations, said, "the E/F Hornet will be the backbone of our future 'Air Arm.' It will be our mainstay strike-fighter tomorrow, and well into the future." At first glance, McDonnell Douglas' new F/A18E/F appears to be a 25-percent scaled-up C/D-model, sporting a longer fuselage and larger wing and tail. But looks can be deceiving.

The aircraft's fabrication, tooling and design is focused on radar signature reduction (the radar cross section is expected to be approximately that of the F-16). Military-industry documents and press releases tout its improved survivability, increased range and greater growth capacity. It is said that, comparatively speaking, the decrease in radar signature is similar to the move from the A/B-models to the C/Ds. Some say the E/F is one-tenth as likely to be detected by radar as the C/D. These efforts have been focused principally on the nose and tail aspects.

Detractors see few true examples of innovation. Critics point to the Super Hornet's predominately conventional profile as a serious design flaw. In light of stealth technology's essential role in the sophisticated battlefields of the future, this may be a valid point. Some detractors say it will not be nearly as survivable as either the A-12 or the A/F-X would have been.

Nevertheless, F-18 general manager Mike Sears counters the argument, saying that the aircraft "is not intended to be an invisible aircraft", but rather a compromise which offers low observability with affordability. Although the Super Hornet cannot be considered a stealth aircraft, it does benefit from advances in stealth technology, notably on the wing leading edges to augment the beneficial effect of skinning with large areas of carbon epoxy.

As a recent Jane's publication points out, the Hornet in this regard may be considered a "bridge" between Cold War fighter technology and the so-called fifth generation fighter.

This sentiment is shared by Secretary of Defense William Cohen who has said:

> Without the F/A-18 E/F we would be sending our pilots into combat at the turn of the century with the 1970s technology of the F/A-18 C/D... The Navy needs the F/A-18 E/F to bridge the gap from the older F/A-18 A/C and F-14 to the Joint Strike-fighter. The 20 F/A-18 E/Fs will deploy with battle groups in 2001, ten years prior to the earliest projected fleet debut of the Joint Strike-fighter.

Regarding “stealth” design changes, new features include:

- larger, rectangular, downward- and outward-angled inlets, which shunt radar returns away from the nose-on aspect;
- fixed airframe-mounted, radial vanes forward of the engine, which prevent radar energy from reaching the rotating fan;
- serrated edges on the main landing-gear and engine-access doors;
- diamond-shaped, laser-drilled metal screens covering all apertures; and
- coatings and other surface treatments.

4) Improvements and Innovations

The area of the twin vertical fins is increased by 15 percent. The rudder area is increased by 54 percent and the range of movement is such that they can be deflected 10 degrees more, up to 40 degrees. The tailplane, the area of which is increased by 36 percent, are made of improved composites. The areas of the leading-edge root extensions has increased by 34 percent in order to restore the degree of maneuverability at 30-35 degree alpha enjoyed by the current Hornet.

CAPT Joe Dyer, Director of the USN F-18 program, confirms that the aircraft's initial ECM suite will consist of the Hughes ALR-67(V)3 radar-warning receiver, Raytheon ALE-50 towed decoy and Tracor ALE-47 “smart” chaff/flare dispenser. The radar is the Hughes AN/APG-73 that is used by later-build F/A-18C/Ds. Indeed, the Super Hornet's avionics suite is 90 percent identical to the Hornet-C/D.

However, the F/A-18E/F crew station features a touch-sensitive, upfront control display, a larger LCD multipurpose color display and a new engine fuel display. The single seat F/A18E replaces the 5” x 5” central display with a new 8” x 8” flat panel active matrix LCD.

The two other 5” x 5” multipurpose CRT screens are retained, as is the existing HUD, except that the control panel just below it is replaced by a monochrome touch-sensitive screen. All displays (two CRTs, one color LCD and one monochrome LCD) are made by Kaiser. The rear cockpit of the F/A-18F has identical instrumentation, except it lacks a HUD. The 8” x 8” screen here is located above the landscape-format touch screen.

McDonnell Douglas demonstrated the E/F's versatility with its E-1 single-seater development aircraft, which was shown carrying six different underwing weapons: the AGM-88 high-speed anti-radiation missile (HARM), the AGM-84D Harpoon anti-ship missile, the AGM-84H standoff land attack missile (expanded response SLAM), the GBU-29 joint direct-attack munition (JDAM), the AGM-154 joint standoff weapon (JSOW) and the AGM-65E Maverick air-to-surface missile (see left).

Though weight has been increased to 30,500 lbs (13,864 kg), the aircraft is some 990 lbs (450 kg) under its specification weight. It has 33 percent fewer parts (11,789down from 17,210)—Boeing claims nearly half as many parts—and fabrication and assemblyman-hours are about 12 percent under budget.

About 27,000 employees in 3,200 companies participated in the R&D project. Northrop Grumman produces and assembles the F/A-18E/F's 26-foot-long center and aft fuselage, twin vertical tails and all associated subsystems at its Military Aircraft Systems Division facilities in El Segundo and Hawthorne, California. It is said that the aircraft was totally constructed by use of a solid-model-calculating computer system.

In fact, the company boasts of its having developed and introduced the world's first paperless aircraft assembly line. It is also alleged that advanced manufacturing techniques offer savings for manufacturer and buyer. These “revolutionary” changes include work cells, robotic X-ray inspection of parts and photogrammetric tool inspection. C/D-models being produced now (i.e., F/A-18s sold to foreign countries) benefit from these new techniques and designs.

As we have seen, the improvements in the Super Hornet are significant. Some more of these include:

- increased space for chaff and flares, allowing from 60 to 120 canisters;
- the fitting of a simplified, strengthened undercarriage, which enables takeoff weights as high as 66,000 lbs (30,000 kg);
- two extra underwing hardpoints (Nos 2 and 10)—located about two-thirds of span outboard of existing pylons—which raise total external stores' carriage capability to 17,750 lbs (8,068 kg); and
- completely redesigned trapezoidal engine air intakes, which replace the D-shaped intakes of earlier Hornets and provide 18 percent more air to new engines, enhancing high-speed performance.

Another change is the uprated, more powerful 97.9 kN (22,000-lb) thrust General Electric F414-GE-400 turbofans, with 35 percent more thrust than its F404 predecessor. It incorporates some of the features intended for the F412, the cancelled A-12 powerplant.

The wing is proportionally enlarged by 25 percent, with an increase in wingspan of 4 feet 31/2 inches, accounting for an increase of 100 square feet in area. The increase in wing size is accompanied by a deepening at the roots to take extra loads. The new wing has no twist or camber and is stressed for extra operating weight. The wing of the Super Hornet has an outboard leading-edge chord extension, leading to a definite “dogtooth” which is not present on the F/A-18C/D (but was early in the original Hornet development). There have been problems, however.

5) Troubled Development

Initial faulty wing design has been blamed for sudden uncommanded wing drops or “wing wobble” which occurred during 6 to 12-degree AOA and banking maneuvers. Defense News attributes this sudden loss of lift to apparent “turbulent separation in the transonic regime”.

Aircraft have been thrown into steep rolls. No crashes were reported due to this phenomenon, which first occurred in March 1996. According to Navy Secretary John H. Dalton, the seriousness of the wing drop rated “a two or three on a 10-point scale.” He told Congress on February 5th that, “We did not view it as a significant problem. “Traditional aerodynamic fixes (such as vortex generators) did not alleviate the problem. Quick, low-cost attempts included flight-control software changes, a 450-mm extension to the leading-edge flap and the installation of porous material along portions of the wing. These did not prove completely successful.

Both the Boeing Company and the USN hoped that this combination of software changes and simple wing modifications would provide a cure. It was feared that a more complex wing redesign, if required, could have delayed full-rate production of the F/A-18E/F. The GAO called for a halt until what it considered some 400 other deficiencies were fixed.

Nevertheless, in April 1998 DoD acquisition chief Jacques Gansler sent a memo to Defense Secretary William Cohen recommending Boeing be awarded the $8.8 billion multi-year contract for 222 units. Two months later, the GAO was still against the idea. It released a report based on 4,000 hours of testing. It identified 84 lingering deficiencies, citing problems in performance (its ability to accelerate, turn, climb and roll) and enemy missile detection in particular, that could cause the aircraft to fail its ongoing Navy evaluation.

The Pentagon is scheduled to decide in March 2000 whether to begin full production.

According to the Pentagon, a five-year purchase of 222 Super Hornets for $8.8 billion would save the Navy more than $700 million from 2002 through 2004. The Navy plans to buy as many as 548 aircraft at $55 million each. It already has bought 62 planes to be used for testing.

6) Increased Range and Bring-Back Weight

An extra fuselage plug increases the overall length of the F/A-18E/F by 2 feet, 10 inches (0.86 m). By enlarging the wing area and adding a fuselage plug, 3,600 lbs (1,636 kg) of additional internal fuel can be carried, which is 33 percent more than the capacity of the standard Hornet. Thus, range has increased by 41 percent and endurance by 50 percent.

Even with a gross weight increase of some 11,600 lbs (5,273 kg), maximum mission time has been stretched to some 2 hours, 15 minutes. For instance, a fleet air defense F/A18E/F carrying four AMRAAMs, two AIM-9s and external tanks could loiter on station for 71 minutes at a distance of 400 nm from its carrier. A similarly configured Tomcat-D must return to base 13 minutes earlier.

In addition, more robust gear allows a higher landing weight; that is, the aircraft may return to its carrier with unexpended ordnance—up to 9,000 lbs (4,091 kg)—without jettisoning its load. This represents an increase of 3,500 lbs (1,591 kg), or three times more, than the Hornet-C recovers. Considering the inflated cost of today's “smart weapons”, this offers obvious benefits. Super Hornets can be recovered with 3,960 lbs (1,800 kg) of fuel and almost 5,060 lbs (2,300 kg) of weapons at its maximum carrier-landing weight of 42,900lbs (19,500 kg). This does not consider the aircraft's 990 lbs (450 kg) under specification weight.

It is said that in a Desert Storm-type high altitude interdiction role (loaded with two 2,000lb Mk 84-based LGBs, two 'Winders, one AMRAAM, a targeting FLIR pod and two fuel tanks), the F/A-18E's combat radius is 621 nm—an increase of 125 nm over a like-configured F/A18C. Super Hornets use two 480-gallon tanks, whereas F/A-18Cs carry 330-gallon tanks.

Fuel consumption in this comparison includes aircraft warm-up fuel, catapult taxi and launch, climb to optimal cruise altitude, cruise to within 50 nm of the target area, accelerate to 540 kts, dash inbound at

540 kts to the target, air-to-ground weapons delivery, 540-ktdash 50 nm outbound, enemy aircraft engagement, a 360-degree turn at maximum afterburner, air-to-air weapons launch, climb to optimal altitude, cruise back, and descend to 500 ft for recovery on the aircraft carrier. This scenario considers enough reserve fuel for a 20-minute loiter at sea level plus a reserve of five percent total initial fuel.

On a fighter sweep mission with three AMRAAMs, two Sidewinders, a targeting FLIR and two fuel tanks, the Super Hornet's 664-nm radius exceeds the C's by 146 nm. In a CAP scenario at 200 nm, the Hornet-E remains on station 80 percent longer than the Hornet-C (1.8 hours vs. 1 hour). View the loadout table to see some various examples of what the Super Hornet can haul.

7) Summary

In most respects, the F/A-18E/F is not a revolutionary aircraft. There is validity to the argument that, in many ways, it is simply a larger, stealthier and heavier-hitting Hornet.

Still, from assembly line to battlefield, the Super Hornet is clearly an improvement over earlier models. Its decreased radar cross section, coupled with its increased range, endurance, weapons delivery and recovery, superior engines, avionics, countermeasures, fuel capacity and overall fighting capabilities make it a more difficult target to detect and hit and a considerably more lethal adversary.

In view of the likely nature of future conflicts, the Super Hornet will be called upon to fight a host of enemies in the air, on the ground and at sea, day and night, under all weather and climatic conditions anywhere in the world. While the end of the Cold War bipolar order fragmented the international system and instigated its own multitude of problems and challenges, the global intervention responsibilities of the United States and its allies, NATO and the United Nations remain constant. In this environment, the F/A-18 represents the mainstay of, in the words of CMDR Robert F. Wood Jr., F/A-18 Requirements Officer, America's “first day of the war” precision strike capability.

CDR Wood points to “relatively inexpensive and sophisticated surface-to-air defense systems in the hands of third-world rogue nations” as the principal threat to U.S. aircraft in the future, “not large numbers of expensive, fourth-generation enemy fighters”. This role punctuates the growing need for rapid-response and multi-role versatility in frontline 21st century air combat. The F/A-18 Super Hornet easily meets these requirements and will do so, according to an A/F-X analysis, by surpassing Hornet-C survivability by 87 percent. As fleet defender, buddy tanker, striker, fighter and reconnaissance platform, it will serve the Navy by tackling hotspots worldwide—well into the next century.

Section 2: Technical Specifications

A. Missions and Tasks

Primary manufacturer, The Boeing Company (formerly McDonnell Douglas Corporation), is responsible for the forward fuselage and wings. Major subcontractor Northrop Grumman produces the aircraft's center and aft fuselage sections, the twin vertical stabilizers and all associated subsystems. General Electric produces the engines and Hughes the radar systems. To date, this team has delivered over 1,400 Hornet strike-fighters.

With a unit replacement cost of some $36.5 million (F/A-18C/D) and $41.6 million (F/A18E/F), the F/A-18 Hornet has demonstrated itself to be one of the most cost-effective, safe, robust and efficient warplanes in military aviation history. With a sturdy time-tested 12,000-hour structural lifetime and more than three million flight hours (A/B/C/D-models combined) to its credit, the F/A-18 has proven three times more reliable and requiring half the maintenance of other fleet aircraft. In fact, during the Hornet's first 1.5 million flight hours, USN/USMC Hornet losses to accidents were 67, compared to 124 F-14s and 102 A6s. In addition, the USN director of air warfare says Hornet squadrons cost some $1,000less per hour to operate at about $17,200 per sortie (GAO figure).

The F/A-18 Hornet, the first tactical aircraft intended from inception for both air-to-air and air-to-ground missions, ultimately emerged as America's first strike-fighter. It was designed for traditional strike applications such as interdiction without noteworthy degradation in fighter performance. In fact, the Hornet's excellent fighter and self-defense capabilities have given rise to the term “self-escorting striker”.

All Hornet configurations may be sea-based (carrier-borne) or land-based from prepared airfields, advanced bases or expeditionary airfields (EAFs). The rather awkward and novel “F/A” prefix—meaning combined “fighter” and “attack”—became official in an April 1, 1984 DoD bulletin (however, McDonnell Douglas/Boeing has maintained its F-18 designation in all of its documents). As a multi-mission tactical aircraft, the F/A-18's primary functions are to attack and destroy surface targets, day or night, under all weather conditions; conduct multi-sensor imagery reconnaissance; engage and destroy enemy fighters and provide supporting arms coordination. In fighter mode, the F/A-18 is used primarily as an escort, combat air patrol (CAP) aircraft and fleet air defender.

In attack mode, it is used for force projection and deep and close air support (CAS). All F/A-18s can be configured quickly to perform either role and to accomplish specific mission types. This is accomplished through slight, but significant, modifications: through software means (in fact a single flip of a switch) and the selected use of other internal and external equipment. Such a “force multiplier” capability gives the operational commander more flexibility in employing tactical aircraft in a rapidly changing battle scenario.

The Marine Corps is the primary user of the F/A-18D, preferring the second crewman as a dedicated WSO. The USMC uses its F/A-18Ds as tactical striker, while the Navy considers them trainer aircraft. F/A-18Ds are deployed not only as strike-fighters, but also as airborne forward air controllers (FAC(A)), tactical air controllers (TAC(A)) and tactical reconnaissance aircraft.

Specific Hornet tasks include, but are not limited to, the following:

- armed and multi-sensor imagery reconnaissance/battle damage assessment (BDA), which includes pre- and post-strike target damage assessment and visual reconnaissance;
- radar search and attack;
- interdiction and strikes against enemy installations;
- support for forward air control;
- tactical air coordination;
- artillery/naval gunfire spotting;
- air superiority and enemy aircraft interception in conjunction with ground and airborne fighter direction;
- battlefield illumination and target illumination;
- armed fighter escort of friendly aircraft, which supplements the F-14 Tomcat as fleet air defender; and
- extended range operations employing aerial refueling.

The torrent of accolades notwithstanding, one must bear in mind that the Hornet is fundamentally a design and performance compromise. World Air Power Journal went so far as to call it a “jack of all trades, master of none.” In principle, this is certainly true, but perhaps unfairly pejorative.

Multi-role and multi-mission capability doesn't imply absolute mastery, just cool competence—nothing more. The Hornet is not a “diluted” fighter with strike capability or a diminished attack plane with air-to-air ability. Granted, it may not be considered a “master” in either role, but it certainly ranks among the best, in either class, against virtually any conventional competition anywhere. There are, however, some valid complaints. One Gulf War Marine pilot has said:

We need to start buying airplanes more like the Air Force, with the full set of gear. Instead, we buy Cadillac with roll-up windows, like the F/A-18 with unsatisfactory radar warning receivers, expendables [e.g., chaff and flares] and [missile and bomb] racks. I would give up one of the 12 aircraft in my squadron in order to fully equip the other 11.

Indeed, it is an ageing aircraft. William Cohen, Secretary of Defense, rightly recognized in 1997 that Hornet-C/Ds with 1970s technology wouldn't cut it in a 21st century air combat zone. In addition to retrofits, upgrades and improvements on the existing Hornet airframe, procurement of a wholly new aircraft was considered paramount to the Navy. Enter the F/A-18E/F Super Hornet.

True, with the Hornet's combat role increasing, detractive sentiment may become more pronounced. Particularly in light of the 1997 retirement of the A-6 Intruder fleet, F/A-18s will be called upon to carry the bulk of USN strike tasking. Tomcats are being outfitted with LANTIRN (Low Altitude Navigation Targeting Infrared for Night) FLIR pods and other air-to-ground enhancements for LGB-delivery capability from high and medium altitudes. TheseF-14 night-time precision improvements (once thought to produce a new F/A-14 designation), will complement, but not entirely alter, the Hornet's strike predominance.

In addition, it will be early in the 21st century before sufficient numbers of Super Hornets enter service to alleviate the burden, still longer for the JSF and other advanced tactical fighters. Like it or not, ready or not, the Hornet will form the backbone of U.S. naval aviation for the foreseeable future.

For actual examples of F/A-18 combat missions, see the sections on Operation Prairie Fire/El Dorado and Operation Desert Storm.

B. Powerplant and Fuel System

1) The F404 Turbofans

As the proto-Hornet matured, it grew increasingly heavier. The fuselage was widened and lengthened, the wing surface expanded, the landing gear and undercarriage reinforced. Asa result, more powerful engines were needed to propel the aircraft. Thus, the YF-17's two15,000-lb. static thrust (lb.s.t.) GE YJ01 turbofans were replaced by their F404-GE-400 derivatives. Each F404 is rated at 16,000 lbs.s.t. with afterburner.

The F404 is an augmented, dual rotor, low-bypass “true” turbofan, rather than a “leaky “turbojet as the YJ101. Weighing half as much as the YJ101, it has essentially the same thrust as the J79 turbojet (bypass ratio increased from 0.20 to 0.34). It does, however, consume more fuel.

Fed by a non-variable air intake with splitters, the engine has a three-stage titanium fan, with one row of fixed inlet guide vanes and one row of variable guide vanes. It is of modular construction, comprised of the fan, high pressure compressor, combustor, low pressure turbine and afterburner modules, plus an accessories gearbox. The unit is slightly toed to align the nozzles.

In addition, the combustor is a through-flow annular type, and the augmenter is fully modulating from minimum to maximum augmentation. The engine control system regulates speeds, temperature levels and fuel flow for afterburning and non-afterburning operation. The lubrication and ignition system are self-contained on the engine. The tailpipes are of variable area type.

They have variable geometry inlet guide vanes on the fan and compressor, and continuous bypass from the fan to the augmentation section. Of the compressor's seven stages, the first three have variable stators. A single-stage low pressure turbine drives the fan, while a single-stage high-pressure turbine drives the 7-stage axial flow high-pressure compressor. Overall, the F404 engine is fairly simple, with relatively few moving parts. Compared to other recent turbofans, the F404 has experienced rather few developmental problems. In particular, it demonstrates high resistance to compressor stalls, even at high alpha. If an unlikely stall should occur, engine and afterburner relight is automatic.

Engine response is remarkable, with spool-up from idle to full afterburner in just three to four seconds. However, acceleration time from Mach 0.8 to Mach 1.6 was originally longer than required. Although some progress has been made in improving this response time, the problem has persisted in spite of numerous attempts to fix it. An In-flight Engine Condition Monitoring System (IECMS) continuously monitors the engine for critical malfunctions and parts life use.

Under emergency conditions, flight is possible with just one engine, for Hornets are dual- engine aircraft. Each unit is 4.03 m long and .88 m in diameter and interchangeable left to right. A/B-models are equipped with F404-GE-400s, each rated at 10,600 lbs.s.t. dry(15,800 lb.s.t. wet, or afterburning). C/D-models were initially outfitted with the same 400s, but later these engines were replaced by the -402 EPE (Enhanced Performance Engine) rated at 18,000 lbs.s.t. (8,145 kg) with afterburning per engine. This upgrade began in January 1991 with Block 36, providing engines which produce up to 20 percent more thrust (36,000 lbs. combined). The 400-series engine is also integral to the X-29, X31, Rafale (single engine), A-4 and USAF F-117.

The new engines pushed the aircraft's top speed at high altitude to Mach 1.8 (less than that of the F-15 and F-16 which exceed Mach 2). Combat thrust-to-weight ratio is greater than one-to-one. Hornet-E/Fs use enhanced generation -400s rated at 22,000 lbs.s.t. (9,955 kg or 98 kN) with afterburning per engine. The -400s have the same length (159 inches), diameter (34.5 inches), inlet flow path diameter (27.7 inches), nozzle area ratio (1.6) and air flow at IRP and above (140 lbs/sec). By summer, 1998 it was reported in Flight International magazine that GE was trying to increase the Super Hornet's -414 engine by another 25 percent. The first two production engines were delivered in August, 1998.

F404 Series Engine Specifications		
	A/B-models (-400)	**C/D-models (-402)**
Max thrust (lb)	16,012	17,775
Max RPM (HPC/LPC)	16,464/13,688	16,728/13,747
Max turbine discharge temp (F)	1,466	1,581
Airflow (lb/sec)	141.5	146.5
Fan pressure ratio	3.9	4.3
Compressor pressure ratio	6.3	6.23
Weight, dry (lb)	2,185	2,282
Weight, wet (lb)	2,237	2,239
Engine compression ratio	25 to 1	27 to 1

A Hornet's engine can be completely replaced and the aircraft back in action in as little as two hours (the A-7E, for example, requires at least six). Harriers are even worse.

2) The Fuel System

In order to provide more space for internal fuel, the width of the aft fuselage of the Hornet was increased by four inches over that of the YF-17, the engines were canted outwards at the front and the fuselage spine was made significantly wider and taller. However, the Hornet lacks the internal fuel capacity of larger U.S. twin-engine combat aircraft (such as the F-15), due to space economy considerations for carrier operations. To make room for the second seat in Hornet-Bs and Ds, internal fuel capacity was reduced still more by some six percent.

Total housed internal fuel is 1,487 gallons (5,635 liters). This translates to 10,110 lbs (4,591 kg) of standard USN JP5 fuel or 9,670 lbs (4,395 kg) of standard USAF and Canadian JP4 fuel. The difference is fuel density). The bulk of the aircraft's internal fuel is housed in its main fuel tanks (containing 426, 249, 200 and 530 gallons) in the swollen dorsal spine.

These tanks are installed in a row (Tank 2 forward, Tank 3 aft) beginning just behind the cockpit and ending just forward of the engines (no fuel is stored between the engines).

Tanks 2 and 3 feed the left and right engines respectively. The 96-gallon (364-liter) wing tanks, 1 and 4, are transfer tanks. Fuel is always burned in sequence: externals first, then the feed (wing) tanks, followed by the transfer (body) tanks.

Although fuel consumption varies with throttle settings and loadout burdens, a fully loaded Hornet can be forced to refuel after only 30 to 40 minutes in the air. For example, a carrier-launched F/A-18C with ordnance and a gross takeoff weight of 40,700 lbs (13,000 lbs of which is internal plus a 330-gallon belly tank) will get approximately .085 nm per pound of fuel. The Hornet's range limitations mean it almost never is flown without at least one external tank, diminishing the number of the aircraft's pylons devoted to bomb-loads. This also makes the F/A-18 particularly reliant on aerial refueling. The single retractable probe and hydraulic jack for the standard probe/drogue in-flight connections is positioned in aflush housing on the starboard side of the fuselage just forward of the windshield.

External tanks may be made of fiberglass or metal. Those of metal construction, however, are restricted on carriers and limited to land-based flights. All tanks and fuel lines are self-sealing, with reticular foam in the main tanks (to suppress possible fire and/or explosion).

The soft inner surface closes after projectile penetration but is less effective against punctures any larger than relatively small-caliber rounds or shrapnel (like most SAM-induced damage). The fuel feed lines in the main gear wells are also wrapped with a self-sealing shell. Tank baffles provide some limited fuel supply in negative-G flight, but there are no provisions for sustained negative or zero-G flight. High Gs are handled by boost pumps.

Full-scale development (FSD) F/A-18s used 315-gallon, elliptically shaped drop tanks. Carrier catapult systems at the time, which were not flush with the deck, were considered incompatible with external belly tanks larger than 300 gallons, due to clearance concerns. However, problems associated with the 315-gallon tanks, coupled with the subsequent conversion of all U.S. carriers to flush deck catapults, prompted the introduction of the now standard 330-gallon (1,250-ll) tank for Hornet-A/B/C/Ds.

When not devoted to ordnance, the two inboard underwing stations (Stations 3 and 7) can also carry these tanks, with only the outermost of the underwing pylons fitted with offensive weapons. The outboard SUU-23 pylons (Stations 2 and 8) are fully capable of carrying empty tanks, but this is extremely rare (likewise for the Super Hornet's Stations 2 and 10).

A belly tank is also often suspended from the SUU-62 pylon at centerline Station 5. Although three such tanks usually suffice for ferry ranges out to some 2,000 nautical miles (3,700 km), 480-gallon tanks can be substituted on any or all three stations. Super Hornets use this larger tank as standard.

During initial introduction of the Hornet-A, McDonnell Douglas sought to develop a conformal external dorsal tank. It would have added only 300 lbs (136 kg) of empty weight, while providing an additional 3,000 lbs (1,361 l) of internal fuel. In 1996-97 at its Patuxent River, Maryland test center, McDonnell Douglas tested the viability of replacing the 330-gallon external tanks with the doubly larger 660-gallon

(2,270 l) tanks. The Hornet's export clientele around the world have the option of purchasing this new addition, but the USN and USMC have opted out, for the bigger tanks are deemed incompatible with carrier operations.

Upgrading to Hornet-C/Ds brought the benefit of computer and sensor “square balancing.”

This system monitors and evenly distributes fuel throughout the aircraft. There are two types of automatic fuel-level sensors: float and jet level. The former is associated with tank refueling, the latter with fuel transfer from Tanks 1 and 4 to 2 and 3 during flight/engine run. This frees the pilot from the tedium of manually managing fuel balance. However, there is no a reserve as such, just the pilot's attentive monitoring of the fuel gauge. Cockpit fuel displays range from 300 to 15,000 lbs/hour.

Over the years, Hornets have experienced various difficulties with their engines, fuel systems and fuel displays. One example found in most, if not all, of the air forces operating the F/A-18, has been a recurring engine fire problem. Strongly suspect is these fires is the fuel recirculation system, which cools the AMAD (Airframe Mounted Accessory Drive, the motive flow pump power source) and the hydraulic 1 and 2 oil. Also check out other bugs and bug fixes.

Another aggravation concerns the cockpit fuel display, which alerts the pilot to fuel consumption rates, bingo and other related data. “Bingo” refers to a minimum fuel for a comfortable and safe return to base. Aircraft can fly and fight past bingo fuel in combat situations, but at considerable peril. Aviators typically set an initial bingo value higher than required by the actual task for just this reason. When the “Bitchin' Betty” aural warning announces “Bingo, Bingo”, the pilot re-sets a “real bingo” accordingly, realizing he'll soon be turning for home.

Ironically, this simple procedure was slowed and complicated by those tasked with making the Hornet pilot's job easier and more efficient. According to engineer Mark Shanks, former Hornet Chief of Human Factors (1986-1991), McDonnell Douglas made a mistake when it replaced the simple, “easy to read, easy to use” crescent-shaped analog gauge with a LCD display called the IFEI (Integrated Fuel/Engine Indicator, pronounced “EYE-fee”).

Characterized by “poor LCDs”, this new digital display (still added to production F/A-18C/Ds as of this writing) proved more difficult to read and use. Not only did it require the pilot to take his hand off the throttle and stare at the display for some time, but it considerably slowed assimilation of the readout information itself. It was, in fact, so hated by one operation squadron that its pilots simply removed it, referenced the fuel display on the DDI and used the hole in the main instrument panel (MIP) as a sort of “glove compartment”!

Of course, the most prominent and often criticized shortcoming has been the aircraft’s persistent range limitations. Although this is an adverse function of the whole plane’s aerodynamic properties, weights and overall design, the fuel/propulsion system is most readily blamed. In a real sense, poor range pertains to much more than simple hindrance in raw sortie distance. Among other factors, this constricts how long it can remain on station, at what optimal altitudes it can operate, what ordnance tonnages it can ferry and how much and often it much tax logistics with aerial refueling demands.

Even following initial trials at NATC Patuxent River in Maryland and follow-on test and operational evaluations by test squadrons VX-4 “Evaluators” and VX-5 “Vampires” at PMTC Point Mugu and NWC

China Lake, California, the Hornet's range limitations were already apparent. In fact, VX-5 recommended against procurement. In a pinch to replace the A-7, however, the Navy proceeded anyway.
Later, despite the introduction of slightly larger external tanks, this oft-cited flaw has persisted to some degree to present day. The Canadians, for example, have flown F/A18C/Ds with still larger tanks than their American counterparts, suggesting longer independent range solutions by maximizing the existing airframe. However, greater ranges in the E/F-models, which are significantly bigger and house more fuel, have superseded these problems with a totally new aircraft. The F/A-18 E/F is 25 percent larger, and expected to fly 40 percent further, remain on station 80 percent longer, carry almost 4,000lbs more weapons and deliver 2.5 times more payload in a ten-day strike campaign than the F/A-18C/D.

C. Armament and Weapons Loadout

1) The Vulcan Cannon

Mounted internally in the aircraft's nose directly in front of the cockpit windshield, it is the only permanently attached weapon system in the F/A-18. Whether employed against airborne quarry in aerial combat or in strafing runs directed against "soft" ground-based targets, this single six-barrel rotary cannon delivers highly destructive bursts of 20-mm semi-armor-piercing high-explosive incendiary (SAPHEI) fire. The gun's 578 M50 series 20mm PGU-28/B rounds are stowed in a cylindrical ammunition drum just aft of the radar set.

2) External Stores Overview

As potent as the Hornet's internal close-in gun is, its range and destructive force pale in comparison to the firepower, accuracy and standoff capabilities offered by externally mounted weaponry. The multi-role F/A-18's impressive armament repertoire represents the broadest array of air-to-air and air-to-ground ordnance and all-round capability of any modern single-seat combat aircraft. The aircraft can rapidly toggle back and forth between air and ground strike roles quite literally with the flick of a single switch.

The Hornet can carry 13,700 lbs (6,227 kg) of stores on nine external weapons hardpoints: one at each wingtip, two underneath each wing, one on each corner of the fuselage just aft of the air intakes and one at the centerline ventral fuselage station. For Super Hornets, two extra underwing hardpoints (Nos 2 and 10) added about two-thirds of span (outboard of existing pylons), raise total external stores carriage capability to some 17,750 lbs (8,068kg) on 11 hardpoints.

As of printing time, the Super Hornet's flight test data on loadout possibilities are largely inconclusive. However, takeoff weights have already exceeded 33 tons. At NAS Patuxent River, Maryland, Northrop Grumman test pilot Jim Sandberg flew test plane E1 with an "Aero Servo Elasticity" stores configuration weighing in at 62,400 lbs (28,364 kg). This loadout comprised three 480-gallon tanks, two 2,000-lb Mk 84 bombs, two AIM-9s and two HARM missiles. Compare this to the Hornet's maximum gross takeoff weight of 51,900 lbs (23,537 kg), an increase of 10,500 lbs (4,287 kg).

Whereas all these hardpoints are capable of receiving various offensive weaponry, they infrequently do so operationally. One reason is the F/A-18's propensity for high fuel consumption. As one of the Fleet's more consistent "gas hogs", Hornets rarely undertake a flight without two, or even three, drop tanks. Usually wing stations 3 and 7 are devoted to them, consuming some 4,400 lbs (2,000 kg) of loadout weight outright (for 450-gallon tanks this figure is 7,160 lbs (3,254 kg)). The centerline station is usually empty or outfitted with a tank. In addition, the two intake stations are often reserved for sensors. This leaves but the two outboard wing pylons and wingtip rails for ordnance.

Mission parameters dictate what weapons loadout configuration will fill these vacancies. In practice, this means many variations and combinations of weapon classes, configurations, sizes and weights may be employed at any given time, depending upon the task at hand.

In addition, to various sensors and fuel tanks sizes, the Hornet is capable of carrying and/or launching an impressive array of disposable stores and external gear. These include air-to-air missiles (AAMs), air-to-surface missiles (AGMs), freefall bombs, guided bombs, dispenser weapons, napalm canisters and ECM pods.

The SUU-63/79 pylon is angled downward to allow the flaps to be fully lowered. Removable from stations 2, 3, 7 and 8, it can carry up to 2,600 lbs (1,182 kg) of certain kinds of stores. Its internal BRU-32 bomb rack can be mounted with a vertical ejector rack (VER), multiple ejector rack (MER) or triple ejector rack (TER). Internal bomb racks are permanent and are not removed for drop tank or missile loadouts. MERs/TERs are only authorized to carry small practice bombs, Mk 58 marine locator markers, LUU-2 paraflares, laser guided training rounds (LGTRs) and ADM-141 Tactical Air-Launched Decoys (TALDs).

MERs/TERs loaded with Mk 82 500-lb bombs are strictly airshow loads and not used operationally. The maximum VER-mounted bomb-load consists of two Mk 82/83s. Otherwise, each pylon can carry only a single store from 10 to 28 inches in diameter. The centerline (Hornet Station 5/Super Hornet Station 6) SUU-62/78 pylon has the same internals the wing pylons. Although this station can carry various sensors and munitions, including bombs, it is incapable of carry missiles. The centerline hardpoint does not accommodate the BRU-32/A but can be outfitted with TER-mounted TALDs.

This applies to the Super Hornet as well, which can deliver almost two tons more weapons than the F/A-18C. The F/A-18E/F's new outboard stations, however, are only half as capable, limited to ordnance no heavier than 1,150 lbs (523 kg) per station. In the strike role, this precludes the Hornet E/F from carrying on these pylons certain nuclear weapons and a number of heavy precision-guided munitions that exceed hardpoint weight specifications. These include the Harpoon, Joint Standoff Weapon (JSOW), Standoff Land Attack Missile (SLAM), Mk 84 bomb, the GBU-24 and Walleye II. Consequently, the F/A-18E/F will carry the same number of these heavier precision-guided munitions as the F/A-18C/D.

The Super Hornets pylons are designated SUU-78 (centerline station), SUU-79 (the two pylons closest to the fuselage on both sides) and SUU-80 (the outboard-most station near the wingtips). Like the SUU-62/63, all have a BRU-32 bomb rack installed. Apparently, the SUU-80 can be used on the SUU-79 stations, but this limits carriage due to the aforementioned weight limitations. It is highly unlikely that this would ever be operationally implemented for obvious reasons.

An improved and wider version of the VER in use is the BRU-33A canted vertical ejector rack (CVER). This system angles attached ordnance five degrees outward and more efficiently horizontally separates and ejects them. At present, a new pneumatic bomb rack underdevelopment at Boeing's St. Louis-based Phantom Works is said to be quite an improvement over other models. It is cheaper, lighter and more durable. Attaining 20 percent higher ejection velocities, it uses clean, dry air rather than the explosive gas cartridges of current racks. It is also being tested on F-15s. Consult the paper’s Loadout Reference.

3) Air-to-Ground Weapons

Most of what a Hornet does is air-to-ground. When a loadout reflects this mission focus, it nonetheless typically includes a pair of wingtip-mounted Sidewinders for defensive purposes (however, Marine F/A-18Ds in Desert Storm removed them when the Iraqi air-to-air threat was deemed to be non-existent). Five/seven hardpoints (the four/six wing-mounted pylons and the centerline) may be devoted to A/G ordnance. These fall into two main categories: unguided ("dumb") and guided ("smart") munitions.

Unguided munitions take the form of Mk 80 series general purpose bombs (GPB), cluster bomb units (CBU) and rockets. The aircraft can employ up to 10/12 general purpose gravity or cluster bombs (on the four/six underwing pylons and centerline station) against a variety of targets from tank formations, naval targets and buildings to bridges, airfields and bunkers. Mk 82/83 GPBs and their derivatives are carried on twin-store vertical ejection racks (VER-2s). Mk 82, 83 and 84 "iron" bombs weigh respectively 500, 1,000 and 2,000 lbs (227, 454 and 909 kg) each.

Mk 82/83s are appropriate for "tank-plinking" and strikes against gun emplacements, barracks, plants, etc. Mk 84s pack more punch and are primarily considered "bunker-buster" fare. As bomb-loads separate from the aircraft, the Hornet "shudders and leaps" as the FBW system scrambles to adjust to the dramatic weight distribution change and new flight dynamics. Of course, this is most pronounced with Mk 84s. If anywhere near the explosion(s), the F/A-18 will be roughly buffeted a second time by the blast wave.

These bombs can also be provided with Mk 15 Snakeye fins to retard their fall. These four metal tail blades (mostly added to Mk 82s) open on launch to provide time for the Hornet to clear the area ahead of the fragmentation envelopes of low-level bombing run blasts. Another modification is the BDU-54 "balute" (a balloon-parachute combination). "Slick "versions (non-retarded) have less drag and are used for higher altitude deliveries or lofting. The F/A-18 can also carry two 5 kT-10 kT B57 fission or 10 kT-100 kT B61 boosted fission tactical nuclear weapons. Needless to say, a nuclear strike is not a typically envisaged Hornet mission.

Cluster bomb units (CBUs) are sub-munition weapons that deliver bomblets, fuel air explosives (FAE) or mines from altitudes of 400 to 40,000 feet. With the exception of sensor-fused weapons, they are unguided munitions designed to cover wide areas using various detonation methods against both general and specific target types. The most common CBU dispenser is the Mk 7.

All but the innermost of the F/A-18's stations can accommodate the 468-lb CBU-59B Rockeye II (with its 700 anti-tank bomblets) or the 610-lb BL-755 CBUs. The CBU-87B/BCEM (Combined Effects Munition), one form of the Mk 7 cluster bomb dispenser, releases 202 bomblets over an area of 800 x 400 ft, whereas the 500-lb Mk 20 Rockeye delivers 247Mk 118 dart-shaped bomblets over an area of 3,300 square yards. The same dispenser allows the CBU-78 GATOR to spread 45 anti-tank and 15 anti-personnel mines. The F/A-18 has also successfully tested the initial AGM-154A variant. This weapon dispenses 145 Aerojet/Olin BLU-97 CEM bomblets over area targets, such as revetted aircraft and air defense radars.

Among a host of others, Hornets can also use Mk 55 Bottom mines, Mk 65 Quickstrike mines and Mk 60 CAPTOR encapsulated Mk 46 torpedoes. Mk 77 fuel gel canisters, or napalm “fire bombs”, may be employed, but are not authorized with carrier operations.

They are restricted to shore-based flights.

Unguided folding-fin aircraft rocket (FFAR) pods are also part of the F/A-18 inventory. These include the LAU-10 4-rocket (5-inch Zuni) pod and the LAU-61 19-tube and LAU-687-tube 2.75-inch versions. All use the standard A/G strafing sight and may be singly or twin-mounted on the outboard hardpoints (the LAU-10 can be inboard pylon-mounted as well). None of these pods can be directly attached to the SUU-63/79 pylon, and therefore always require VERs and CVERs. Twin-mounting is achieved through use of the LAU-115 adapter. USMC Hornet-Ds in the fast forward air controller (FAC) role during the Persian Gulf conflict fired 5-inch Zuni rockets as target markers. Their white phosphorous warheads indicated Iraqi positions to other aircraft.

The Hornet's external (optional) laser target designator and ranger enables the delivery of highly accurate precision-guided munitions (PGMs). One such PGM class is the GBU, or guided bomb unit (also known as “glide bombs”). Kits add special nose sections (consisting of a semi-active laser homing seeker, guidance electronics and control fins) and tail sections (consisting of a set of folding stabilizer aerodynamic surfaces) to normal Mk 80 series ordnance. Laser, inertial navigation system (INS) and/or global positioning satellite (GPS)in-flight guidance continually updates the bomb's controlled fall to target.

Examples of these are the Mk 82-based 610-lb GBU-12B/C/D Paveway II LGB; the Mk 83based GBU-16B/B and C/B Paveway II LGBs; and the Mk 84-based 2,081-lb GBU-10 and “bunker-buster” 2,350-lb GBU-24B/B Paveway III LGB (as a result of Operational Flight Program 10A (OFP-10A) improvements, upgraded Hornets will be able to carry and release this hard target penetrator). Version III was developed in 1981 for low altitude delivery, with high-lift folding wings and an improved guidance system. Hornets can also use the AGM-123 Skipper, a powered version of the GBU-16, or AGM-62-derived Hughes Walleye IIER/DL electro-optical guided bombs on the outboard wing stations.

The latest in this class is the GBU-40, formerly known as the Joint Direct Attack Munition(JDAM) in the U.S. Navy. These bombs are said to have a range of 15 miles and enhanced adverse weather precision. The JDAM kit adds a new tail section with a GPS/INS control unit. It is intended for existing inventories of Mk 83 and BLU-110 1,000-lb bombs, and the Mk 84 and BLU-109 2,000-lb bombs.

Missiles comprise the final major category in this air-to-ground class. F/A-18s are capable of hauling four Texas Instruments AGM-88A high-speed anti-radiation missiles (HARM) for “Iron Hand” suppression of enemy air defenses (SEAD) missions. These are connected via the LAU-118/A launcher (providing the required umbilical interface), which is in turn attached to a BRU-32/A bomb rack. The AGM-45 Shrike, the forerunner of the HARM, is also employed against radars and SAMs in conjunction with the Hornet platform. The AIM-122A Sidearm anti-radiation missile can replace wingtip Sidewinders. These are essentially AIM-9C variants with the infrared seeker head replaced by a broadband passive radar-homing device.

In addition, F/A-18s can carry four Hughes AGM-65 Maverick television-guided missiles. Later versions of the Hornet can accommodate the infrared-homing 675-lb version of this missile as well. Hornets can also be configured to carry two over-the-horizon AGM-84D Harpoon anti-ship missiles with their range of around 70 nautical miles. The AGM-84E SLAM and SLAM ER (expanded response) missiles are Harpoon-derived, Maverick-seeker headed standoff weapons, with ranges of over 50 and 150 nautical miles respectively.

The Hornet is also cleared for use with the AGM-154A/B/C Joint Standoff Weapon (JSOW)[pictured above]. According to Flight International magazine, the baseline JSOW-A is outfitted with 145 combined effects bomblets. Under development are the B-variant, with six sensor-fused anti-armor sub-munitions, and C-variant, with a 500-lb (225-kg) unitary warhead.

4) Air-to-Air Weapons

In addition to delivery capability for virtually every air-to-ground weapon in the Navy/Marine arsenal, the primary air-to-air weapons are the AIM-7 Sparrow semi-active radar-homing (SARH) missile, AIM-9 Sidewinder infrared-homing missile and AIM-120 AMRAAM (Advanced Medium Range Air-to-Air Missile). If not singly parent-mounted on the SUU-63/79 pylon, without exception these all directly or indirectly make use of the LAU-115 adapter mount.

The LAU-115 adapter requires the same type missile; they cannot be mixed and matched on the same pylon. Also, the mountings and firing systems, for example, are different for Sidewinders and AMRAAMs. Sidewinders are attached via LAU-7 rails to LAU-115 adapters on the SUU-63/79 pylon. AIM-120s and AIM-7s are directly attached to the LAU-115A/A and LAU-115A respectively.

Double AMRAAM loads are attached to the SUU-63/79 pylon’s internal BRU-32 bomb racks via a LAU-115 with twin LAU-127 launchers.

The AIM-9, like the 20-mm M61 cannon, was retained from the YF-17. The “fire and forget” AMRAAM, however, which may have teamed with the F/A-18 as early as December 1987, was not cleared for use with the Hornet until after Desert Storm (officially September 1991). In active Fleet service since their Hornet debut aboard the USS ABRAHAM LINCOLN (CV-72) in late 1993, it has almost entirely superseded the Sparrow as the F/A18's primary beyond-visual-range (BVR) weapon. It combines the BVR performance of the AIM-7 in an airframe not much larger than the AIM-9. Hornet-A/Bs, however, are incapable of using the AIM-120.

All Hornets incorporate a corner station underneath both sides of the fuselage. When the aircraft operates in an air-to-air configuration, AIM-7s are cupped by the C-shaped LAU-116 ejectors on the intakes. These stations alternatively carry FLIR and laser designation pods when operating in attack mode. For visual-range encounters, F/A-18s can haul two Sidewinders on each of their outboard underwing stations and one on each LAU-7 wingtip rail (totaling six for Hornets and eight for Super Hornets).

Alternatively, the aircraft can carry as many as four Sparrows, one on each side of the fuselage (LAU-7s) and one on each outer underwing pylon via LAU-115As (this figure likewise jumps to six on the E/F-models). As an interceptor, a10/12-missile loadout of eight AIM-120 AMRAAM Inertial Guided/Active Radar Homing(IGARH) missiles and two AIM-9 Sidewinders is possible. This loadout uses the LAU-115A/A adapter on the four/six underwing points.

Also, F/A-18s delivered large numbers of the ADM-141 decoys during the Gulf War to expose Iraqi anti-air positions. TALDs proved to be an effective tactic in fooling enemy air defense radars, causing them to energize and thus become vulnerable to SEAD aircraft. These can be twin or triple mounted on C/VERs and TERs.

5) Sensor Pods

Hornets in ground attack mode operate various external sensor gear. Usually, the fuselage corner intake stations (Stations 4 and 6), ordinarily occupied by AIM-7s when the aircraft operates in fighter mode, are alternatively devoted to this equipment. Intake LAU-116s, which eject missiles away from the aircraft, are not removed before installation of sensors.

Such pods include the Ford Aerospace AAS-38A/B Nite Hawk forward-looking infrared (FLIR)camera, the Hughes AAR-50 thermal imaging navigation set (TINS) and the Martin-Marietta ASQ-173 laser detector tracker/camera (LDT/CAM). The TINS, also called Navigation FLIR or NAVFLIR, and the LDT/CAM, formerly known as the laser spot tracker/strike camera(LST/SCAM), are both mounted on the starboard fuselage (Station 6). In contrast, the AWW-9/13 advanced datalink pod for the Walleye I/II ER/DL (as well as the SLAM and SLAM ER) is mounted on the ventral centerline.

The AAS-38 targeting FLIR unit, or T-FLIR, is mounted on the port fuselage (Station 4). It enhances night attack capability (often in conjunction with NVGs) by providing real-time thermal imagery, which is displayed on one of the cockpit CRTs. The FLIR can be fully integrated with the other avionics of the F/A-18 and data from it can be used in the calculation of weapons release solutions. It also is capable of laser designation for laser-guided munitions delivery. The only four of these available during the Gulf War were used by VMFA(AW)-121. The improved AAS-38A was cleared for Fleet service on Hornet-C/Ds in January 1993. It is officially referred to as the laser target designator/rangefinder (LTD/R).

The AAR-50 NAVFLIR (TINS) is usually associated with night attack Hornets. It is a fixed FLIR with no designation capability and is therefore used only for night navigation purposes. Its raster video displayable on the HUD. Officially cleared for Fleet duty in October 1992, the unit was in training status with VMFA(AW)-121 already two years earlier.

The ASQ-173 LDT/CAM was developed from the USAF's Pave Penny pod. It is used for accurate bombing in bad weather but is day-only gear. This pod lacks the capability to laser illuminate autonomously. Rather its passive tracking device locks onto reflected laser energy from a pre-designated target, whether lased by ground troops, other aircraft or the Hornet’s own targeting FLIR on the other side of the fuselage. It then relays symbology to the HUD and target location information to the cockpit displays and mission computers. A35-mm strike camera in the rear section of the ASQ-173 aids in battle damage assessment(BDA). It has a 35-degree field of view and pans 180 degrees.

6) Future Growth

The Hornet is a dynamic weapons-delivery platform insofar as it readily accommodates most new ordnance and sensor technologies (provided they don't exceed the aircraft's weight limits). For example, Hornets were slated to carry the Northrop Grumman Tri-Service Standoff Attack Missile (TSSAM) before its cancellation. Along with F-16C/Ds, it is expected that F/A-18s will now deliver a standard load of two Air Force-Navy JASSMs (Joint Air-to Surface Standoff Missile). These TSSAM replacements have a touted range of over 180 miles, pin-point accuracy, small radar signature and 1,000-lb warhead.

Another future weapon is the AGM-154 Joint Standoff Weapon, a glide munition intended for heavily shielded targets, such as reinforced bunkers. The first Hornet launch took place on March 8, 1994 with NF/A-18A (BuNo 161925).

D. Cockpit and Electronics Suite

1) Introduction

The F/A-18 was primarily envisioned as a single-seater, without a GIB to aid with many duties. Reduction of the pilot's workload through extensive automated systems became paramount. The resulting Hornet cockpit—among the most advanced in the world when it entered service—does much to accomplish this goal. Its canopy provides excellent visibility and opens upward from a separate windscreen. Inside the “glass” cockpit, a pressurized and environmentally controlled

Many of the dial-type instruments are eliminated in favor of cathode-ray tubes (CRT) and liquid crystal displays (LCD). The control panel is dominated by two multi-function CRT displays or DDIs (Digital Display Indicators) and a single horizontal situation CRT display.

The cockpit is 40 percent smaller than the A-7's and is almost eight times more compact than the F-4's, both of which the F/A-18 replaced.

The pilot is provided with a hands-on throttle and stick (HOTAS), with all the controls required for combat located on either the throttle lever or control column for easy access. This means that the pilot need not take his eyes off his target(s) during the stresses of combat or reach around the cockpit.

The pilot sits on a non-reclined, microprocessor-controlled Martin Baker zero-zero rocket-assisted ejector seat (“zero-zero” means deployment is possible even at zero airspeed-zero altitude, or essentially at rest on the ground). These “bang seats” have saved many pilots'

lives, mostly during peacetime carrier operations. Ejections normally take place after a “flameout” (when one or both engines lose ignition and power), following a “cold cat” (when the steam catapult fails to impart sufficient takeoff speed) or as a result of combat damage, botched landings or other emergencies.

2) Night Attack Hornets

As their D-model counterparts, F/A-18Cs since BuNo 163985 are easily recognized by their gold-tinted canopies. This night attack suite allows the F/A-18 to conduct operations below weather and at low altitude aided by infrared (IR) equipment. The F/A-18C night attack Hornet has a pod-mounted Hughes AAR-50 TINS, which displays a thermal representation of the terrain ahead on the Kaiser AVQ-28 raster HUD. Night Attack Hornets also employ the Loral AAS-38B Nite Hawk forward looking infrared (FLIR) targeting pod and pilot's GECMXV-810 Catseyes night vision goggles (NVGs).

These binocular Anvis-6 NVGs enhance overall Situational Awareness (SA). They are lightweight and easy to use, requiring the pilot to just click them onto the helmet and flip the switch. A major drawback is “washout”, the condition that occurs when any bright light temporarily disables them. Although they will eventually adjust until the light is minimized, their overall effectiveness is often degraded. The brighter the light, the harder it is for the goggles to compensate.

Upgraded fully NVIS (Night Vision Intensification System)-compliant console lighting makes the instrumentation readable through the green-hued vision of the NVGs (although cockpit instruments are often read by glancing beneath the goggles themselves). The Night Attack Hornet also features two Kaiser-developed 5” x 5” KROMA MFDs, which use variable orientation LCD electronic “shutters” to show three colors (green, amber and red) via a single CRT gun (these DDIs were monochrome in previous Hornets). F/A-18s also are equipped with the Smiths 2100 color digital moving map navigation display, which provides geographical CD-ROM data on the Horizontal Indicator (HI).

The first 31 F/A-18Ds built featured improved avionics with AMRAAM and IR Maverick capability but were not considered fully equipped for night attack duties. The prototype for the fully-capable night attack Hornet-D was created by modifying the first F/A-18D (BuNo163434), the same aircraft used for F/A-18D ATARS development. A minor software upgrade and the introduction of beacon mode bombing gives the Delta Hornet “all-weather” CAS capability, but this is quite limited.

Production switched to the night attack capable F/A-18D with BuNo 163986. All Hornet-C/Ds from Lot 12 (but not Hornet-Ds from Lots 10 and 11) are night attack models. The F/A-18 two-seat version carry flight controls in the front cockpit only and are intended as a tandem night attack aircraft rather than a tandem trainer (such as the Hornet-B). Two controllers are added to the sides of the aft occupant. These deal with radar, sensor and ECM systems, with switches at the center of both associated with the HARM.

However, if desired, night attack F/A-18s may be fitted to standard configuration, with the(re)installation of the throttle and control column. During the Gulf War, only one aircraft was so configured, deployed with VMFA(AW)-121. In practice, the similar aft cockpit reconfiguration from trainer to a night attack is extremely impractical and has probably never been done. Originally, it was seen as an eight-hour job. It involves removing the throttles, “fixing” the rudder pedals (no movement), removing the stick and installing the two side-console hand-controllers.

The flight officer, seated in the aft cockpit, is provided with two stationary hand controls (one on each side of the seat) for weapons systems operation. Here the moving map display is positioned higher. The F/A-18D is configured for the night attack role with FLIR, TINS, raster HUD and instrumentation and cockpit arrangements (such as an aft cockpit storage case) modified for use with Anvis-6 NVGs. The primary user of the night attack Hornet-D is the Marine Corps. All told, 96 examples were ordered for all-weather attack units previously operating the A-6E Intruder, plus one ex-Phantom reconnaissance unit.

3) The APG-65 and APG-73 Radars

Since the Navy desired all-weather capability and the ability to carry and launch radar-homing missiles such as the AIM-7 Sparrow, the small radar of the YF-17 had to be replaced with more powerful gear that could effectively handle beyond visual range (BVR) missiles.

At the end of 1977, the Hughes APG-65 digital multi-mode radar with pulse-Doppler beam-sharpening was selected over its Westinghouse competitor. This required an enlarged nose to accommodate the four-cubic-foot, 340-lb system (not counting the 28-inch radar dish) in order to meet the Navy's search range requirement of over 30 nautical miles.

The water-cooled APG-65 has 8,000 less parts than the F-4 Phantom's radar, yet 20 percent greater range. It operates in the I/J-band (8-12.5 GHz). The set is provided with built-in test equipment (BITE), which assists in identifying and isolating failures. According to Hughes, this “provides total end-to-end radar preflight checkout and continuous monitoring”. Some two dozen onboard computers operate in conjunction with the radar and weapons delivery systems. For maintenance, both the APG-65 and APG-73 can be pulled forward and out on fixed rails once the radome has been swung through 180 degrees to starboard via its hinge-point.

Radar-linked computers convert data generated by onboard sensors to a readily comprehensible display for the pilot. Simultaneously, they relieve the pilot's workload by performing rapid ballistics, wind, velocity, altitude and other fire control calculations to ensure accurate weapons delivery to target. Release cues alert the pilot by means of HUD and CRT displays.

Today, the APG-65 radar has been superseded by the more capable APG-73. With no corresponding increase in weight, this radar is three times faster, has greater memory than its predecessor and provides for easier maintenance. It is characterized by a changed bandwidth, upgraded power supply, increased internal operating rates of the receiver/exciter, raised processing speed in the radar signal processor and new radar data processing hardware to boost throughput. Further upgrades will make high resolution radar ground maps comparable to those of the F-15E's APG-70 and the U-2.

The first APG-73-equipped F/A-18 flew on April 15, 1992 and the first APG-73-equipped Hornets entered service on May 25-26, 1994 with VFA-146 “Blue Diamonds” and VFA-147 “Argonauts” at NAS Lemoore, California. Although this radar’s tracking and detection ranges are about half of the Tomcat’s AWG-9 or APG-71, the Hornet's APG-73 is a superior air-to-ground radar. APG-73 retrofits to Hornets in 1998 allow USMC Harrier II Pluses to be outfitted with surplus APG-65 sets. The APG-73 suite is standard in export F/A-18s, such as the Finnish, Malaysian and Swiss Hornets.

Several air-to-air modes are used. The Velocity (VS) Search Mode is used for maximum-distance encounters, sacrificing detail for range. This provides velocity and azimuth information only. In this mode, targets can be detected at ranges up to 92 miles (150 km). The software controlling

the radar is programmed to pay attention to those contacts with positive closure. In the Range-While-Search Mode, the radar provides information on all contacts occupying the portion of the sky ahead of the Hornet at maximum ranges between 40 and 80 nm.

Matched to the AIM-7 Sparrow AAM, Track-While-Scan Mode (TWS) is employed for ranges up to 46 miles (74 km). In TWS mode, the system can track up to ten targets simultaneously and will display the eight deemed most threatening. The computer also presents additional data, typically that of aspect, altitude and velocity.

If a specific target comes within range while the radar is operating in the Range-While-Search Mode, a Single Target Track Mode can be selected by the pilot for HUD output.

Simultaneously, steering commands and weapons launch data are displayed. The system also provides a “SHOOT” cue when it obtains a firing solution. The system sports a Raid Assessment Mode, with a range of 35 miles (56 km). It uses Doppler beam sharpening to examine a specific return more closely to distinguish between a single target or a group of aircraft in close formation.

The short-range fire-control modes operate within 23-mile (37 km) and 6-mile (10 km) ranges, which are used with the Sidewinder short-range AAM and the M61A1 Vulcan cannon. Once a target has been selected for attack, the system uses the Boresight Mode if the Hornet is in a traditional tail-chase encounter with the enemy. In this mode, a very narrow 3.3-degree beam scans a small area of sky directly ahead of the aircraft.

When both the target aircraft and the Hornet maneuver heavily, the Vertical Acquisition Mode is used. In this mode, the radar scans an arc 5.3 degree wide and extends 60degrees above boresight axis to 14 degrees below. In order to achieve automatic lock-on, the pilot rolls the aircraft into the same plane of motion as the target, ideally positioning the enemy just above the canopy bow and aligned vertically with the HUD.

The system can also do a Head-up Display Acquisition Mode, in which the radar antenna scans a box corresponding to the field of view of the HUD itself. This typically extends ten degrees left and right of centerline, 14 degrees above and six degrees below. These combat modes are effective from ranges of 500 feet to five nautical miles. When in any one of these modes, the radar automatically locks onto the first acquired target. Lock-on indicators are displayed on cockpit CRTs and the HUD.

However, the pilot can override the system and reject specific targets until he acquires the most desired one. Alternatively, the pilot can use a moveable cursor to designate the target manually. The Gun Director Mode is employed at ranges under five nautical miles. The radar provides target position, range and velocity data to drive the gun aiming point on the HUD. The pilot then positions the pipper on the selected target and squeezes the trigger.

There are several air-to-surface modes available. The Real Beam Ground Mapping Mode is used for identifying substantial geographical features ahead at long ranges. A small-scale radar map displays a representation of this terrain. The computer automatically adjusts the display so that it appears as a vertical “God's eye” view rather than the oblique view that the radar actually sees. There are more detailed mapping modes which employ Doppler beam sharpening for higher navigation and target location resolutions.

Once a ground target is identified, the Air-to-Surface Ranging Mode provides information on the distance to target. It is best employed in a steep dive. Fixed and Moving Ground Target Track Modes use two-channel monopulse angle tracking to provide precise information on ground targets. The Hornet does not have automatic terrain following capability, but the radar can be used for terrain avoidance, warning the pilot if he is about to fly into anything hard. It is up to the pilot to avoid any collision, with helpful suggestions from the “Bitchin'' Betty” aural warning system. There is also Sea-Surface Mode. In this mode, a computer filters out clutter reflecting off sea waves. This simplifies the detection, identification, tracking and attacking of enemy surface vessels.

In a clear weather day strike scenario, visual targeting provides the preferred and most accurate delivery, with a circular error of probability (CEP) generally under 37 feet. FLIR targeting is second-best and labor-intensive, with a standard CEP of less than 100 feet or so. Radar targeting is the least precise option, with a CEP of even hundreds of feet. It is said that a software fix has improved the accuracy of radar somewhat. GPS munitions will allow CEPs of under 50 feet.

4) Other Electronics and Countermeasures

The Hornet carries an impressive defensive electronic warfare suite. This includes ALQ-126 jammer transmitter and the Itek ALR-67 radar homing and warning (RHAW) receiver set, which detects, isolates, classifies and initiates countermeasures against a variety of electronic threats. The pilot is then informed of threat location(s) via cockpit displays.

Consequently, the pilot may elect to carry out more active countermeasures, such as the release of chaff or the dropping of decoy flares via the ALR-47 dispenser.

Aircraft built from 1993 onwards have improved defensive systems. Their ALE-39 chaff dispensers are replaced by ALE-47s and their ALR-67 radar warning receivers are upgraded models. The F/A-18 can theoretically carry up to 60 decoy flares.

The aircraft deals with a barrage of voice and other transmissions, including that mediated by the Link 4A datalink. Two blade antennae are located on the dorsal spine. The forward antenna is for the Collins ARN-118 VHF tactical air navigation (TACAN) and the rear antenna is for UHF/DF communications, which can be made secure by the KY-58 encryption device.

Other antennae are for upper and lower coded IFF response (Mode 1-3 “Parrot” and secure Mode 4 “India”), HF automatic direction finding (ADF) and global positioning system (GPS)signals.

E. Airframe and Aerodynamics

Early pre-Hornet design, research and development occurred in parallel with the F-5 improvement program. Focusing on drag reduction, Northrop developed the idea of the LEX, or LERX, the leading-edge wingroot extensions (the characteristic “cobra hood”).

Wing/fuselage blending with the LERXes reduced wave drag, increased lift by ten percent and improved turning performance. They generated powerful vortices over the upper surfaces of the wing, reenergizing the boundary layer and thus reducing tip-stall tendencies.

In 1967 a larger LERXes than envisioned for the F-5 and air inlets moved farther back were integrated with the Hornet project. The following year the leading-edge extensions were enlarged still more and the single vertical tail replaced by twin surfaces (their significance is discussed more below). These were soon enlarged and moved farther forward, as the fuselage was modified. The again modified LERXes were cambered, which added 50 percent to the trimmed lift of the wings and maintained aileron effectiveness up to 15 degrees AOA. This design was known as P-600.

Later, the Hornet project was known as Model 267 by its prime contractor, McDonnell Douglas. Model 267 retained the overall configuration of the Northrop YF-17 LWF prototype, with its two engines, twin outward-canted vertical tail surfaces and LEXes. In other ways, the Hornet was quite different from the YF-17. Unrelated to the LEX, the original YF-17 was outfitted with nose strakes (narrow horizontal “fins” along the nose at 3 and 9 o'clock) for attitude stability. Found to be unnecessary, they were deleted when the redesigned F/A-18 appeared with its lengthened and deepened nose (necessary to accommodate the radar set).

More significant structural changes would prepare the Hornet for the stresses and strains of a carrier career. The aircraft was widened, increasing fuel capacity. Thus, improved, the aircraft more closely approached the Navy-specified combat mission radius of 400 nautical miles for fighter escorts. In this regard, the Hornet actually attained 380 nautical miles. Both the airframe and the undercarriage were strengthened (and thus made heavier) to meet the 24 feet/second descent rate requirements for arrested carrier landings and the force of catapult launches. With stronger landing gear, the Hornet would not need to flare or round-out for recovery.

The main gear was moved farther back to both increase stability on a pitching deck and to preclude tipping onto its tail while under tow. Powered, wing-folding and were also incorporated. The simple undercarriage of the YF-17 had a track of 6 feet 10 3/4 inches. On the F-18, the track was increased to 10 feet 2 1/2 inches for greater stability during carrier landings.

Formation panel lights were added to the upper and lower surfaces of the wingtips. As compared to the YF-17, the Hornet's wing was also increased by an additional 50 square feet (from 350 to 400 square feet). This span and chord increase improved low-speed performance. The wing had a trapezoidal planeform (swept on the forward edges, but straight on the trailing edges—clearly visible at left) and incorporated a variable camber.

The variable camber is achieved by using full-span leading edge flaps and hydraulically actuated, single-slotted flaps on the inner trailing edges. These computer-controlled surfaces manage extension and retraction. They set the surfaces to the most desirable angle for optimal performance throughout the entire envelope.

The full span notched ailerons on the outer portions of the wings' trailing edges (which were not present on the YF-17) can double as flaps to enhance low-speed handling qualities.

Differential operation of flaps and ailerons can serve as roll control. The outer wing panel is hinged at the inboard edge of each aileron for folding aboard carriers. The all-flying horizontal tailplanes are of aluminum honeycomb construction with graphite epoxy skinning.

They can be used in concert for pitch control or differentially for roll control, acting as “tailerons” for enhanced roll performance.

The twin vertical tails of the F/A-18 were necessary to offset the vortex flows off the leading-edge extensions of the wings. The twin tails are mounted far forward in order to close the aerodynamic gap between the trailing edge of the wing and the leading edge of the vertical tail. This results in a smooth and drag-free fuselage airflow. In addition to the tails' forward position reducing airflow interference around the engine nozzles, it also saves weight by eliminating the need for any major rear fuselage carry-through structure.

The D-shaped intakes of the Hornet-C/D [picture here] and the trapezoidal intakes of the Hornet-E/F [picture here] are set well back underneath the LEXes. The cobra-shaped extensions (which are more pronounced on the Super Hornet) guide air into the engine intakes and somewhat protect them from high angle of attack (alpha or AOA) airflow disruptions. Since the Hornet is not required to exceed Mach 2 (top speed is 1.8), the aircraft does not need sophisticated variable-ramp air intakes. The intakes thus sport a simple, fixed splitter plate mounted next to the fuselage. The only moving parts are two ducts cut into the top of the LEX which upwardly eject bleed air into the LEX-generated airflow.

The intake ramps/boundary layer splitter plates are solid at the front end with perforations directly ahead of the inlet. This permits sluggish boundary layer air to be bled away and dumped via spill ducts atop the LEX. The twin-hinged, hydraulically-activated airbrake is mounted on the rear dorsal fuselage between the vertical tail surfaces. This configuration affords minimal pitch change upon airbrake extension. The main undercarriage units retract aft and rotate through 90 degrees so as to lie flat underneath the air intake ducts. The twin nosewheel gear retracts forward into the nose.

The Hornet uses advanced composite materials for large portions of its structure. Aluminum comprises about half of structural weight, while steel contributes about 16.7 percent.

Titanium makes up some 12.9 percent, used for a considerable fraction of the wings, fin and horizontal tail attachments and wing-fold joints. About 40 percent of the aircraft's outer skin is covered by a graphite/epoxy composite material, accounting for up to 9.9 percent of the aircraft's weight. The remaining 10.9 percent is composed of plastic, rubber, steel, fiberglass, aramid and other materials.

F/A-18s incorporate a quadruply redundant digital fly-by-wire (FBW) flight control system, the first of its kind to be installed in a production aircraft. Even in the YF-17 prototype, it was superior to the YF-16. The proto-Hornet was an inherently stable airframe with a FBW system that lacked autostabilization, but had a mechanical back-up. The YF-16's airframe, which was unstable, had an autostabilizing FBW system, but no mechanical back-up.

With FBW, the plane will trim itself for airspeed, (steady state, hands-off, 1-G flight), but cannot recover from an “unusual attitude”. It functions via stick and rudder inputs directed into a computer, which then interprets them and issues the appropriate commands to the various control surfaces. There are numerous flight control system (FCS) failure displays, with variations for stabilator actuators, servo valves, rudder channels, AOA and backup airdata sensors, leading edge flaps and more.

The FBW system disallows the pilot the opportunity to overstress the airframe (although in a pinch the pilot may opt to override). The system operates by the principal of majority vote: if one of the four systems disagrees with the other three, this is interpreted as a failure. The dissenting system is then ordered to shut down. FBW redundancy is such that should a second system fail, the remaining two systems, granted they remain in agreement, can still operate the controls.

The two flight control computers each have two flight control channels, which each deal with pitch, roll and yaw (the independent failure of one axis control does not affect the others). In the absence of normal control augmentation system (CAS) function, each computer also provides a direct electrical link (DEL) between stick inputs and flight control surfaces. If roll or yaw digital DEL fails, the computers provide an analog DEL to the ailerons and rudders.

Since the November 14, 1980 crash of production aircraft 161215 into the Chesapeake Bay (the pilot lost control at 20,000 feet and had to bail out), all production Hornets are outfitted with a spin recovery switch.

Likewise, if pitch digital DEL fails, a direct mechanical backup (MECH ON) conveys stick inputs to the differential stabilator actuators, providing the pilot some degree of pitch and roll control in an extreme emergency. In addition to a complete four-system collapse (such as inoperative ailerons and rudders and complete electrical—including battery—failure), the pilot can also deliberately choose this option. Battery power conservation for landing purposes is one such example. Guided by experience from

Vietnam, duplicate hydraulic systems are routed separately as much as possible. This arrangement diminishes the likelihood that a single hit may disable the aircraft.

Combined, these advanced aerodynamic and flight control features form the core one of the most popular and capable airframes in military aviation history, guaranteeing the F/A-18 a prominent place in the history books of modern aerial warfare. Today, the C/D models continue their successful production run in the U.S., following their service in the U.S.

Navy/Marine Corps with introduction into foreign air forces from the arctic to the tropics.

F. Combat Aircraft Comparisons

The F/A-18 has a large, wide-span mid-wing, twin afterburning turbofan engines and extremely avionics and cockpit displays. Compared with the original YF-17 it is wider, sports much greater fuel and gross weight, has a longer and deeper nose and is powered by bigger and newer engines. It remains in flight at slower speed angles of attack than any other fighter, which is especially advantageous for carrier landings. The angle may exceed 45 degrees without significant degradation in handling.

The aircraft's short takeoff and landing requirements (with special equipment for the latter) make possible operations on special sections of highway or STOL expeditionary airfields.

This has been a positive factor in foreign military sales (FMS) marketing. Finland, for example, in keeping with a three-decades-old tradition, bought portable arresting gear for its FN-18s in order to use prepared national highway strips as crisis road bases.

The F/A-18's initial experience with VFA-125 “Rough Raiders' (NJ) was more favorable than that with VX-4 “Evaluators” (XF) and VX-5 “Vampires” (XE), the U.S. Navy's primary test and evaluation squadrons). As a result, original concerns about the Hornet's range were only slightly alleviated.

A “clean” Hornet can usually exceed that of a “clean” McDonnell F-4J Phantom (which it replaced). In the fighter escort role, the F/A-18's range is still greater. Although in the strike role, the range of the F/A-18 is 10-12 percent less than that of the LTV A-7E, it can do more over target on less fuel.

However, the Hornet has a chronic reliance on external fuel tanks. This drop tank requirement steals precious pylons that could otherwise be devoted to bomb-loads or other offensive weaponry, particularly larger, heavier ordnance. Comparatively high drag, particularly with full loadouts, contributes to the aircraft's unbridled fuel thirst. Seen by many as the aircraft’s single most critical deficiency, it clearly invalidates many of the “clean” comparisons such as the one above.

Combat radius

A/A mission (fighter)	A/G mission (striker)
480 mi (768 km)	662 mi (1,059 km)

Endurance, CAP 150 nm from carrier 1 hour, 45 minutes
Ferry range, unrefueled More than 2,000 nm (3,700 km)

The F/A-18s ground radar is precise and reliable. This, coupled with consistently high bombing accuracy rates with relatively little practice, has actually delayed the phase-in of laser-guided munitions-delivery capability to the Hornet platform by the Navy itself. This partly limited Hornets during Desert Storm, where Grumman A-6 Intruder attack planes were forced to compensate heavily. However, only one-in-three Hornets at the time of equipped with FLIR pods, whereas A-6Es sported a permanently chin-mounted target recognition attack multi-sensor (TRAM). The TRAM, unlike the FLIR [picture here], allows for autonomous laser-guided designation and tracking. This made the A-6 all-weather attack capable, which the Hornet cannot match. This deficiency appears to be true of precision guided munitions (PGM) in general, as, for example, only one in four deployed Hornet pilots are trained to use the Standoff Land Attack Missile (SLAM) [picture here].

It should be noted that claims touting the F/A-18's all-weather strike prowess are misleading and exaggerated. Whereas the Hornet is not wholly incapable of attacking ground targets in poor weather/low visibility situations, it is plainly not the best choice.

Bombing accuracy has actually proven quite disappointing under such conditions, as evidenced in the Kuwait/Iraq theater. For small, fast-moving or otherwise difficult targets to hit—such as those nestled in civilian zones that cannot take collateral damage or loss of life, where pin-point accuracy is paramount—F/A-18s just don't have the tight CEPs of others. strike platforms. The F/A-18's overall poor record at foul-weather bombing underscores the need to more fully integrate PGM technologies. This would partly level the playing field.

Yet in most respects the F/A-18 meets or exceeds specifications, demonstrating impressive air combat capability. In this regard, the Hornet's overall fighter and strike capabilities are clearly superior to the A-7. Unlike the A-7, the F/A-18 does not require a separate fighter escort; it escorts itself. It's been claimed that, as a striker, a Hornet with drop tanks can carry the same bomb-load as an Vought A-7 Corsair II without tanks (theoretically 17,500lbs or 7,938 kg on its six wing and two body-side hardpoints). This is not entirely true, considering that the A-7 can load up multiple ejector racks (MERs) and triple ejector racks(TERs) with impressive bomb-loads. The F/A-18 cannot. Partly for this reason, the Hornet flexes less muscle in terms of brute bomb tonnage delivery capability than the now-retired A-6. During the Gulf War, Intruder loads on some sorties consisted of over 20 Mk 82 bombs or Rockeyes.

Even referred to as “[not] much more than an air-to-air target”, the A-6 was larger, slower, older and harder to maintain than the F/A-18. Despite its less capable avionics, the A-6E had five hardpoints, each rated at 3,600 lbs (1,633 kg). Four of these were plumbed for 250-gal (1,136 l) tanks. Its maximum stores load could exceed some 18,000 lbs (8,164 kg). Due to its greater range, larger loadout potential and TRAM, the Intruder could more leisurely loiter on-station, “trolling” for targets, which it could work over more completely before departing the battlefield.

During air-to-air combat exercises, the Hornet bested the A-4, F-4 and F-14. In air-to-air engagements against the Tomcat, the F/A-18 outmaneuvered into a rear aspect firing position in short order. The Hornet has proven, however, to be less maneuverable than the Gripen or the F-16. Also, in terms of sorting and dealing with BVR missile and aircraft threats, the F/A-18 is considerably less capable than the F-14. This is due primarily to the long-range restrictions and limited processor power of the Hornet's radar suite, which is half as effective as the Tomcat's AWG-9 or the Super Tomcat's APG-71 pulse doppler radars.

These systems can detect and track up to 24 targets and simultaneously engage six of them out to 110 nautical miles. Also speaking of avionics disparities, the Hornet does not share terrain-following capabilities and other features of its Air Force brethren (such as the F-15 and F-16).

Although the Hornet is heavier, longer and wider than the Dassault Mirage, the JAS-39 Gripen or the General Dynamics F-16, it is a more efficient aircraft offering greater weapons loadout potential. It is also a dual-engine fighter, like the MiG-29 Fulcrum. Although the MiG-29 is better-armed, cheaper and handles excellently at low speeds, it lacks the Hornet's superior takeoff/landing abilities; low-workload cockpit; easier, cheaper and less frequent maintenance; and ground attack capabilities. Like the F/A-18, the MiG-29 fuel capacity and consumption are seen as considerable liabilities (the fact that the MiG-29 cannot be aerially refueled only compounds the problem).

There is no doubt that the Hornet is outgunned by the Fulcrum. For example, one capability that the F/A-18 cannot match is the MiG-29's ability with the Vynpel R-73 (AA-11 Archer) AAM to target pursuing aircraft. Additionally, the Fulcrum's infrared search/track (IRST)equipment is a superior way to locate, track and target enemy aircraft, because it is a totally passive system. No emissions mean drawing no attention. MiG-29 pilots also have the added advantage of helmet-mounted targeting sights and an ultra-accurate laser-ranger for the 30-mm gun mounted in the left wingroot. It is also said to be the lightest gun of its type in the world. Although the all-weather radar suite of the Fulcrum is said to be a based on Soviet era espionage surrounding the APG-65.

G. Bugs and Bug Fixes

All aircraft experience difficulties during their development phases and early careers. The F/A-18 is no exception. For the Hornet, these have ranged from aerodynamic considerations and cockpit displays to ejection seats and fuel capacity issues. Most have been eliminated or worked around, whereas some were never completely fixed. A few others cropped up as implemented changes where no problems existed before. Some issues continue to dog Hornet drivers to present day.

Most flaws, of course, turned up early in-flight testing. For example, during competition with the YF-16, the airbrake was found to be inadequate. Nosewheel lift-off speeds were too high and takeoff roll too long. These were solved by whole-wing redesign, including filling in the dogtooth on the inboard leading edge of the horizontal stabilator.

This gave the stabilator greater authority earlier in the takeoff run. Initially, the dogtooth had been added to the leading edge stabilator in anticipation of the same flutter problems which afflicted F-15 tailplanes. When these problems did not materialize, however, the dogtooth was eliminated after a brief appearance on early full-scale development (FSD) aircraft. It has, surprisingly, made a reappearance on the Super Hornet.

In addition, automatically toeing in the rudders on takeoff was found to provide greater nose up pitching. It reduced rotation speed by some 30 kt (35 mph or 56 km/h).

Leading edge flap software problems were corrected with internal programming changes.

The outer wing panels were stiffened, the ailerons were increased in span and differential flap movement was added to the flight control software. Insufficient acceleration speeds above Mach 1 were corrected through engine improvements. It turned out that the main undercarriage was insufficiently strong, which led to the use of a twin-chamber oleo leg.

The cooling of the cockpit and the avionics bay was found to take up excessive space that could otherwise be dedicated to fuel. Naturally, this adversely affected range. In response, external tanks were switched from elliptical [see a photo of these type here] to circular cross-section tanks and their capacity increased from 315 to 330 gallons.

Range nonetheless remained slightly below Navy requirements (in fact, only E/Fs now actually meet these original specifications). Indeed, the Hornet's range deficiency has been its most-often criticized defect. Evident even as a prototype, this problem has never really been fully corrected despite numerous attempted fixes, including engine and airframe modifications in an attempt to boost performance.

Perhaps one of the most significant changes was an alteration of the boundary layer air discharge (BLAD) slots. Early service test machines originally flew with long BLAD slots cut between the fuselage and the upper surface of the LERXes (the “cobra hoods” on the sides of the nose, beginning at the windshield and stretching back to the leading edges of the wings). These slots beneficially generated a strong, high-energy vortex extending down each side of the fuselage, increasing high angle of attack (AOA) directional stability.

Unfortunately, these slots also generated a lot of drag, which adversely affected range and acceleration. Consequently, from Hornet 8 onwards, 80 percent of the slots' length was filled, leaving only one small slot on each side. These slots eject the boundary layer air bled from the engine intake. Introducing drooping ailerons cut approach speed by 10 kt (11.5mph or 18.5 km/h). Roll response was enhanced by lengthening the ailerons, moving the differential trailing-edge flap and stiffening the wing.

With increased service experience, another unexpected problem appeared. Hornets were flown more than anticipated in the high AOA regime, where aerodynamic loads on the tail area from LERX-generated turbulence were particularly severe (the site offers additional information on flight dynamics and high alpha research). Fatigue-related cracks began to appear at the base of the vertical stabilizers. For this reason, the F/A-18 fleet was briefly grounded in late-1984 while a fix was developed. McDonnell's solution was a modification kit which added 4-inch steel doublers to two of the tail mountings. A non-structural fairing was replaced by a stronger fairing. However, this failed to alleviate the crack-inducing tail stresses.

Later F/A-18As had a small wing fence added to the top of each LERX at the position of the wing leading edge in order to broaden the generated vortices causing structural cracks.

Known as “LEX fences”, these May 1988 (official) metal plate additions ultimately proved to be cheap, easy to retrofit and highly effective. The ensuing reduced loads on the tail unit ceased the cracking, improved controllability at high AOA and replaced the initially fairly large brackets at the base of the vertical stabs. LEX fences are clearly visible in many of the photos in this paper, but perhaps one of the best is here. Tip: look directly above the starboard engine intake.

Other woes were associated with the NACES ejection seat. The Hornet's original SJU-5/A and SJU-6/A (Bu Nos 161353 through 164068) were later superseded (since BuNo 164196) by the NACES SJU-17 1/A and 2/A. However, these replacements presented visibility and ejection problems, but were apparently considered an improvement. The larger “headbox” parachute storage section on the taller NACES SJU-17 1/A and 2/A proved to be a clear liability when “checking six”. This bug remains uncorrected.

In addition, China Lake sled tests revealed that the aft cockpit NACES, though firing its rocket, couldn't break through a heat-softened canopy. As a result, all NACES-equipped B- and D-models were for a time restricted from carrying a backseat occupant. One proposal included adding an explosive cord like the AV-8B's to the canopy to shatter it prior to ejection. The idea of sharpening the canopy breakers on top of the seat was discarded as too hazardous. Added seat propellant was also abandoned. Ultimately, a new canopy solved this problem. For more info on this, try The Ejection Site.

Also, in the mid-1980s, the F/A-18's landing gear proved too weak to handle carrier “traps.”

They would break off at the trunnion hinge upon catching the wire on the flight deck. Many a wheel with attached axle lever exploded out at 90-degree angles, shot over the side and splashed into the sea.

H. Hornet-C Data

Performance

Speed

• Class: high subsonic to supersonic
• High altitude, maximum: Mach 1.8
• Low altitude, maximum: 812 mph (1,300 km/h)
• Carrier landing, minimum: 131 kts
• Cruise: 660 mph (1,062 km/h)

Ceiling

• Combat ceiling: 50,000 ft (15,400 m)
• Attained altitude: > 68,800 ft (21,000 m)

Roll

• Take-off, minimum: < 1.400 ft (430 m)
• Landing, minimum: < 2,800 ft (850 m)
• Landing, arrested: < 650 ft (200 m)

Wind Over Deck

• Launch: 35 kts
• Recovery: 19 kts

Climb rate: 60,000 ft/min (18,287 m/min)

Descent rate, survivable: 17 ft/sec (5.2 m/sec)

Appendix A: M61A1 Vulcan Cannon

1) Lessons from Vietnam

Fighter experience in Vietnam (U.S. involvement 1961-1973) demonstrated that combat aircraft need a gun for closest range encounters. Early in the conflict, the fatal mistake of exclusive reliance on BVR weapons culminated in only half of the two-crew F-4 Phantoms sent into enemy territory making it back to their launch points. The surprising success of the cheaper but smaller, more maneuverable and tighter-turning single-seater MiG-17 contributed to these appalling combat losses. In addition, despite superior American avionics, the new AIM-7 Sparrow's initial failure rate of some 90 percent, many historians consider the chronic deterioration in dog-fighting skills among American pilots a contributing factor.

Perhaps most compelling, a close-range gun was notably absent from Vietnam-era U.S.

fighters. This deficiency was eventually rectified. Today the cannon is standard apparatus in subsequent generations of frontline U.S. combat aircraft. For the Hornet, the gun is the General Electric M61A1 Vulcan, basically a 1950s piece of technology (it entered service with the F-105 Thunderchief in 1958). Today, it is the standard internal gun in U.S. combat aircraft. The same weapon also equips the A-7 Corsair, AH-1G Cobra, F-4 Phantom, F-14 Tomcat, F-15 Eagle, F-16 Fighting Falcon, F-104, F-105, F-106 Delta Dart, F-111, B-58 and B-52H. A ram-driven version forms the central hardware for the SUU-16A pod for those aircraft on which the gun is externally mounted. It also is often associated with the SUU-23 pod as well.

2) Versatile and Deadly

Whether employed against airborne quarry in aerial combat or in strafing runs directed against “soft” ground-based targets, this single six-barrel rotary cannon delivers highly destructive bursts of 20-mm semi-armor-piercing high-explosive incendiary (SAPHEI) fire.

Armor penetration is 45 mm at 500 m and 31 mm at 1 km. Mounted internally in the aircraft’s nose directly in front of the cockpit windshield, it is the only permanently attached weapon system in the F/A-18. It has a length of 6 ft, 1.4 in (1.86 m), a diameter of 1 ft, 1.5in (343 mm) and a recoil of 0.25 in (6.4 mm). It takes a full third of a second to reach its optimum firing rate.

Based upon the same efficient rapid-fire principles set forth by Dr. Richard J. Gatling in the 1860s, this gun is externally powered to eliminate jamming from misfired rounds. Its six barrels are mounted on a geared rotor driven by a 20-hp motor, which allows one barrel to fire while the other five are each in their respective phase of the reload cycle. With each rotation, the cam follower on the bolt of each barrel follows a fixed cam path inside the gun housing. The bolt is thus opened and closed once per revolution, actually reducing each barrel's firing rate below that of most single-barrel revolver cannons. It is said that this has the effect of “sharing the thermal duty cycle” and ultimately extends the life of each barrel.

The gun's 578 M50 series 20-mm PGU-28/B rounds are stowed along longitudinal rails within a cylindrical ammunition drum just aft of the radar set. The feed system is rotary inkless, double-ended, hydraulically driven and electrically controlled. Inside the drum, rounds are moved to the gun end by a fiber-reinforced plastic (FRP) helix. A rotating scoop disc assembly transfers rounds to a rotating retaining ring. Part way around this ring, the exit unit loads the chute that feeds the gun. Empty cases are returned to the drum for storage. The drum, coupled with the barrels and breach above it, forms a single modular unit.

Its rate of fire depends upon two selectable firing modes: 4,000 (GUN LOW) and 6,000(GUN HIGH) rounds per minute (maximum rate is 7,200 rounds per minute). Muzzle velocity is 3,450 ft (1,052 m) per second, with an effective range from half a mile out to 19,700 ft (6,002 m). The system lifetime is about 150,000 rounds with a 15,000-round mean failure rate. Average recoil force is 2,661 lbs (1,207 kg) at 4,000 rounds per minute and 3,818 lbs (1,732 kg) at 6,000 rounds per minute.

The weapon sports a McDonnell Douglas director gunsight (with a conventional backup gunsight) and is primarily intended for close-up visual-ID dogfight encounters or air-to-ground close air support (CAS). For more on CAS, see the Gulf War section. The gun barrel is elevated approximately two degrees to improve target tracking and has a lifetime of approximately 40,000 rounds. Altogether, the entire system weighs 841 lbs (381 kg). The feed system alone weighs 270 lbs (122 kg), the gun 252 lbs (114 kg) and the ammunition 319 lbs (145 kg). A lightweight version of the gun weighs 205 lbs (93 kg), or 47 lbs (21 kg) less than its heavier counterpart. It sports a linear linkless feed system and extended effective envelope due to AIM-GUNS fire control software changes.

Although the gun port is located directly above the nose radar, the pilot can fire without damaging the delicate APG-65/73 and sensitive adjacent avionics black boxes. The avionics bays are extensively protected against gun gases, smoke, heat and vibration, but still take a pounding when the weapon is fired. This considered, for those who would champion a gun with a little more punch, the feasibility of a 30-mm replacement for the M61A1 remains questionable.

There are three distinctive apertures in front of the gun: the central muzzle hole flanked by two lateral holes for gas ejection. Also ram air vents situated on the underside of the nose just aft of the pitot tubes (air data sensors) prevent the buildup of potentially dangerous gases in the gun bay. A noticeable pattern of soot appears on the nose of the aircraft after the Vulcan has been fired [an example of this can be found here].

From the initial R&D stage, designers concluded that swift operational turnaround (essentially getting the aircraft back into the air as quickly as possible in a battle situation) depended upon ease of access for installation and removal, repair, maintenance and rearming. The entire gun system (including the ammunition tank and feed mechanism) is pallet-mounted and can be quickly winch-removed for servicing through the underside of the nose. The gun can only be rearmed by weapons maintenance personnel on the ground.

3) Recce and Night Attack Hornets

Two development cycles have sought to replace the cannon with a 140-lb (64-kg) multispectral ZSD-1 Advanced Tactical Air Reconnaissance System (ATARS), with Loral UPD-8 high-resolution synthetic-aperture side-looking airborne radar (SLAR). Roll-stabilized optronic sensors include low-to-medium altitude panoramic cameras (KA-99) and blister-mounted infrared linescan (AAD-5). Data is recorded on digital tape and can be transmitted real-time datalink, day or night (the latter in conjunction with night-vision goggles) and under all weather conditions. In 1984 with FSD aircraft No 1 (F/A-18A BuNo 161214) and1993 with F/A-18D (BuNo 163434), the gun bay doors were replaced with camera access doors and integral sensor windows. [see photo below, notice the circular “Hornet” logo on the tail] These “Recce Hornets” were to be designated the single-seater RF-18 in the Navyand the F/A-18D(RC) tandem to the USMC. They were intended to replace the McDonnell Douglas RF-4B Phantom II. This has not come to pass, however.

It was claimed that such an aircraft could be converted back to stock fighter configuration in only a few hours. Ultimately, this proved easier said than done, for it was tedious, time-consuming and largely unnecessary. To date, it has probably never been implemented operationally for these reasons. The scheme was eventually abandoned and any subsequent reconnaissance equipment will be externally installed. An external configuration was tested in 1992 with the same F/A-18D as above. The pod was a modified 330-gallon tank suspended from a BRU-32 bomb rack-equipped pylon on the centerline. This may or may not represent a model for future ATARS integration, slated for Fleet Marine Force F/A-18Ds sometime around 2003-2005.

Finally, a note on the M61A1's night attack compatibility. Earlier versions of helmet-mounted light amplification devices proved rather susceptible to washout from Vulcan cannon muzzle flash, sometimes with severe degradation in operator visual acuity. While subsequent night vision goggles (NVGs) have significantly diminished these effects, they have not been entirely successful.

Appendix B: Loadout Possibilities

This is not meant to be a comprehensive list. Below are examples of individual-, dual or triple-mounted (the latter TALDs only) items, showing where they physically fit onto which hardpoints on the F/A-18. Depicted are maximum loads per pylon and do not necessarily show how many of a given external store would or could be operationally employed simultaneously or in conjunction with other ordnance. Naturally, size, weight, availability, mission, deployment and design considerations prevent certain combinations.

Hang things from a Hornet is no simple task. Stores can be either parent-mounted (attached directly to the pylon with or without intervening adapters) or may be loaded in pairs on vertical/triple ejector bomb racks or special missile rails. C/VERs (78 lbs.) and TERs allow multiple stores to be mounted on a single hardpoint. For example, LAU-10 andLAU-68 FFAR pods cannot be parent-mounted to the SUU-63/79 pylon. They require a C/VER, whether singly or twin-mounted. Also, the ADM-141 TALD may be mounted on C/VERs or TERs. The SUU-62 centerline pylon accommodates a variety of single parent stores but does not take missiles or C/VERs (TER-mounted TALD loads are the exception).

Not all Hornet variants are created equal. F/A-18A/Bs are not AIM-120-capable platforms, nor can they use IR Mavericks (AGM-65). They are also not fully NVIS compliant. Hornet-Bs have historically been primarily training aircraft. These limitations considered, some elements of this data are not relevant to early production models.

Maverick weights vary by type. The Maverick family of air-to-ground missiles uses three different types of guidance. Variants A and B are electro-optically (EO) controlled and weigh460 lbs; variants D and G are infrared (IR) AGMs, weighing 483 and 668 lbs. respectively; and the E variant is laser-guided (LG) and weighs 675 lbs.

Hornets can carry drop tanks on the outer wing pylons—but only empty ones. Weight and size considerations aside, these are “dry” hardpoints and lack fuel system “plumbing.” “EMPTY” is used in the table to denote this.

In general, F/A-18E/F loads follow these basic guidelines:

- Two Wingtip LAU-7 Rails (Stations 1 and 11): Almost always AIM-9 AAMs. Reports of AIM-122A ARMs (rare). Test sensors occasionally mounted.
- Two Outboard SUU-80 Wing Pylons (Stations 2 and 10): A/A or A/G ordnance. According to U.S. government statements, these hardpoints are limited to 1,150 lbs, precluding heavier weapons, such as Mk 84 GPBs and derivatives. However, some unofficial estimates place this figure closer to 1,800 lbs. Can transport empty drop tanks (rare). Ordnance is parent-mounted only.
- Two Mid-Wing SUU-79 Pylons (Stations 3 and 9): A/A or A/G ordnance, including 2,000-lb-class missiles and bombs, or VER-mounted pairs up to same limit.
- Can transport empty drop tanks (rare). Ordnance can be either parent- or MER-mounted.
- Takes TER-mounted ADM-141 TALDs.
- Two Inboard Wing SUU-79 Pylons (Stations 4 and 8): A/A or A/G ordnance, including 2,000-lb-class missiles and bombs, or VER-mounted pairs up to same limit.
- Fully plumbed for 330-gal or 450-gal drop tanks. Ordnance can be either parent- or MER-mounted. Takes TER-mounted ADM-141 TALDs.

- Two Nacelle Fuselage Hardpoints (Stations 5 and 7): A/A or gear. AIM-7 orAIM-120 AAMs or a variety of targeting, navigation and reconnaissance sensors.
- Examples are the AAS-38 Nite Hawk T-FLIR (port) and the ASQ-173 LDT/CAM andAAR-50 NAVFLIR (starboard).
- One Centerline Fuselage SUU-78 Pylon (Station 6): Usually empty but can accommodate parent-mounted bombs or Mk 7 munitions. Fully plumbed for drop tank. Takes Walleye I/II and SLAM/SLAM ER datalinks or TER-mounted TALDs.

Section 3: Hornet in Finland

A. Draken and MiG Predecessors

At the start of the 1960s, Finland had the option to purchase the French Mirage III or Swedish Saab 35 Draken, but in the end settled on the MiG-21 single-seat interceptor offered by the USSR. On April 24, 1963, Russian pilots delivered the first ten MiG-21F13s to Rissala. These aircraft were F-12s, a sub-type of the common F-13, which were specially adapted to the conditions in Finland. The rest were delivered in November of the same year, for a total of 22 aircraft. They first entered service with Fighter Squadron 3 of the Karelian Air Command. From 1966 to the beginning of the 1970s the MiGs were also deployed to the Häme Air Command at Luonetjärvi.

The first ten were originally designated MG-1 through MG-10, but later all 22 were designated MG-31 to MG-35, MG-46 to MG-50, MG-61 to MG-65, MG-76 to MG-80 and MG91 to MG-92. All of the F-model MiGs eventually were transferred to the Luonetjärvi Reconnaissance Squadron (LRS) in 1978-1980 when the newer MiG-21bis fighters arrived.

In the LRS the MiG-Fs underwent rather extensive modifications to better adapt to their new recce role. MG-33 was the last of this type to be decommissioned from the Finnish Air Force.

Its final flight was on January 17, 1986, piloted by CAPT Hannu Vartiainen. About the time Finland was purchasing the MiG-21F, the tandem-seat trainer version known as the MiG-21U was in development. Eventually, Finland purchased two from the Soviet Union (MK-103 and MK-104), which saw service from April 1, 1965 to May 29,

1981. Two MiG-21US trainers (MK-105 and MK-106) entered service in June 1974. In the1980s they were equipped with the improved Tumanski R-13-300 engine, which essentially upgraded them to the MiG-21US successor aircraft, the MiG-21UM. Two UM Mongol tandem trainers (MK-126 and MK-143) entered service in 1982. In the latter part of their service periods, all the MiG-21 models eventually ended up in the Luonetjärvi recce unit.

The first two MiG-21bis Fishbed-N all-weather fighters (dubbed MG-111 and MG-114) were delivered on September 21, 1978 to the Rissala Air Base, Fighter Squadron 31 (Karelian Air Command). These replacements for the MiG-21F Fishbed-Cs suffered a heavy attrition rate from engine trouble and were supplemented by a second smaller batch ordered in 1984 and delivered in 1986. They were primarily interceptors but had a second ground attack capability. All told, 26 MiG-21bis were delivered to the Finnish Air Force. Most of the MiG21bis are flown by HavLLv 31 (Fighter Squadron 31) and some are in use with the TiedLLv (Reconnaissance Squadron). The MiG-21bis aircraft are numbered MG-111, MG-114 to MG125, MG-127 to MG-136, MG-138, MG-139 and MG-140.

The Draken (meaning “Dragon” in Swedish) was born in the 1950s and entered service with the Swedish Air Force in the summer of 1960. The J-35A was the first in the series, which was followed by modified models through to model F. The C-model tandem trainer was essentially a modified A-model. The E-model was a photo reconnaissance aircraft. The Draken Fs remained in production until the end of the 1980s with improved avionics and weapons systems, which received the designation J-35J. Altogether, over 600 Drakens were built, with exports—besides to Finland—to Austria and Denmark, as well.

Finland's MiG-21F fighters were fair-weather aircraft only, and the Häme Air Command needed a replacement for its 13 British Folland Gnat Mk.1s in service since 1958 (which were later retired in 1972). The Draken was an all-weather fighter-interceptor with radar and infrared target acquisition systems. It had a supersonic operating radius of about 1,100 km in the intercept configuration. From Rovaniemi in the heart of Finnish Lapland it could reach the frontier in a little over five minutes. It was a logical choice. On April 8, 1970 the government approved the purchase of 12 J-35S (Swedish F-model) interceptors.

Draken-B trainers were originally rented from Sweden, but Finland decided to buy six of them, along with six F-model Drakens, in 1972. The first two of these were flown by MAJ Mikko Järvi and CAPT Pekka Kanninen on May 2 at Häme Air Command's Luonetjärvi Air Base. They entered service in 1974. The J-35C tandem trainer was purchased in 1976 for deployment to the Lapland Air Command, and two C-models were delivered to the Satakunta Air Command beginning in 1985. S-models were shipped for Valmet license assembly the same year and first flew on March 12, 1974, entering service the same year through 1977. The Satakunta Air Command purchased 18 Draken FSs in 1984; 12 were delivered between 1985 and 1988 after Valmet modification and modernization. The first three Saab J-35CS Draken (Swedish designationSk35C, sk stands for skol, or “training”) dual-seater trainers entered service in 1975, followed by two more of this model in 1984.

All told, Finland purchased 47 Drakens, beginning in 1972. The BS-models were phased out thusly: DK-202 (No. 35265) on September 9, 1993; DK204 (No. 35261) on November 29, 1994; DK-206 (No. 35266) on January 18, 1974; DK206 (No. 35245) on October 6, 1995; DK-208 (No. 35214) on May 11, 1995; DK-210 (No. 35243) on July 11, 1995; and DK-12 (No. 35257) on September 26, 1991.

Pushing their service life to the limit, the S-models will continue in service in the Lapland Command until the end of this century. The 35FSs, however, are being eliminated from service starting in 1995. The first of these was DK-261 and DK-237. The Air Force's November 14, 1995 flight accident at Luonetjärvi claimed the life of one young pilot in addition to retiring DK-231.

Retirement of the MiGs has proceeded in this manner: MiG-21bis MG-111 flew for the last time in 1993 and is now in the Finnish Aviation Museum in Vantaa (greater Helsinki). June 1994 saw MG-136 removed from service. In 1995 MG-123's last flight was in August and MG-132's in October; an in-flight engine fire finished off MG-122 in March (the pilot ejected safely). Accidents removed units MG-115, MG-117, MG-120, MG-128 and MG-139. One tandem-seater MiG-21UM (MK-143) flew for the last time in December 1993. The Karelian Air Command's Mig-21bis fighters are scheduled for retirement in the latter half of 1997.

B. Selecting the Hornet

In March 1990 Finland publicly sought to replace these ageing “tired metal” (as they say in Finnish) Mikoyan-Gurevich MiG-21s (slated for operational phaseout 1994-1997) and Saab J-35 Drakens (slated for operational phaseout 1991-2002) with a next generation fighter.

The official green light to do so was granted in the spring of 1989. Finland invited manufacturers to demonstrate their respective fighters' capabilities in competition. This was done on February 23, 1990 through requests for quotations (RFQs) on 20 single-seater and five tandem designs to Dassault Aviation (France), General Dynamics (USA) and Saab Scania (Sweden).

Although not specifically named in the requests, the main choices were the Saab JAS-39 Gripen (still a prototype at the time), the Dassault Mirage 2000-5 and the General Dynamics F-16C/D Fighting Falcon. Finland was looking for approximately 40 aircraft.

During late 1991 and early 1992, the Finnish Air Force conducted research flights of the various Swedish-, French- and U.S.-manufactured aircraft. All were evaluated in two phases: in the country of manufacture first, then in Finland. In addition, the MiG-29 was evaluated in Russia. Each phase represented two weeks of intensive scrutiny.

McDonnell Douglas' F/A-18 Hornet entered the picture in April 1991. The quotations were received on October 31, 1990. An alternate request for quotation on 60 single- and seven double-seaters was addressed to the same manufacturers on January 3, 1991. The same request was dispatched to McDonnell Douglas on April 12th.

Finland began looking more and more seriously at McDonnell Douglas' F/A-18. On February 12, 1992 the first Hornet to ever land on Finnish soil, BuNo 164652 on loan from the U.S.

Marine Corps, touched down in Halli. The D-model departed on the 25th after 15 Finnish trial flights. On May 6, 1992 the Finnish government under Prime Minister Esko Aho announced its intention to acquire the McDonnell Douglas F/A-18C and F/A-18D, 64 aircraft in all: 57 single-seater C-models (designated HN-401 through HN-457) and seven tandem D-model conversion trainers (designated HN-461 through HN-467). The letter of acceptance was signed on June 5th.

The following month two VFA-83 squadron Hornet-Cs (Bu Nos 163502 and 163499) from the carrier USS SARATOGA (CV-60) participated in the Kauhava Midsummer Day's celebration.

The third Hornet visit was that of the Blue Angels precision flying team, consisting of two F /A-18Bs (Bu Nos 161932 and 161943) and six F/A-18As (Bu Nos 161973, 161978, 161984,161955, 161957 and 161952) at a presentation in Turku in August-September 1992. The fourth visit—another C-model from the USS SARATOGA (BuNo 163481)—was at SIL's (Suomen Ilmailuliitto, the Finnish Aviation Society) 75th anniversary celebration in Jyväskylä in May 1994.

The recommendation of the FAF Headquarters to proceed with the purchase of seven F/A18Ds and 57 F/A-18Cs from McDonnell Douglas was made by the end of April 1992. The MoD and the Finnish government signed the letter of offer and intent (LOI) on May 6, 1992, followed by the signing of the letter of offer and acceptance (LOA) on June 5th, one day after the government finalized its decision. The letter of agreement on purchasing weapons, maintenance, operation and training systems would not be signed until January 20, 1994. The offset agreement was signed the following day.

The FAF's decision to purchase what was considered the “black sheep” of the fighter competition came as something of a surprise, as the goal of the aircraft acquisition was to choose an inexpensive and light fighter-interceptor. The Hornet can't realistically be considered either. It was relatively heavy and clearly a more expensive fighter than the competition. The Hornet acquisition therefore changed Finland's traditional mostly fighter interceptor policy towards the advantages offered by a more versatile multi-role—and costlier—aircraft. Even the D-models are outfitted with night equipment and conversion-ready from trainer role to battle configuration. Without a doubt the Hornets in Finland, as one Demari article put it, have “opened a concretely new era in Finnish military and security policy thinking.”

Finnish Air Force Headquarters has listed some “decisive factors” for selection of the F/A-18. Primary was “the superior quality/cost ratio, including both purchase costs and life-cycle running costs.” The overall price was actually reduced somewhat by eliminating unnecessary equipment for the Finnish Air Force (such as most carrier equipment), while leaving the fighter’s overall battle capability intact.

According to FAF MAJ-GEN Heikki Nikunen, the flight time-maintenance ratio makes the Hornet a favorable choice. Unlike the Draken and MiG's maintenance timetable of every 50 to 100 hours, the Hornet—by virtue of longer intervals between preventative maintenance schedules (PMS)—spends more time aloft and less time in the repair hangar. In most respects, ease of maintenance makes the use of reserve and conscript maintenance personnel a realistic and routine (and now fully implemented) matter of course.

According to the Finnish Air Force's test pilot and engineer LTCOL Jyrki Laukkanen, the Hornet's main feature is its weapons and radar system, as “its missiles are able to operate at greater distances and under worse conditions than our old fighters”. He also cites the aircraft’s look-down shoot-down ability (against cruise missiles, for example), tight-turn maneuverability and dogfighting prowess as major assets. LT Juha Kauhanen of Fighter Squadron 21 has told Aamulehti newspaper that the Hornet is easier to pilot than the Draken, which requires more of the pilot and is less “forgiving” in its aerodynamics and performance.

Laukkanen also touts the AIM-120 AMRAAM's technical superiority, namely its 60+-km range and its ability “to destroy a Draken without the Draken's pilot even knowing what hit his plane. Inside the AMRAAM itself is a better radar system than in the entire Swedish fighter”. These missiles are costing the Finnish taxpayer dearly, however. For economic reasons, therefore, the Finns have chosen to outfit each F-18 with only four such missiles, though it is easily capable of carrying ten at a time.

Finland's versions of this air-to-air missile are AMRAAM-Bs, probably in excess of some one million marks apiece.

Additionally, the dual engines' larger fuel consumption is greater than a single engine’s, but—according to one report—only by six to eight percent. MAJ-GEN Matti Ahola, Commanding Officer of the Finnish Air Force, maintains that additional fuel consumption is about 1.3 times current levels. In addition, the overall flight-hour cost for Hornet ops is roughly equivalent to the Draken's 22,000 - 26,000 FIM, that is, not greater than 25,000FIM according to current estimates.

Overall, the Ilmavoimat was particularly impressed by the aircraft's flight performance, weapon system and ground support. Some of the other criteria in selection were the agreeable payment schedule, foreign military sales (FMS) procurement, 100 percent offsets commitment from all manufacturers, spare availability and ongoing Hornet production.

C. Purchasing the Hornet

Modern fighters are expensive to purchase, arm, operate, hangar and maintain. In addition, ground crews, pilots and support personnel must be trained, paid and berthed. Though Finland’s political status in the North has changed and its membership in the European Union is opening up new avenues and possibilities, geographical imperatives remain constant. Finland pays for its independent, credible defense forces, which must stand alone according to the country's—enduring but modified—policy of military nonalignment. Despite the performance accolades, praise and impressive testimonials concerning the superior technology incorporated into the sleek F/A-18 airframe, for a small country, the Hornet is quite a significant financial burden. This is particularly true considering Finland's persistent double-digit unemployment and sluggish economic recovery after the recession of the late 1980s and early 1990s.

First estimates placed the price of a single aircraft at 203 million marks (around $47.2million), once the critical equipment was factored into the cost. In May 1992 original estimates, excluding weapons, placed the initial purchase cost at 9.5 billion FIM (Finnish marks), or about $2.2 billion. By the beginning of April, then-Defense Minister Elisabeth Rehn stated that, according to the most current data, the figure had risen to 16-17 billion FIM ($3.7 billion to almost $4 billion).

At its worst, the unfavorable exchange rate placed the cost at 20 billion FIM (around $4.65billion), but the cost has largely stabilized at around 14 billion -15.3 billion FIM (approximately $3.26 billion - $3.56 billion). As Harri Mannonen points out in his Yhteishyvä magazine article “Millaisia hävittäjiä saa 14 miljardilla?” (“What kind of fighters do you get for 14 billion marks?”), this equates to about 3,000 FIM per Finn.

According to the 1994 estimate set forth by Heikki Hiilamo and Simo Sipola's book Aavelasku (“Phantom Bill”), the total price tag is expected to exceed 37 billion FIM (around$8.6 billion), which includes maintenance and fuel. Weaponry alone was first estimated at3.5 billion FIM (about $814 million), but in January 1994 the approved AIM-120 AMRAAM acquisition came to 4.42 billion FIM (about $1.03 billion). Total payment for the aircraft has-been agreed to conclude by 2000-2001. By 1994, Finland had already paid about 4 billion FIM (around $930 million).

As mentioned, the total final cost is subject to exchange rates and indices. The fighter purchase budget dictates that the funds be divided into two parts, or authorization to order(ATO) phases, thusly:

- **First Authorization to Order (ATO-1):** 9.5 billion FIM (1992-2000) Purchases all the aircraft, funds Finnish industry, administrative costs and the prerequisites for the first phase of maintenance, training and operations.
- **Second Authorization to Order (ATO-2):** 4.42 billion FIM (1994-2001) Procures part of necessary equipment; the majority of maintenance, ground support and training systems; weaponry and part of communications system.

The published base price tag for an unarmed F-18 is $33.7 million. One wry Kainuun Sanomat columnist suggested that Satakunta (literally “Hundred District”) should be renamed Miljardikunta (“Billion District”) instead, to more appropriately reflect the hefty Hornet price tag. By the closing years of the decade, the Hornets and other air defense expenditures will have consumed half of the defense budget, largely at the expense of the ground forces, which must endure some “lean years” on the eve of the 21st century. With political pressure to remove the cost-effective anti-personnel landmine from Finland's stockpiles and much recurring talk of attack helicopter procurement for the Army (now an agreement between Finland and its Nordic partners for a joint acquisition program), the sucking sound of Air Force funding is increasingly more difficult to bear by the other Finnish military branches.

In any case, Hornet delivery started in November 1995 and is expected to last until the year 2000, with four entering Air Force service in 1996 (for a total of 11), ten in 1997 (for a total of 21), 13 in 1998 (for a total of 34), 18 in 1999 (for a total of 52) and 12 the last year (for 64 total aircraft by 2000). The Ds were completely built in the United States, but the C-models are a different story. They've been transported by ship to Finland, for assembly by Finnish personnel. This is currently taking place at Valmet's (now Finavitec) facilities. Here the craft are being pieced together with components from the company's Kuorevesi factories in Halli (where, incidentally, almost all of the company's Hawk trainers have been manufactured). Engine assembly takes place in Fighter Squadron 21's backyard, at the Linnavuori plant in Nokia (just outside Tampere). There are 137 GE-supplied kits.

Already, at least 150 Finavitec personnel have been trained in the U.S. for C-model assembly. The first F404-GE-402 engine in Finland was produced in August 1995, while airframe construction of the first Hornet-C launched at the same time. Instrumentointi Oy, the largest independent avionics repair unit in the Nordic countries, has been tasked with installation of ground support and training equipment, including flight simulators, in addition to responsibilities for testing Hornet computer software. This first F/A-18C (HN-401) was expected to fly in the summer of 1996 and enter service in the FAF in September 1996. This actually happened ahead of schedule, as we shall see in a moment.

Valmet/Finavitec, the Finnish state-owned corporation which started out as a government arms producer, has always had close ties to Finnish military production. Valmet has experience with aircraft manufacture. It already assembles the MD-80 engine as a Saab contractor and is the sole manufacturer of the aircraft's airbrakes. With heavy lobbying, Valmet’s primacy in the government bid was secured. McDonnell Douglas sold the assembly and maintenance know-how to the Finns as part of the agreement, with technical support and assistance, training, equipment and weapons manufacturing information. This guarantees government contractual support of Valmet for the duration of the Hornet program in Finland.

In addition, Valmet's dual-seater Redigo prop-trainer aircraft became the decisive element of the deal. Redigos, under a sales assistance agreement signed in December 1991 with McDonnell Douglas, will be marketed abroad for the first time using McDonnell Douglas’s local sales network to Persian Gulf states, Japan, Taiwan and other countries (eventually, however, the Italians stole the fire of these hopes when they purchased Redigo rights and promptly began beating the Finns at marketing the aircraft overseas). In any case, every Valmet division, excluding the tractor division, has been included in the reciprocal Hornet deal.

Not surprisingly, after news of the contract, Valmet's shares rose from 18 FIM to 46 FIM. The company calculated that it would benefit 2,600 man-hours from spare parts manufacture and assembly, along with the creation of a few hundred new jobs. Later, Valmet wants to secure long-term civil aviation contracts through foreign deals, with prospects in the pipeline such as the MD-12 McDonnell Douglas-Taiwanese joint deal, predicted to be the first real challenger to the Boeing 747. McDonnell Douglas' carrier-based Hawk trainer, currently in the development phase, may offer Valmet some additional future contract work.

By the end of October 1995 about 40 percent of the $3 billion offset obligation for the Hornets had already been fulfilled. As a result, in addition to technology transfers, small and medium-sized Finnish companies have been offered inroads into the U.S. market. As of October 1995, total booked offset credit amounted to $1.37 billion (about 6 billion FIM). The share of direct offsets consists of assembly and part manufacture of the aircraft; indirect offsets include export (68 percent), technology transfer to Finland (14 percent), marketing assistance (ten percent) and miscellaneous (eight percent). The total offset covers the entire purchase price of the Hornets. The obligation must be fulfilled by the year 2005.

Although it is the author's personal opinion that the offsets were probably a little too optimistic, confirmation of just how much or how little they have lived up to Finnish high expectations has not been forthcoming. If the Redigo debacle and consistently unfavorable exchange rates are any indication, the Finns did not make out as well as they had hoped.

In any case, Valmet Aircraft Industries has been rechristened Finavitec. With its new name, it is setting new production records. Finland's first single-seater Hornet (number HN-401) was delivered three months ahead of schedule on June 28, 1996. It entered active service the same week. The delivery ceremony at the Air Force's Kuorevesi plant in Halli was attended by Finnish President Martti Ahtisaari and Minister of Defense Anneli Taina.

Other VIPs included USN Vice-Admiral John Lockard, Herbert Lanese (McDonnell Douglas' director, military aircraft division) and Finavitec's Chief of Operations Veijo Vartianen. At present, about one Finnish FN-18 per month rolls out of Finavitec's plants and into aviation history.

D. Finnish FN-18s

At Lambert Field in St. Louis, the first Hornet manufactured for Finland (D-model HN-461), undertook its maiden flight at 8:30 on the morning of Friday, April 21, 1995. The test flight was piloted by McDonnell Douglas test pilot Fred Madenwald. Seated behind him for the 123-minute flight was USN LCDR Dave Stuart. Afterwards, it received its battle-gray paint and Finnish military insignia. This aircraft's official rollout was August 7th. By the end of August, five of the seven D-models had been test flown. Evaluation of Hornet 461's instrument landing system (ILS)—which, incidentally, American Hornets lack—took place in June at Naval Test Flight Center Patuxent River, Maryland. More tests followed at China Lake Naval Air Station, California.

Finland's first four F/A-18 Hornets (all D-models, designated HN-462, HN-464, HN-465, and HN-466) were delivered on November 7, 1995 to the Satakunta Air Command's Pirkkala Air Base south of Tampere. Over 5,000 observers were on hand to watch the aircraft land after their 9-hour, 35-minute flight, which lasted 8,200 km across the Atlantic Ocean. The first touched down in Pirkkala at 3:06 p.m.

These dual-seaters were piloted by American Naval aviators from VFA-125 “Rough Raiders” (NJ). Their Finnish officer counterparts rode shotgun. All the Hornets were outfitted with two 330-U.S. gallon external tanks.

Accompanying the fighters was a McDonnell Douglas KC-10 Extender strategic tanker, which refueled each fighter nine times (averaging every 64 minutes) during the trip [These operations were similar to the one depicted at right]. The tanker was itself refueled twice by a Boeing in-flight-refueling tanker KC-135 Stratotanker. The KC-10 departed with the Hornets from St. Louis but broke off for England when the formation reached Norway.

During each 4-minute refueling operation the fighters took on an average of 660 gallons (2,500 liters) apiece (equivalent to topping off their drop tanks). Each burned about 7,920 gallons (30,000 liters) of jet fuel on their way to Finland, averaging 14 gallons (52 liters) a minute or 826 gallons (3,130 liters) an hour.

The journey was uneventful. Visibility was poorest over Iceland. After having gained permission to pass through Swedish airspace, the F/A-18s were joined briefly over Sweden by two Saab JA-37 Viggen interceptors. The Viggens maintained a higher altitude than the Finnish fighters, never closed under 1.5 km and made no radio contact. So much for Swedish hospitality! It was reported that the trip from Rymättylä (west of Turku) to Pirkkala lasted less than ten minutes.

Finns themselves first flew Hornet HN-465 on November 17, 1995. The aircraft was moved to the Halli Test Flight Center by MAJ Juha Grönmark and MAJ Kauko Vilpponen. Ten days later HN-464 was flown by LTCOL Jarmo Lindberg and CAPT Kim Jäämeri.

Following the November 1995 Satakunta Air Command deliveries, the Karelian Air Command received its own Hornets—the three remaining D-models from the United States—on Friday, February 16, 1996. The three aircraft (referred to as Zesty 41-43 for the flight) touched down at Rissala Air Base near Kuopio at about 12:30 p.m. after a non-stop flight of over nine hours from St. Louis. The USMC aviator-piloted flight (by Ross Roberts, John McSherry and Brian Grant) proceeded as planned, though take-off was delayed by an hour in Missouri for ice removal. The “shotgun Finns” were CO, Karelian Air Command COL Heikki Harjunmaa; CO, Air Force Headquarters COL Osmo Tolvanen; and CAPT Jari Tuominen of the Lapland Air Command. COL Harjunmaa reported a pleasing, quiet journey at a 12-kilometer flight ceiling. In addition to hundreds of spectators, on hand to meet the air crews were MAJ-GEN Matti Ahola, Ilmavoimat CO.

Finland's Hornet procurement brings with it three years' worth of spares; I- (Air Command),O- (Squadron) and D- (Depot) level logistics; the majority of repair shop maintenance logistics; product support throughout delivery; training equipment and training of personnel in the United States; 300,000 pages of manuals and support material; pilot equipment and the participation of Finnish industry. A complete Hughes-manufactured simulator placed at the Pirkkala Air Base is supplemented by computer training equipment at all the Air Commands, as well as at the Air Force Technical School, the site of a system simulator for the conversion training of pilots and maintenance personnel.

Finland chose that its Hornets be equipped with the APG-73 coherent pulse doppler radar system, which hasn't even yet been installed in the U.S. military's own aircraft. It is a further developed version of the standard APG-65, which is also being placed in the new E/F-models, will be in the Swiss and Malaysian Hornets. This Hughes-manufactured system flew for the first time in April 1992. Its signal processor is nearly ten times faster than its predecessor, with improved ECM capabilities, though the antenna and transmitter unit are the same as the APG-65's. The APG-73 fire-control radar will be built entirely in the USA.

However, the Hornet's onboard computer will be manufactured by Valmet. The computer is known as Dlec. It is reported to be of a new and revolutionary type.

Enhanced receiver sensitivity has extended range to over 250 km in Velocity Search Mode,150 km in Range While Search Mode and 75 km in Track While Scan Mode and 55 km in Raid Assessment Mode. The entire system weighs just over 200 kg. The radar provides target information to the missiles after firing. At mid-flight to target, the missile switches over to its own inertial instruments, and in the final phase before detonation utilizes its own radar.

Finland's Hornets are outfitted with the ITT/Westinghouse ALQ-165 ASPJ (Airborne Self Protection Jammer) system. The ASPJ contract was signed on September 30, 1994. The Ilmavoimat is the first customer for the ASPJ, the U.S. Navy having cancelled its order in 1992. The ASPJs will cost about $2 million apiece. Integration of the ASPJ with the Finnish Hornets will be handled by the U.S. Navy. The aircraft's datalink is Finnish-built. As their Kuwaiti and Canadian counterparts, Finnish Hornets are equipped with a searchlight on the port side of the nose [see picture of Hornet-C and Hornet-D showing port-side shots].

Remarkably, however, Finland did not choose the cold-weather equipment. The most recent information indicates the Hornets' take-off and landing performance under Finnish foul weather conditions has been generally favorable, though reported icing around the engine air intakes initially caused concern. Nevertheless, the Hornet's handling during take-off and landing has been described as exceptional even on ice-covered runways. There has been some talk that the Hornet is less successfully operated from dirt and gravel airfields due to the position of its intakes than competing fighter designs, but the severity of this liability appears to be negligible. In any case, Finland operates its aircraft from premium airfields or specially prepared dispersal launch-points, so this is not a problem.

In the beginning, according to Commander, Satakunta Air Command, COL Jouni Pystynen, there were no complaints of noise in the Tampere area when the Hornets began flight ops. However, by the following autumn, civilian complaints had reached the ears of successor CO LTCOL Markku Määttänen. He has explained that the approach path Pirkkala Air Base is dictated primarily by prevailing wind conditions. For this reason, the majority of the time the aircraft are forced over Tampere's southernmost residential areas.

Evidently, the Hornets' approach path is determined by wind direction at any given time, because at Pirkkala the FN-18s land braking against the wind. Wind direction about 80 percent of the time is from Vesilahti (the rural area on the other side of the base) towards Tampere, so the heavily populated urban area routinely suffers. It would seem that the airfield is grossly inadequate, in any case, with a critical equipment shortage due to lack of funds. Civilian aircraft are forbidden to land there with tailwinds over 10 knots, which further demonstrates the runway length problem (which does not affect Hornet flight ops).

Flight controllers at the base oppose any bi-directional runways. They feel that poor visibility under adverse weather conditions could lead to collisions between approaching and departing aircraft.

The Hornet's growing pains in Finland are only just beginning. On Friday, November 8, 1996 an American test pilot flew a little too low on approach and damaged Finland's sixth F-18 by colliding with landing lights at the Halli facility. He was unaware of his error until told after landing (mostly in the form of some weakened structural support joints and hydraulic damage). Yet, as Finavitec's Air Safety Director Jukka Koskela has said, “when one speaks of aircraft repair, that's money up in smoke... tens of thousands of marks.”

According to Aamulehti and Helsingin Sanomat newspapers, both reporting on Wednesday, May 14, 1997, an engine fire occurred in one of the C-models at Pirkkala during a routine training flight on Monday, May 5. The plane was a new and had just been delivered the week before. In fact, it had been flown but six hours when the incident occurred. Until this event, reportedly nothing out of the ordinary characterized the newly assembled aircraft. The pilot shut down the burning engine immediately according to procedure and was able to return safely to base on the other engine. Finnish Air Force COMAJ-GEN Matti Ahola admitted that situation was dire enough to have warranted an ejection in any single-engine aircraft.

Upon inspection (particularly under high pressure tests), it became apparent that a leaky fuel coupling was the culprit. It is located between the fuselage and the engine compartment, where fuel is directed laterally to cool an oil pump. Fuel leaked from this area into the engine, vaporized and ignited in the afterburner like a roman candle. The same fault was discovered in another F-18 assembled at Kuorevesi. Such engine fires have reportedly plagued many Hornets in U.S. service, as well as in the Swiss and Canadian air forces. Word was sent immediately to the USMC and MDC contacts in the States. Technical experts were promised by week's end. Needless to say, the Finns were determined to get to the bottom of this fault.

By summer 1998, the FAF had noticeably fallen victim to that all-to-familiar pilot retention problem that plagues most air forces around the world. Whereas a Hornet pilot may earn some 20,000 Finnish marks per month (around $48,000 a year), his civilian counterpart at Finnair brings home double that figure, probably with all-round better benefits to boot. Air Force pilots suggested upping pay by some 45 million marks (over $8 million), which equates to a monthly salary increase of about 16,000 to 18,000 FIM per pilot. This will make them think twice about "selling their freedom" over the 10.5-year mandatory commitment to the Service.

The saga continues...

Despite this collage of problems, there is no doubt that Finland's overall interceptor and air defense capability is greatly enhanced. Although, the maximum combat ceiling and speed of the country's new aircraft is roughly analogous to that of former performers, there is a clear improvement in acceleration, climbing, turning capacity, endurance and range. Other performance upgrades are airborne radar-related (better look-down capability, improved target detection range, multi-target tracking ability, radar navigation ground map features and heightened ECM capacity) and AAM-related (missile launch at greater distances, improved performance in an ECM environment and higher missile payloads per aircraft for multi-missile shots).

The chart at left presents some basic size and weight stats to the reader in order to get a general picture of Finland's move up to the FN-18. Similar data can be found at the site's Combat Aircraft Comparisons page, which analyzes select aircraft payloads, ranges, sizes, weights, engines, avionics and so forth. Fighters discussed include the F-4, F-14 Tomcat, JAS-39 Gripen, F-16C, Mirage and MiG-29 Fulcrum; strike aircraft include the A-6and A-7.

Finnish Fighter Comparison Chart

	F/A-18C	**Draken FS**	**MiG-21bis**
Weight (kg)	10,680	8,250	5,750
Wing Area (m2)	37.16	49.2	23.04
Wingspan (m)	11.43	9.42	7.15
Length (m)	17.07	15.34	15.76
Height (m)	4.67	3.89	4.10

As LTCOL Jyrki Laukkanen has said, “At the moment our air defense is good, although on the surface the amount of aircraft is immeasurably small”. He's right. The FAF is a miniscule air force by Super Power standards, yet, arguably, it ranks among the top-notch military organizations in the world for its size. This is a matter of quality, not quantity. Now that fundamental changes are under way in the structure, procurement and deployment of Air Force resources (in particular the introduction of the Hornet into service), the Ministry of Defense reports that at least ten MiGs have been phased out and all will be eliminated from active service by the year 2000 [here is a picture of an FAF MiG-21]. The Ilmavoimat will continue for some time in a state of flux, upgrading facilities and equipment and absorbing the next generation fighter into its ranks.

Aamulehti newspaper states that there are approximately 20 aircraft deployed to therein Air Command. According to the Air Command HQ CO Hannu Myöhänen, Fall 1996 hangar construction at a cost of about 18 million FIM (c. $4.19 million) and renovation and repair of other structures at the base, will carry a 30 million - 40 million FIM (c. $6.98million - $9.3 million) price tag over the next four years. The Lapland Air Command expects to receive its own Hornets in 1999.

A Finnish fighter wing corresponds to its regional air command: western, eastern or northern. Each operates a single fighter squadron of 12 to 20 aircraft, plus a few liaison planes, as well as maintenance, logistics, administrative and base defense personnel. Up until a few years ago Finland deployed its older aircraft in the following manner:

- **North:** 18 Drakens (six F- and 12 S-interceptors, five B- and three C-OCU trainers) Lapland Air Command, Fighter Squadron 11;
- **West:**12 Draken F-interceptors Satakunta Air Command, Fighter Squadron 21; and
- **East:** 30 MiG-21 (30 interceptors and six tandems) Karelian Air Command, Fighter Squadron 31.

According to Pekka Parantainen, a frequent Hornet article contributor to Aamulehti newspaper, Fighter Squadron 21 is now exclusively an FN-18 unit. This move ends 25 years of faithful service afforded by Saab Draken interceptors [here is a picture of an FAF Draken]. The last of these Drakens were flown to the Lapland Squadron at Rovaniemi, where they (all 25-30 now stationed in the north) will continue their service until the end of the century. Their aircrews, however, did not accompany them and have remained at the Satakunta Command. The final Saab 35CS “Cesar” was piloted by MAJ Markku Viitala with LTCOL Jarmo Lindberg in the backseat.

E. FinnFacts

- **Kickin' “A”:** Finland's Hornet designation differs from the standard F/A (Fighter/Attack), being simply FN-18, as, other than strafing capability, they lack ground attack armament. (You can jettison a drop tank or two onto the enemy's head, right?)
- **Buckle Up:** The first modification the Finns made to the Hornet was replacement of its seatbelt!
- **Live Long and Prosper:** The operational lifetime of the Hornet in the Ilmavoimat is expected to last until around the year 2030.
- **Round-trip Ticket:** FN-18s can fly round-trip between Rovaniemi and Helsinki—roughly the entire length of the country—without refueling.
- **Gas Slurper:** A Hornet burns in the neighborhood of 10,000 liters an hour (costing 10,000FIM or about $2,326). However, this accounts for only about eight percent of the aircraft’s overall repair and operating cost.

- **Flight Hours or Bust:** The Air Force's eventual target for the Hornet is 10,000 flight-hours per annum, which will cost around 250 million FIM.
- **Street Hooker:** The Ilmavoimat's F-18s are equipped with the arresting hook system, making 300-meter landings possible on short runways. This is possible on even smaller pre-prepared highway strips, if necessary.
- **Grounded:** By the end of January 1996, critical technical manpower shortages, budgetary restraints and, to some degree, foul weather, limited ops at Pirkkala Air Base to a couple of dozen flight-hours for the Hornets' first month in Finland.
- **Ye Olde Junk:** The fate of Finland's old MiGs and Drakens? Some have been put in museums, some preserved for crisis service, and the rest sold for scrap. For instance, the last BS-model "Peter" Draken-35 (DK-206) was piloted by MAJ Markku Anttonen from Rovaniemi (Lapland Air Command) to the Helsinki Museum of Aviation on October 6,1995.
- **The Finnish Air Force:** The Finnish Air Force (FAF), or Ilmavoimat, today consists of 4,500 personnel (1,300 of which are conscripts), who serve in three air commands (Karelia Air Command, Lapland Air Command and Satakunta Air Command), one reconnaissance squadron, one transport squadron and the Air Force Academy.

Section 4: Acronyms

A/A air-to-air

A/F-X Attack/Fighter Experimental

A/G air-to-ground

AA anti-aircraft

AAA anti-aircraft artillery

AAM air-to-air missile

ACF Air Combat Fighter

ACLS Automatic Carrier Landing System

ADF automatic direction finding

ADLP Advanced Data Link Pod (AAW-9/AWW-13 Walleye I/II & SLAM ER) AGM air-to-ground missile

ALARM Air-Launched Anti-Radiation Missile (AIM-122)

AMRAAM Advanced Medium-Range Air-to-Air Missile (AIM-120) AOA angle of attack or alpha

ASM Anti-Ship Missile (AGM-84A/D Harpoon)

ASPJ Airborne Self Protection Jammer

ASR armed surface reconnaissance

ASTA Aerospace Technologies of Australia, formerly Government Aircraft Factory ATARS Advanced Tactical Air Reconnaissance System

ATF Advanced Tactical Fighter

AWACS Airborne Warning and Control System

BITE Built-in Test Equipment

BuNo bureau number

BVR Beyond Visual Range

C3 Command, Control and Communications

C3I Command, Control, Communications and Intelligence

CAG carrier air group

CAP combat air patrol

CAPT Captain

CAS Close Air Support or Control Augmentation System

CASA Construcciones Aeronauticas SA (Spain)

CATGME Canadian Air Task Group Middle East

CEM combined effects unit

CEP circular error probable

CMDR Commander

CO commanding officer

COL Colonel

CRT Cathode Ray Tube

C/VER see CVER and VER

CVER Canted Vertical Ejector Rack (BRU-33A bomb rack, see VER) DASC Direct Air Support Center

DCA defensive counter-air

DDI digital display indicator

DEL Direct Electrical Link

DoD Department of Defense

EAF expeditionary airfield

ECM Electronic Countermeasure

EO Electro-Optical (AGM-65A/B Maverick)

EPE enhanced performance engine

ER/DL Extended Range/Data Link (AGM-62 Walleye II)

FAC(A) Forward Air Controller (Airborne)

FAF Finnish Air Force

FBW Fly by wire

FCS Flight Control System or Fire Control System

FCSL forward support coordination line

FFAR Folding-Fin Aircraft Rocket (LAU-10 and LAU-68)

FIM Finnish markka (monetary unit)

FLIR Forward-Looking Infrared (AAR-50 and AAS-38)

FMS foreign military sales

FRS fleet replacement squadron

FSD full-scale development

GAO Government Accounting Office

GBU glide bomb unit

GE General Electric

GIB Guy in Back, aka RIO or WSO

GPB General Purpose Bomb (Mk 80 series)

GPS Global Positioning System

HARM High-Speed Anti-Radiation Missile (AGM-88)

HARV High Angle of Attack Research Vehicle

HOTAS Hands-on Throttle and Stick

HUD head-up display

HVU high-value unit

HQ headquarters

IADS integrated air defense system

IECMS In-flight Engine Condition Monitoring System

IFEI Integrated Fuel/Engine Indicator

IFF Identification Friend or Foe

IGARH Inertial Guided/Active Radar Homing

ILS/VOR Instrument Landing System/Very High Frequency Omnidirectional Ranging INS Inertial Navigation System

IR infrared

IRST Infrared Search/Track

JASSM Joint Air-to-Surface Standoff Missile

JDAM Joint Direct Attack Munition (GBU-29 and GBU-31)

JSF Joint Strike-fighter

JSOW Joint Standoff Weapon (AGM-154)

KBX killbox

LANTIRN Low Altitude Navigation Targeting Infrared for Night LCD Liquid Crystal Display

LCDR Lieutenant Commander

LDT/CAM Laser Detector Tracker/Camera (ASQ-173)

LERX Leading Edge Wingroot Extension, aka LEX

LEX Leading Edge Extension, aka LERX

LGB Laser Guided Bomb

LOA Letter of Offer and Acceptance

LOI Letter of Offer and Intent

LRS Luonetjärvi Reconnaissance Squadron

LTD/R Laser Target Designator/Rangefinder (AAS-38), aka T-FLIRLT Lieutenant

LTCOL Lieutenant Colonel

LG laser-guided

LGB laser-guided bomb

LGTR laser-guided training round

LST laser spot tracker

LWF light weight fighter

MAJ Major

MAJ-GEN Major General

MCAS Marine Corps Air Station

MDC McDonnell Douglas

MER multiple ejector rack

MFD Multi-Function Display

MiG Mikoyan-Gurevich

MIP main instrument panel

NACES Navy Aircrew Ejection Seat

NACF Navy Air Combat Fighter

NAS Naval Air Station

NASA National Air and Space Administration

NATC Naval Air Test Center

NATF Naval Advanced Tactical Fighter

NAVFLIR Navigation Forward Looking Infrared (AAR-50), aka TINSNVG Night Vision Goggles

NVIS Night Vision Intensification System

NWC Naval Weapons Center

OCA offensive counter-air

OFP Operational Flight Program

PGM precision-guided munition

PMS Preventative Maintenance Schedule

PMTC Point Mugu Test Center, Navy

R&D research and development

RAAF Royal Australian Air Force

RFQ Request for Quotations

RHAW Radar Homing and Warning

RIO Radar Intercept Officer, aka GIB or WSO

RoE Rules of Engagement

RoKAF Republic of Korea Air Force

SA Situational Awareness

SAM surface-to-air missile

SAPHEI Semi-Armor-Piercing High-Explosive Incendiary

SEA Southeast Asia

SEAD Suppression of Enemy Air Defenses

SIL Suomen Ilmailuliitto (Finnish Aviation Society)

SLAM Standoff Land Attack Missile (AGM-84)

SLAM/ER Standoff Land Attack Missile/Expanded Response (AGM-84) SLAR Side-Looking Airborne Radar

SWA Southwest Asia

TAC(A) Tactical Air Coordinator (Airborne)

TACAN tactical air navigation

TALD Tactical Air-Launched Decoy (ADM-141)

TAOC Tactical Air Operations Center

TER Triple Ejector Rack

T-FLIR Targeting FLIR, aka LTD/R

TINS Thermal Imaging Navigation Set (AAR-50), aka NAVFLIRTNB Tactical Nuclear Bomb (B57 and B61)

TRAM Target Recognition Attack Multi-Sensor

TSSAM Tri-Service Standoff Attack Missile (cancelled)

TUDM Tentar Udar Diraja Malaysia (Royal Malaysian Air Force)

TWS Track-While-Scan (radar mode)

USAF United States Air Force

USMC United States Marine Corps

USN United States Navy

USS United States Ship

V/STOL Vertical/Short Takeoff and Landing

VA Attack (Navy squadron prefix)

VER Vertical Ejector Rack, aka VER-2 (BRU-33 bomb rack, see CVER)

VS Velocity Search (radar mode)

VF Fighter (Navy squadron prefix)

VFA Fighter/Attack (Navy squadron prefix)

VFAX Carrier-borne Fighter/Attack Experimental (aircraft)VFC

VHF Very High Frequency

VMFA(AW) Marine Fighter/Attack (Marine squadron prefix)

VMFAT Marine Fighter/Attack Training (Marine squadron prefix)

WSO Weapons Safety Officer, aka GIB or RIO

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