



CANADA AVIATION AND SPACE MUSEUM AIRCRAFT

McDONNELL DOUGLAS CF-188B HORNET
CANADIAN ARMED FORCES SERIAL 188901



By T.F.J. Leversedge
Canada Aviation and Space Museum Research Volunteer

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INTRODUCTION

The McDonnell Douglas (now Boeing) CF-18 *Hornet* (official military designation CF-188) is a Canadian Forces / Royal Canadian Air Force (CF / RCAF) jet fighter aircraft based on the American-made F/A-18 *Hornet* fighter. In 1980, the CF-18 was selected as the winner of Canada's New Fighter Aircraft (NFA)



Two CF-18s from 433 Tactical Fighter Squadron high over Bagotville, Quebec - (CF Photo 2007-03-19-07HQ)

competition, and a production order was awarded. The Canadian Forces began receiving the CF-18 in 1982. CF-18s have since routinely supported North American Air Defence (NORAD) Command air sovereignty patrols in North American and North Atlantic Treaty Organization (NATO) missions in Europe. The fleet has also participated in combat operations during the Gulf War in 1991, the Kosovo Air Campaign in the late 1990s, and also as part of the Canadian contribution to the international Libyan no-fly zone in 2011.

By the time the CF-18 fleet is fully retired sometime in the 2020 timeframe, the type will have seen 40+ years of front-line operations.

The use of the CF-18 *Hornet* in CF / RCAF service has been exclusively as a land-based fighter, which is slightly unusual in that the original F/A-18 *Hornet* design was intended to be a carrier-based naval fighter. Canada was the first nation to select the aircraft type for more conventional operations but other nations quickly followed suit.

This modified use of a naval fighter design has however caused some in-service problems for the fleet while in Canadian use and eventually necessitated an extensive structural repair program. The fleet has also recently received a two-part modernization program which encompassed not only structural improvements but an extensive overhaul and replacement of critical systems on board along with cockpit improvements. The aircraft is now fully capable of using the most sophisticated precision-guided weapons.

Cover Photo Caption - CF188901 following delivery to the (at the time) Canada Aviation Museum - (Bill Upton Photo)

Aircraft Design Evolution ¹



Two prototype YF-17 Cobra fighters in formation - (Bill Upton Collection)

Perhaps surprisingly, for a naval aircraft, the F/A-18 *Hornet* can trace its origins to an air force fighter design competition. The F/A-18 design originates from the Northrop-designed P-530 *Cobra* which was first unveiled as a prototype in 1973. The P-530 derived its *Cobra* name from the hooded appearance created by the leading edge extension, or LEX, of the wing on the forward fuselage. Re-designated as the YF-17², it was nominated as a finalist against the General Dynamics YF-16 *Fighting Falcon* in the United States Air Force (USAF) lightweight air superiority fighter program.

Unfortunately, for Northrop, the YF-16 went on to win the USAF competition and the F-16 was selected for USAF production. But losing the lightweight design competition was not the end of the line for Northrop as the US Navy (USN) had also expressed interest in a new multi-role fighter to complement its Grumman F-14 *Tomcat* fleet. The USN, however, was skeptical that a single-engine aircraft with a narrow-track landing gear like the YF-16 could be safely adapted to carrier operations. The USN was demanding an aircraft with the superb dog-fighting characteristics of the YF-16 but also one that could carry the medium-range AIM-7 *Sparrow* missile along with other munitions for a multi-role capability. Two engines were also seen as preferable and the YF-17 already possessed many of these design characteristics.

To go after this US Navy competition, consequently, Northrop teamed with McDonnell Douglas aircraft company which previously had extensive experience in providing successful naval aircraft. McDonnell Douglas and Northrop agreed that any production of this new naval fighter design, now designated the F-18, would be split roughly 60/40 between the two contractors with roughly 20% being absorbed in final assembly. McDonnell Douglas was to become the “prime” contractor for these naval versions but if a land-based competition presented itself in the future, these proportions would be reversed with Northrop performing the final assembly and being the “prime”. Regardless of the variant, Northrop was to build the centre and aft fuselage sections, as well as both vertical stabilizers, while McDonnell Douglas would build the wings, stabilizers and the cockpit and the forward fuselage. Northrop consequently retained the YF-17 prototype, now designated as the F-18L, as a potential competitor for future land-based fighter competitions.

In cooperation with McDonnell Douglas, the basic YF-17 design underwent a radical transformation for naval operations. While the basic twin-tail configuration was retained, virtually no dimension or mold line from the original design went untouched. The F-18 was intended to be heavier than the YF-17 so there was an obvious need for more thrust from the engines. General Electric F-404 engines were adopted in place the YF-17’s General Electric YJ-101 powerplants. In order to provide an all-weather capability, provisions were made for *Sparrow* missiles and other munitions along with a suitable multi-mode radar, fire control system and appropriate avionics for the specified all-weather attack role. The Hughes APG-65 radar, which was selected, necessitated that the nose of the YF-17 design be enlarged and reshaped to accommodate it.

Naval operations demanded greater range capability, so the internal fuel capacity was increased by nearly two-thirds to 4,472 kg (9,860 lbs) of fuel. Provisions were also made for additional fuel to be carried in wing pylon and fuselage centerline drop tanks along with a retractable air-to-air refueling probe. The high impact forces associated with carrier landings and take-offs demanded a considerable “beefing up” of the nose and main undercarriage along with additional structural reinforcement throughout the airframe. A strengthened tail hook for arrested landings was included. The single nosewheel of the YF-17 gave way to a twin-wheel design with provision for a catapult launch bar. The wing area was increased by 4.645 square metres (50 square feet) and the span was enlarged by 0.762 metres (2.5 feet) along with an extension in the wing chord. Provisions were also made for folding wings. The trademark LEX, which aerodynamically faired the wings to the fuselage, was both refined and increased in size. Further aerodynamic refinements were made to the leading edge and trailing edge flaps, ailerons and horizontal stabilizers. The cockpit design received significant attention with emphasis being placed on improved “user friendliness” involving cathode ray tube (CRT) and hands-on-throttle-and-stick (HOTAS) technologies.



The prototype F/A-18 Hornet retained the basic planform of the YF-17 but not much else - (Bill Upton Collection)

All of these changes added another 4,535+ kg (10,000+ lbs) to the original YF-17's 10,432 kg (23,000 lbs) gross weight. Approximately half of the structural weight of the F/A-18A is made up of aluminum, while steel contributes another 16.7 percent. Titanium makes up about 13 percent of the weight, being used for significant portions of the wings, vertical stabilizers, horizontal stabilator attachments and the wing-fold mechanisms. About 40 percent of the aircraft's surface area is covered in a graphite-epoxy skin, making up approximately 10 percent of the aircraft's overall weight. The remaining structural weight is accounted for by various other materials including plastic and rubber compounds.



This overhead view of a prototype F/A-18 Hornet illustrates the trademark LEX extensions retained from the YF-17 design. Note also the slots in the LEX which later disappeared on production aircraft in order to solve aerodynamic issues - (Bill Upton Collection)



A view of the prototype F/A-18D Hornet. The dual aircraft is interchangeable with the single-seat variant being fully combat capable - (Bill Upton Collection)



The F/A-18 Hornet was cleared for USN carrier operations to replace the both F-4 Phantom and A-7 Corsair fleets - (Bill Upton Collection)

Canada's New Fighter Aircraft Program ³

In 1977, the Canadian government identified the need to replace the NATO-assigned CF-104 *Starfighter* the NORAD-assigned CF-101 *Voodoo* and the CF-116 *Freedom Fighter* (although the decision was later made to keep the CF-116). Consequently, the government proceeded with the New Fighter Aircraft (NFA) competition, with a budget of approximately \$2.4 billion to purchase up to 150 of the winning aircraft design in the competition. The NFA candidates included the Grumman F-14 *Tomcat*, McDonnell Douglas F-15 *Eagle*, Panavia *Tornado*, Dassault *Mirage F.1* (later the *Mirage 2000*), plus the competitors of the American Lightweight Fighter (LWF) competition, the General Dynamics F-16 *Fighting Falcon*, and the McDonnell Douglas F/A-18 *Hornet*, along with the de-navalized version of the *Hornet*, the F-18L. The government stressed that the winner of the competition must be a proven off-the-shelf design and also provide substantial industrial benefits as part of the order.



A view of the prototype F-18L (YF-17) sporting Canadian markings - (Author's Collection)



An artist representation of the F-16 in Canadian colours - (Bill Upton Collection)

By 1978, the NFA competitors had been short-listed to just three aircraft types: the F-16 and the two F-18 offerings. The F-14, F-15, and the *Tornado* had been rejected due to their high purchase price, while Dassault, with the *Mirage F.1* and *Mirage 2000* had voluntarily dropped out of the competition. The F-18L combined the systems and twin-engine layout of the F-18 that Air Command favored with a lighter land-

based equipment setup that significantly improved performance. But Northrop, the primary contractor for the F-18L version, had not yet put the F-18L into production by the time of the NFA program, waiting on successful contracts before doing so. While Northrop offered the best industrial offset package, it would only "pay off" if other F-18L orders were forthcoming, something the Department of National Defence (DND) was not willing to count upon. Unfortunately for Northrop, this proved to be the case and the F-18L never did go into production.

Used F-14 *Tomcats* almost entered Canadian service as a result of the Iranian revolution. In the aftermath of that revolution, the United States cut off all military supplies to Iran, which meant that the Iranians' new fleet of F-14s would be potentially rendered unflyable due to a lack of spares. Canada then offered to purchase them at a steeply discounted price but these negotiations ended before a deal was reached when it was revealed that Canadian involvement had been crucial in the smuggling of American embassy personnel out of the new Islamic Republic.

In 1980, the McDonnell Douglas F/A-18 *Hornet* was declared the winner of the NFA competition. The reasons listed by the Canadian Forces for the selection of the *Hornet* were many of the same features originally desired by the USN; two engines for reliability (considered essential for conducting Arctic sovereignty and over-the-water patrols), an excellent radar and mission suite, while being considerably more affordable than either the F-14 and the F-15. The ensuing order included 98 single-seat variants and 40 dual-seat variants, for a total of 138 aircraft, along with options for another 20 (but these were never exercised). The F/A-18 *Hornet* was then officially designated the CF-188 in Canadian service. But in almost every context, except for the most official of military documents, the aircraft are simply referred to as CF-18 *Hornets*.



The CF-18 Hornet (188901) is shown here with the three Canadian fighters it was originally intended to replace the CF-104 Starfighter, the CF-101 Voodoo, and, the CF-116 Freedom Fighter - (CASM Collection)

The Canadian order for the CF-18 *Hornet* represented the first international export order for the design. Like most American-made military aircraft with large production orders, the F/A-18 *Hornet* was built in various production batches, known as production "Lots". Each of these lots featured slight improvements

and other changes resulting from engineering testing or from early operational experience. The CF-18 order was delivered over the period from 1982 to 1988 drawn from Production Lots # 5, 6, 7, 8, 9 and 10.

CF-18 design changes ⁴

The most visible difference between a Canadian CF-18 and a US F/A-18 *Hornet* equivalent is the 600,000 candle power night identification light intended for NORAD operations. This spotlight is mounted in the gun loading door on the port side of the aircraft. In service some CF-18s have had the light temporarily removed, but the window is always in place. Also, the underside of the CF-18 features a painted "dummy canopy" on the lower fuselage. This design feature is intended to disorient and confuse an enemy in air-to-air combat. Subsequently, the United States Marine Corps and the Spanish Air Force also adopted this "dummy canopy" design.



The maritime survival package on the *Martin Baker*-designed ejection seat gave way for cold-weather survival gear and the Automated Carrier Landing System (ACLS) was replaced by a more conventional instrument landing system (ILS). The aircraft were also cleared to carry three 2,182 litre (480-gallon) drop tanks in place of the standard 1,249 litre (330-gallon) USN units. Finally the Canadian aircraft also featured ALQ-162 electronic warfare jammers to complement the normal ALQ-126B jammer and the ALR-67 Radar Warning Receivers.



Many basic features that made the F/A-18 suitable for naval carrier operations were also retained by the Canadian Forces, such as the robust landing gear, the refueling probe, the arrestor hook and wing folding mechanisms, and these proved very useful when operating these fighters from smaller airfields and Forward Operating Locations (FOLs) such as those found in the Arctic.



In service, the single-seat aircraft was designated CF-18A (official designation CF-188A) and the two-seat variant became the CF-18B (CF-188B). Initially the dual aircraft were known as the CF-18D's following previous Canadian practice, but this was subsequently changed to CF-18B to avoid confusion with planned future variants of the F/A-18 which were to become the F/A-18 C/D.

The first production CF-18 made its maiden flight at the McDonnell Douglas' St. Louis plant on 29 July 1982 and the first two aircraft (188901 and 188902) were delivered on 25 October. The CF-18As were assigned military serials 188701 through 188798 and the 40 dual CF-18Bs were assigned serials 188901 through 188940. All of the CF-18s were initially delivered to No. 410 "Cougars" Operational Training Unit (OTU) in Cold Lake, AB for acceptance testing prior to allocation to operational squadrons, with the last aircraft being delivered on 28 September 1988.



Images Top to Bottom: The identification light on the port side is removable as seen in the next image but the window remains and is blanked off. The main landing gear is both robust and complex. The refueling probe on the starboard side is retractable. - (CF Images)

Infrastructure Requirements



A CF-18 Hornet taxiing straight in to one of the purpose-built hangars at Inuvik, NWT - (CF Image CK2007-0456-29)

The introduction of the CF-18 also necessitated additional infrastructure and support requirements. The sophisticated nature of the on-board flight control and mission computers on the aircraft required specialized software support. Second and third-line software support units were therefore established. Similarly, a variety of training aids and full motion simulators were procured and put into use. The CF also

constructed four FOLs in the Arctic specialized for CF-18 ops at Yellowknife, NWT; Inuvik, NWT; Rankin Inlet, Nunavut; and at Iqaluit, Nunavut.

OPERATIONAL HISTORY

Introduction into Canadian service

The first two CF-18s were formally handed over to 410 "Cougars" (OTU) Squadron at CFB Cold Lake, Alberta on 25 October 1982. Further deliveries fleshed out the OTU then equipped 409 "Nighthawks", 439 "Tigers", and 421 "Red Indians" Squadrons at CFB Baden-Soellingen in what was then West Germany, followed by the 416 "Lynxes" and 441 "Silver Foxes" Squadrons at Cold Lake and the 425 "Alouettes" and 433 "Porcupines" Squadrons at CFB Bagotville, Quebec. Introduction into full Canadian service was initially problematic due to early issues with structural fatigue on the tails which delayed the initial deployment. As the initial bugs were worked out, the CF-18 started filling both the NORAD interception and NATO roles as intended.

Below - The crests and badges of the CF-18 squadrons / units - (CF Images)





In Canadian Forces Europe, the CF-18 Hornet replaced the CF-104 Starfighter in the NATO role and the CF-18 became a familiar sight in the skies over Lahr and Baden-Soellingen. Shown above are two representative Aerospace Engineering Test Establishment (AETE) aircraft - a CF-104D and CF-188B. The lower photo is the classic German fly-by of the Hohenzollern Castle in Baden-Wuerttemberg - (Both images courtesy Bill Upton Collection)

Structural Problems ⁵

The use of an aircraft designed for naval carrier operations exclusively in a land-based operation which was considerably different from the planned maritime operations for the design began to cause structural / fatigue problems very early in the life of the Canadian *Hornets*.

The F/A-18 was originally designed for a USN service life of 6,000 flight hours. McDonnell Douglas therefore designed a representative flight spectrum and performed a full-scale fatigue test on a prototype aircraft to 12,000 hours therefore using a safety factor of 2 for the overall design. This was acceptable to USN based on its safe life philosophy in the approach to aircraft structural integrity which demanded no cracks be present in airframe. Each *Hornet* airframe was also equipped with a Maintenance Signal Data Recording System (MSDRS) which allowed key flight parameters and structural loads data to be captured on each flight.



The vortices over the LEX are clearly seen here - (CF image)

The initial CF-18 problems were with cracks in the vertical stabilizers. This fatigue cracking was traced to excessive air loads being placed on the twin tails by the vortices streaming from the LEX. The vertical stabilizers were repaired and strengthened to allow the initial deliveries to continue.

But a further more serious problem revealed itself after the fleet was in regular active service. From the MSDRS recordings, CF-18 in-service usage was found to be much more severe than the original design spectrum. More critically, on the McDonnell Douglas fatigue test, critical wing carry-through bulkheads in the fuselage were found to have

cracked prematurely. The most serious of these cracks was on the bulkhead at fuselage station 488 (FS488). The ensuing problem was that these cracks also grew rapidly and could have resulted in catastrophic failure of wings and fuselage. The discovery of these cracks naturally caused the bulkheads to be further redesigned and modified on subsequent production lots but these changes had never been suitably verified or tested. The Aerospace Engineering Test Establishment (AETE) in Cold Lake then conducted flight test program on a heavily instrumented CF-18 test aircraft and the worst fears were confirmed.

The CF-18 fleet had various configurations of these bulkheads (depending on the Lot #) and unfortunately the critical fatigue locations were inaccessible for inspection on the airframe. Consequently as result of the serious nature of the problem and the lack of critical information, a very conservative approach had to be adopted. A safety factor of 3 was imposed on the overall airframe, reducing the life of most of the aircraft from 6,000 to 4,000 flight hours. Unfortunately, eleven of Canada's CF-18's (701, 901-910) had the earliest (Lot # 5) configuration of modified bulkheads, and the life of these aircraft was further lowered to just 2,000 flight hours.

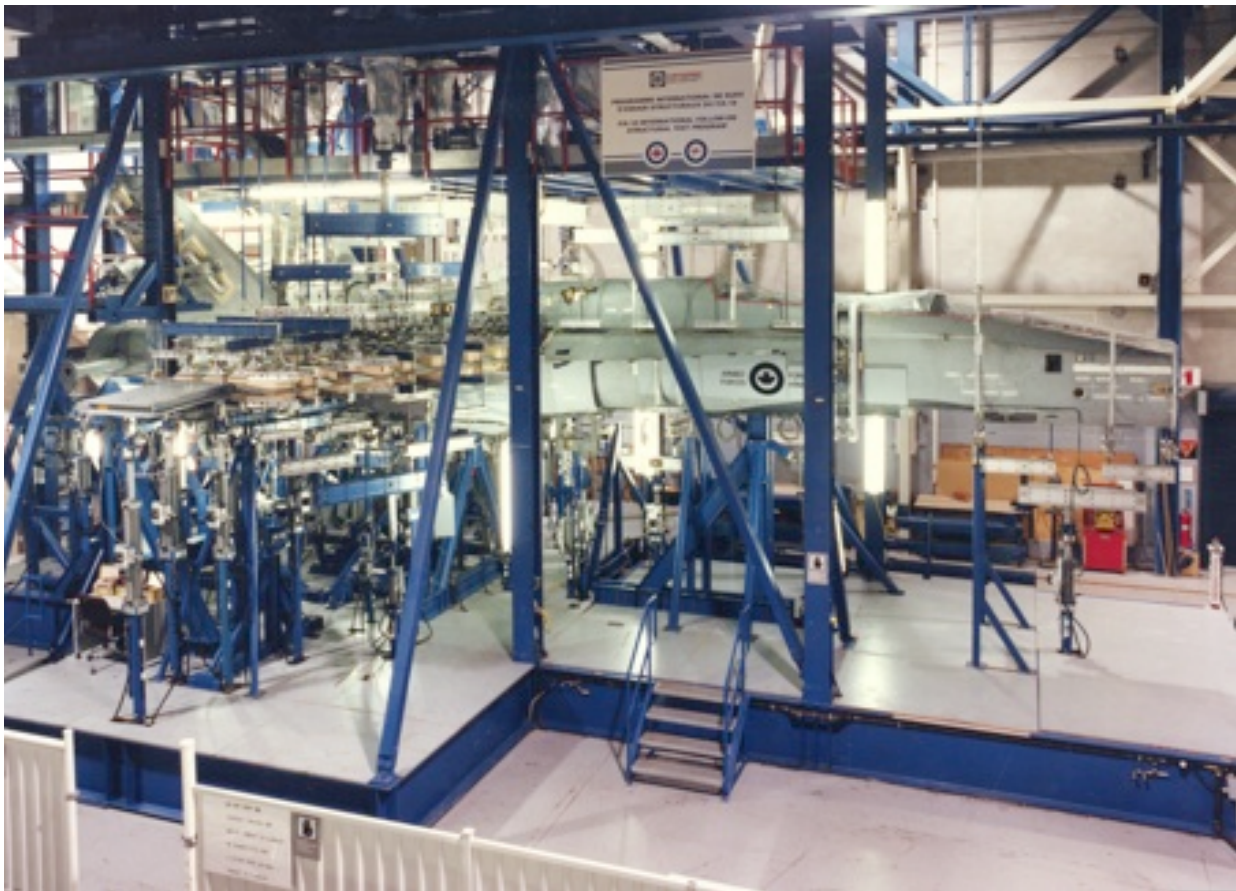
Both the Royal Australian Air Force (RAAF) and the Canadian Forces (CF) then embarked upon an ambitious fatigue life management program to control and better understand the structural problems being faced by the their land-based fleets. In 1989, the RAAF and CF agreed to jointly conduct the International Follow-On Structural Test Project (IFOSTP). The objectives of the IFOSTP were to:

- Determine the true safe life of the primary structure of the aircraft;

- Determine the economic life of the aircraft's structure;
- Validate repairs and modifications to the structure;
- Where applicable, obtain crack growth data to support the management of a safety-by-inspection approach to operations; and
- Obtain engineering data to enhance overall fleet management.

The IFOSTP actually consisted of three complementary tests as follows:

- A centre fuselage test conducted by Bombardier Defence Services in Mirabel, Quebec;
- A wing test conducted by the National Research Council / Institute for Aerospace Research in Ottawa, Ontario; and
- An aft fuselage test conducted by the Aeronautical and Maritime Research Laboratory in Melbourne, Australia



The IFOSTP centre fuselage test (on CF188755) underway at Bombardier Military Aircraft Systems in Mirabel, Quebec - (Bill Upton Collection)

A great deal of information came from these tests, and the fleets of both countries were further modified and upgraded as a result. The tests confirmed both known problems and predicted other previously unknown issues. The information was incorporated into an Aircraft Structural Integrity Program (ASIP) and also into an Aircraft Life Extension Program (ALEX).



The complexity of the CF-18 structure and the IFOSTP testing is seen in these images. At the far left, the centre fuselage of the Hornet is revealed, the centre image shows the wing test underway at the NRC in Ottawa and the final image illustrates the aft-fuselage test in Australia - (NRC and ARML images)



The aerodynamic fix for the vortex problem was the installation of this plate or "fence" on top of the fuselage - (CF Image)

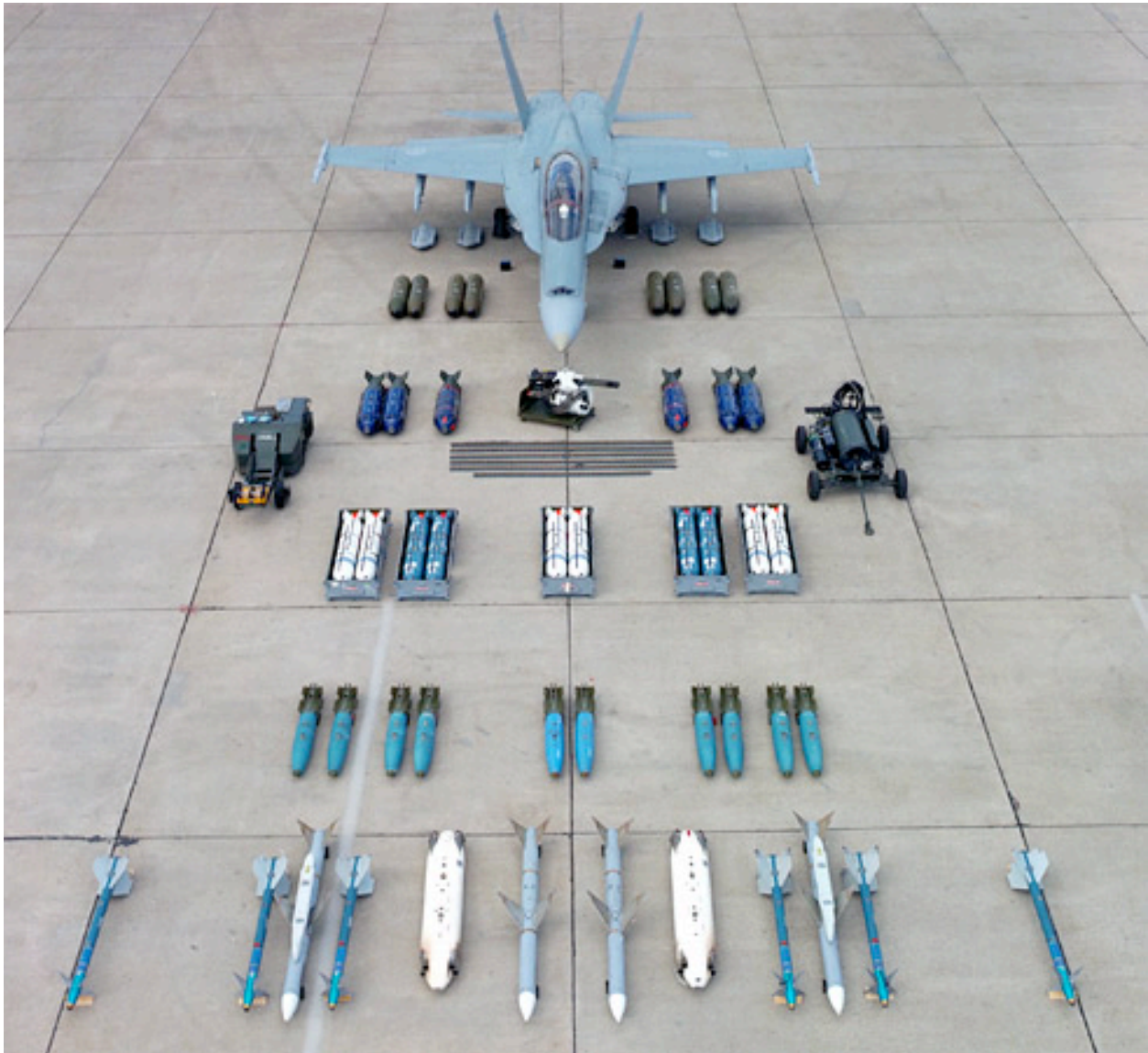
In the end, the aerodynamic fix for the tail problems was relatively simple. A small cast-aluminum 'fence' was fitted to each LEX to modify the vortex pattern being generated in order to alleviate the airflow stresses being generated on the tailplanes.

The problems with the centre fuselage of the aircraft were far more complex. An entire series of ALEX modifications was developed and implemented on the fleet. But again, the differences in Lot # configurations caused further issues and, on some aircraft, it was deemed less risky and more cost effective to replace the entire centre fuselage of the aircraft. This necessitated splicing the aircraft in two and removing and replacing

the entire centre "barrel" or section of the aircraft. This complex procedure was developed initially by Bombardier Aerospace Defence Services in March 2002 on prototype aircraft #188747 and later implemented on other aircraft in the fleet by L-3 Military Aircraft Systems in Mirabel, Quebec. This program was referred to as the Centre Barrel Replacement project and selected aircraft in both the CF and RAAF fleets have received this radical surgery.

Clearance of Canadian Weapons

The NATO role of Canadian CF-18s necessitated clearance of various stockpiles of munitions already in use for previous Canadian operations. The CF-18s were cleared to fire the LAU-5003 rocket pod which contained the Canadian-designed Bristol Aerospace 70 mm (2.75 inch) CRV-7 folding-fin unguided rockets. BL-755 and *Rockeye* Mk. 20 cluster bombs were also cleared for service along with a series of conventional "dumb" bombs equipped with either low-drag or high-drag tail fins. These weapons further necessitated the clearance of the SU-5003 dispenser which could fire up to four rockets while simultaneously carrying practice bombs.



Above - A view from early in the CF-18 Hornet's service of the array of weapons that the aircraft could carry (although not all at once). The aircraft is equipped with five underwing / under-fuselage hard-points plus four missile launchers. These hard-points could also be equipped with twin-store carriers which effectively doubled the payload to be carried. Starting from the bottom, the first row illustrates six AIM-9 Sidewinder missiles, four AIM-7 Sparrow missiles and two SUU-5003 practice bomb / rocket dispensers. The second row illustrates ten Mark 82 bombs with high-drag fins. The third row consists of ten Mark 20 Rockeye cluster bombs. The fourth row illustrates the armament loader and ammunition loader used to install weapons and ammunition along with six BL755 cluster bombs and in the centre is the 20mm Vulcan cannon with its ammunition. The fifth row consists of eight LAU-5003 rocket pods and the final row (directly under the aircraft wings) are the twin-store carrier racks - (CF image)



ABOVE - Two shots of CF-18 Hornets from the Aerospace Engineering Test Establishment (AETE) in Cold Lake performing weapon clearance tests. On the left, the aircraft is carrying eight BL-755 cluster bombs and on the right the aircraft is firing a LAU-5003 rocket pod containing 19 CRV-7 70 mm (2.75 in) unguided rockets. BELOW - A close-up of the installation LAU-5003 rocket pods on twin-store carriers for each of the underwing pylons. The CRV-7 rockets were fired through the frangible aerodynamic nose cones on the pods; an AETE CF-18 aircraft carrying the noticeably larger 2,182 litre (480 gallon) underwing fuel tanks; an AETE aircraft carrying a LAU-5003 and an Airborne Instrumentation Subsystem (AIS) pod and a CF-18 carrying the maximum load of ten Mk 82 "dumb" bombs equipped with high-drag tail fins - (CF Images & Bill Upton)





Clockwise from left to right - A close-up of the installation SUU-503 rocket pod and practice bomb dispenser on the outer wing pylon. An underneath view illustrates the SUU-503 from beneath. The false canopy design also shows up clearly in this same view. The Airborne Instrumentation SubSystem (AIS) Pod is carried on the outer LAU-7 launch rail in lieu of a missile. The AIS pod is used to provide real-time spatial positioning data for post-training mission debriefs - (CF images - AE2006-0039-016, AE2003-0053-003, & unknown #)



Top - In a scene reminiscent of a movie, a trio of CF-18s fire their AIM-7 Sparrow missiles, in this case against a practice target drone.. Lower left - the AIM-9 Sidewinder missile is typically carried on the outer wing launcher as shown here. Lower right - The CF-18 also carries a 20 mm cannon in the nose (the central hole in nose radome) with 578 rounds, with a firing rate of either 4,000 or 6,000 rounds per minute - (CF Images - Top - BN2011-0028-79)



A close-up of the AIM-9 Sidewinder short-range missile. The AIM-9 is a heat-seeking air-to-air missile. Its heat-sensitive infrared (IR) guidance head enables it to home in on a target aircraft's engine exhaust - (CF image)



CF-18s also carry chaff and flare dispensers for self-protection. A flare, seen deployed here, would decoy incoming heat-seeking missiles away from the aircraft - (CF image)

The potential operational danger of using these conventional weapons on the CF-18s led to a further push to employ more sophisticated precision-guided munitions on the aircraft. The first of these weapons to be cleared was the TV-guided AGM-65 *Maverick* missile.



The AGM-65 Maverick missile shown here loaded on a USAF F-15 Eagle - (USAF Photo)

A USN F/A-18D Hornet firing the AGM-65 - (USN Photo)

Later in the life of the CF-18, the fleet was furthered cleared to carry an array of precision-guided munitions including GBU-10, GBU-12, GBU-16 and GBU-24 laser-guided and Joint Direct Attack Munitions (JDAM) bombs.



A CF-18 dropping a precision guided bomb. The weapon is steered to the target by reflected laser energy - (CF image)

DOMESTIC OPERATIONAL MISSIONS

In NORAD, CF-18s have responded to thousands of possible threats to Canada and United States. A task group of CF-18s and CH-146 *Griffons* were deployed during Operation *GRIZZLY* to Kananaskis, Alberta in June 2002 where they were deployed to secure the airspace during the G8 Summit. Interestingly in 2007, a number of CF-18s were deployed to Alaska where they were based during a two week period to defend United States airspace as a result of the USAF's F-15 *Eagle* fighter fleet being grounded due to structural defects. CF-18s were also deployed during Operation *PODIUM* to secure the 2010 Olympic Winter Games in Vancouver.



CF-18s have routinely intercepted Russian TU-95 "Bear" bombers probing the border in Canada's high Arctic in both night and day operations - (CF images - FA2007-0141 & REC87-3675)

INTERNATIONAL OPERATIONS ⁶

THE GULF WAR - OPERATION *DESERT STORM*

Operation *DESERT STORM*, the 1991 Persian Gulf War, may have been "the mother of all battles" for Saddam Hussein, but for western militaries it was a watershed event which established the primacy of Precision Guided Munitions (PGMs). It also demonstrated that modern air power could shape the battlefield, giving ground commanders the freedom to manoeuvre without prohibitive interference. After an overwhelming air superiority and interdiction operation, it took just four days for Coalition forces to cause the Iraqi Republican Guard to capitulate. It was legitimized by the United Nations (UN) and came at an opportune time for the United States to demonstrate the utility of their incredibly advanced and increasingly costly military. For Canada, it had been four decades since the military's last offensive operation in Korea.

Initially, Canada deployed two destroyers and a supply ship to conduct interdiction operations. By the end of the war, they would be joined by 26 CF-18 fighter aircraft, a CC-137 (Boeing 707) tanker, a Field Ambulance Hospital and a modest contingent of army personnel to provide force protection.

The CF-18 Option

CF-18s were not an immediate consideration because they could do little to enforce the initial embargoes and Canada's commitment to NATO in Europe had not been officially reduced. However, the Soviets' tacit support of UN Resolutions against Iraq and the Cold War abeyance permitted NATO to release the *Hornets* from their German bases without leaving the European theatre vulnerable. It did not take long for

the air force to conduct staff checks and determine that they were in fact a viable option. For the government, deploying fighter aircraft in a defensive role would be 'meat on the bone' of Canada's contribution.



The Desert Cat badge worn on flight-suits - (CF Image)

On 14 September 1990, before the Canadian Naval Task Group had even arrived in theatre, Canada's Prime Minister, Brian Mulroney, announced that Canada would "...deploy a squadron of CF-18 fighter aircraft from Lahr, West Germany to the Gulf ... and provide air cover for our own ships and the ships of friendly nations." Less than a month later, 18 Canadian *Hornets* were in Doha, Qatar poised to commence Operation *FRICTION*, the name given to the deployment of CF-18s to the Middle East. The Task Force was unofficially known as the "*Desert Cats*" since the majority of the personnel were from the 416 "*Lynx*" Squadron and the 439 "*Tiger*" Squadron. For the first time in over four decades, Canadian fighter aircraft would fly in combat.

A Defensive Role and the UN Deadline

Initially, CF-18s were assigned defensive combat air patrols to protect coalition naval assets conducting intercept operations and embargo enforcement. The first few months were relatively uneventful; the Iraqi Air Force was never bold enough to really test coalition fighters over the Gulf. However, Saddam Hussein was bold enough to remain in steadfast defiance of all resolutions and international pressure. As a result, the UN passed Resolution 678 which established 15 January 1991 as the deadline for Iraq's withdrawal from Kuwait. If Iraq did not comply with the deadline and all previous resolutions, it authorized under Chapter VII of the UN Charter the use of "all necessary means to ... restore international peace and security in the area." As the deadline approached, Prime Minister Mulroney was in close contact with President Bush regarding the invasion plan and Canada's role.



The Desert Cats operated from a crowded ramp in Doha, Qatar during Gulf War I - (CF Image)

Initial Sweep / Escort Role

On 16 January 1991, Prime Minister Mulroney authorized CF-18s to conduct sweep and escort missions across the border of Kuwait. The new mission involved escorting coalition aircraft without an air-to-air capability into enemy territory. It was a much riskier endeavour than air patrols over the Gulf since it required CF-18s to enter Iraq's air defence umbrella. The air force sent an additional six aircraft and maintenance crews to Doha in early January 1991 to accommodate increased sortie rates and to allow for potential combat attrition.

The first sweep and escort mission was launched on 20 January 1991, and to the frustration of Canadian pilots, CF-18s were still not challenged by the Iraqi Air Force. Laden with offensive air-to-air weapons, they became "de facto bait" for the Iraqi air defence system so that trailing USAF F-4G *Wild Weasel* attack aircraft could engage or electronically jam radar sites that showed any interest in the Canadian fighters. Being "locked up" by surface-to-air missile (SAM) radars initially created some very tense moments of "jinking and chaffing," but over time the CF-18 pilots grew accustomed to it. As long as pilots stayed above 4,572 m (15,000 feet), they would remain above the effective altitude of anti-aircraft artillery (AAA) and could evade the SAM radars using manoeuvres and countermeasures. For several weeks, Canadian pilots provided comfort to the unarmed bombers they escorted, but grew frustrated by a seemingly futile mission.

First combat

The Iraqi Air Force was targeted heavily during first few days of the war, compelling many of Saddam Hussein's pilots to make a low-level 'defection dash' to Iran. The coalition recognized this trend and set up combat air patrols between Baghdad and the Iranian border, successfully intercepting and destroying several MiG-23s. Any Iraqis brave enough to look for action were outmatched technologically and their pilots were at a severe proficiency deficit. The vast majority of the 34 confirmed Allied victories against fighter aircraft were achieved by the USAF's F-15C *Eagle*, a pure air superiority fighter dedicated to defensive counter-air, sweep and escort missions for the entire conflict. Only three victories were claimed by multi-role aircraft: two by US Navy F-18C *Hornets* and one by a US Navy F-14A *Tomcat*. Canada's multirole *Hornet* manned the combat air patrols to the south where Iraqi aircraft never ventured while the sweep and escort missions occurred with air superiority already achieved. It was becoming clear that Canadian *Hornets* would have to take the fight to the enemy.



A Desert Cats CF-18 carrying an extra AIM-7 Sparrow on the outboard wing station - (CF Image)

This occurred in an unconventional way on the night of 30 January 1991, when a formation of CF-18s attacked an Iraqi patrol boat. After two weeks of uneventful combat air patrols, Capt Steve 'Hillbilly' Hill and Major Dave 'DW' Kendall did not hesitate to accept their ship borne controller's unexpected request: "would you like to strafe a boat?" The boat in question had escaped a USMC EA-6B *Prowler* attack when the American jet ran out of ordnance. After receiving final clearance to engage from their controller, the two Canadian pilots emptied their 20mm cannons with multiple strafing runs. With only air-to-air missiles remaining they attempted to acquire an infrared lock to fire an AIM-9 *Sidewinder* missile. The boat's heat signature was too low and after some trouble 'Hillbilly' acquired a radar lock and fired an AIM-7 *Sparrow* semi-active radar missile at the boat. The missile impacted the water short of the target at which time both pilots returned to base. The boat was eventually finished off by US bombers; but, the Canadians were officially awarded an 'assist' to its destruction at sea. Hill and Kendall were extolled by senior military officials at home for their "...example of Canadian can-do" attitude. However, the Canadian Commander Colonel Roméo Lalonde conveyed to the press in theatre a different opinion, asserting they should have made less passes to minimize their exposure – he was not entirely happy about the attack. They had, after all effectively wasted a \$250,000 air-to-air missile on a boat in the first offensive action by the Canadian military since the Korean War. The engagement was admittedly unorthodox but Lalonde's criticisms were viewed to be a little harsh by most officers in the fighter community.

Sweep / Escort Missions Progress and Bombing Missions Finally Authorized

Meanwhile, acting as 'bait' during the sweep and escort missions marginalized the CF-18's capabilities and frustrated Canadian pilots who were capable of much more. In early February, after months of combat air patrols and weeks of evading air defences, CF-18s were finally authorized to conduct bombing missions.

The *Desert Cats* anticipated changing to an air-to-ground role and had already completed ground school and reviewed their bombing theory by the time the announcement was made. After a few days of training flights to consolidate the theory, the pilots and aircraft were ready to go; but one critical resource was missing – actual bombs. While war stocks were enroute from Germany, the United States generously provided ordnance for the first few days of the Canadian offensive. On 24 February 1991, a flight of four CF-18s (call-sign *Talon 01*) dropped the first bombs from Canadian aircraft in combat since the Second World War. Before the fighting stopped on 28 February 1991, Canada had conducted 56 bombing sorties and dropped more than 100 tonnes of ordnance, mainly dropping 230 kg (500 lb) conventional ("dumb") bombs, on Iraqi artillery positions, supply dumps, and marshaling areas behind the lines. At the time, the Canadian *Hornets* were unable to deploy precision guided munitions (PGMs) due to equipment deficiencies.



A CF-18 returning from a mission in sight of its brethren - (CF Image)

CANADIAN FORCES EUROPE DRAWDOWN

The end of the Gulf War coincided with an important restructuring underway within the CF-18 *Hornet* fleet. As an economy measure, the decision had been taken to end the permanent basing of Canada's fighter aircraft in Europe. The European-based squadrons (409 TFS, 421 TFS and 439 TFS), were disbanded and their aircraft were ferried home to be consolidated in just five squadrons: (410 OTU, 441 TFS and 416 TFS in Cold Lake and 425 TFS and 433 TFS in Bagotville). AETE also retained its test aircraft. These now exclusively Canadian-based squadrons were still to retain a rapid-reaction capability to re-deploy for NATO missions as required.

Bosnia and Kosovo - OPERATION ALLIED FORCE

Shortly after the Persian Gulf War, another regional conflict became the focus of international attention. In the Balkans, the perfect storm of complex ethnic divisions and independence movements created conditions which degenerated into widespread violence and human suffering. During the 1990s, there were no less than seven named UN missions in the region ranging in scope from police force training to enforcing ceasefire agreements between belligerent parties. However, peace was transitory and, when diplomatic efforts failed, air power was relied upon to avert a humanitarian crisis.

The Canadian Air Force was slow to mobilize as the Balkan conflict evolved, but eventually a contingent of CF-18s arrived in Aviano, Italy to conduct offensive combat operations over the Federal Republic of Yugoslavia. From 24 March to 9 June 1999, Canadian *Hornets* joined aircraft from 14 other countries in a 78-day NATO-led air campaign called Operation *ALLIED FORCE*.

In contrast to the Iraq experience eight years earlier, the government approved CF-18 offensive operations from the outset of the Kosovo Air Campaign. The political restraints which relegated CF-18s to almost purely defensive operations during *DESERT STORM* had been removed but the government's failure to modernize and recapitalize the Canadian Forces throughout the 1990s was beginning to take its toll. The CF-18s had recently been modified to employ precision guided munitions, but they lacked several capabilities which detracted from the overall favourable assessment of their performance in theatre. The growing capability gap between the CF-18 and other Allied platforms was bringing Canada's front line fighter to the verge of obsolescence. In spite of the many challenges and deficiencies, CF-18s flew nearly ten percent of all strike missions during the campaign with just two percent of the total number of coalition aircraft – a tribute to the dedication and professionalism of all personnel involved.

SEQUENCE OF EVENTS

Operation *DENY FLIGHT*

The roots of the ethnic and religious disputes in the Balkans go back centuries, but the first trigger of the modern regional conflict occurred during the summer of 1991. When Croatia declared independence from the Socialist Federal Republic of Yugoslavia, Croatian Serbs backed by the Yugoslav People's Army, violently opposed it. After a series of diplomatic efforts failed to curtail the fighting, a United Nations Protection Force (UNPROFOR) was authorized to re-establish peace and security on the ground. Subsequently, ethnic divisions in Bosnia-Herzegovina resulted in an expansion of the original UNPROFOR mission. On 13 March 1993, an aerial attack by an unidentified combat aircraft on villages east of Srebrenica compelled NATO to commence Operation *DENY FLIGHT*, a no-fly zone with an "all measures" UN mandate. It commenced on 12 April 1993, drawing fighter aircraft from several nations into the region. Even though the operation was focussed on airborne threats, aircraft conducted isolated precision strikes in response to requests from the UNPROFOR commander. CF-18s deployed to Europe

for a NATO exercise four months after *DENY FLIGHT* began – ironically as a demonstration of Canada's ability to respond to a European crisis. The reality was that CF-18s were not suited for the Balkan theatre at this stage because they still lacked a PGM capability and the Fighter Force was busy repatriating their German-based squadrons to Canada.

Operation *DELIBERATE GUARD*

In early 1997, the Fighter Force finally acquired the *Nitehawk* Forward Looking Infrared (FLIR) pod and a limited number of laser guided bombs. On 14 August that same year, six CF-18s deployed to Aviano, Italy in support of Operation *DELIBERATE GUARD*, the NATO Stabilization Force no-fly zone over Bosnia. The 'air policing' deployment was an opportunity for the Canadian government and the air force to show its recently acquired targeting pods and precision capability were deployable in support of a coalition operation. It was an uneventful three month mission which received very little media attention and was all but forgotten by air force historians. However, the deployment was significant because it signalled that Canada had finally acquired a real PGM capability and demonstrated the government's willingness to push fighter aircraft into theatre with a potential for offensive action. When they left, the situation on the ground appeared to be stable, but that did not last for long.

Operation *DETERMINED FALCON*

On 11 June 1998, after months of increased violence on the ground, NATO defence ministers agreed that a 'show of force' might help defuse the situation. Operation *DETERMINED FALCON* was planned as an air power demonstration to be conducted over Albania and Macedonia. NATO hoped it would encourage Slobodan Milosevic, President of the Federal Republic of Yugoslavia, to cease his aggression towards ethnic Albanians in Kosovo. However, the deployment of Canadian fighters was delayed because Canada lacked strategic airlift and air-to-air refuelling platforms. Canada also lacked strategic airlift platforms, making delays inevitable when a contracted Antonov was initially denied access to the airbase in Aviano. On 15 June 1998, the show of force initially went ahead without CF-18s. But in the end, *DETERMINED FALCON* did not achieve its desired effect making Canada's absence a moot point.

Operation *ALLIED FORCE*

In 1997 the Balkan conflict migrated from Croatia and Bosnia to Kosovo where violence between Serbian forces and ethnic Albanians rapidly escalated. Milosevic believed that Kosovo was historically the heart of Serbia. For years he promoted Serbian nationalism and advocated autocratic rule in the area while actively suppressing Albanian desires for self-determination. The Kosovo Liberation Army (KLA) emerged to counter what they viewed as oppressive Serbian aggression. A series of increasingly violent KLA guerrilla attacks and Serbian reprisals led Milosevic to begin targeting key Kosovar leadership and to commence a 'scorched earth' campaign against Albanians in the region. By September 1998, it was estimated that 250,000 Kosovo Albanians had either fled or been driven from their homes with tens of thousands homeless as the cold winter approached. Recognizing the grave nature of the situation, the UN Security Council passed Resolution 1199 on 23 September 1998 calling for all parties to cease fire. Months of diplomatic negotiations and sanctions failed to arrest hostilities between the KLA and Serbian forces. When Milosevic mobilized nearly one third of his army around Kosovo in preparation for an obvious offensive, NATO was forced to take action. After months of uneventful no-fly zone missions, Canadian fighter aircraft launched on 24 March 1999 as part of the first wave of strike missions in support of Operation *ALLIED FORCE*. For 78 days, they conducted offensive counter air, defensive counter air, and interdiction missions to compel Milosevic to end his ethnic cleansing crusade.

LESSONS LEARNED

Canada's contribution to the Kosovo Air Campaign was initially six CF-18s, which increased later to 18. They deployed to Aviano on 24 June 1998 under the Canadian name Operation *ECHO*. The CF-18 detachment in Aviano called themselves the *Balkan Rats* – a name chosen by the detachment personnel, who were drawn from a wide variety of units, in order to create a cohesive identity. Over 78 days the *Balkan Rats* conducted 678 combat sorties and logged approximately 2,600 flying hours against a wide variety of targets including surface-to-air missile sites, airfields, bridges and fuel storage areas. They delivered 532 bombs of which 361 (68%) were precision guided. Approximately 18% of these missions were strictly defensive combat air patrols. Over the course of the campaign, Canadians achieved an air-to-ground success rate of approximately 70%, which was on par with many allies with more capable platforms and avionics. CF-18 pilots were also chosen to lead many strike packages – an implicit recognition of their abilities and professionalism. Combined exercises like *MAPLE FLAG* and frequent cross border training with US fighter units had developed a level of interoperability few other nations enjoyed. In contrast to Canada's experience during Operation *DESERT STORM*, the CF-18s conducted a consistent ratio of counter-air and strike missions from the beginning to the end of the Kosovo Air Campaign. Multi-role fighters like the *Hornet*, capable of employing precision guided munitions, were exactly what the Air Component Commander wanted. Canada's fleet of CF-18s had been given the minimum tools necessary to be effective but they certainly were not technological leaders.



A CF-18 being marshaled on a busy flight-line in Aviano. The aircraft is fully loaded with three fuel tanks, two laser-guided bombs, two AIM-9 missiles and the Nighthawk FLIR pod is visible underneath the intake - (CF Image - ckd99-2009-01)



CF188794 lifting off for a mission over Kosovo. It is carrying a laser-guided bomb on the outer wing station - (CF Image - ckd99-2085-09)

The capability and effectiveness of the CF-18 had improved significantly since *DESERT STORM*, but the aircraft and pilots still lacked several very important systems. The most notable deficiencies were: a lack of interoperable jam resistant radios, night vision goggles, a Global Positioning System (GPS) navigation system, sufficient numbers of FLIR pods, and adequate precision weapon war stocks. Many lessons learned from Kosovo stemmed from these observations and provided justification for a later 1.2 billion dollar CF-18 modernization program. Task Force *AVIANO* was successful due to the outstanding performance of Canadian pilots which compensated for not having the best equipment available.

Jam Resistant Radios

During *ALLIED FORCE*, Canada was the only nation which lacked jam resistant communications, relegating the entire strike force to use a single ultra-high frequency (UHF) radio plan. Anyone on the ground with a simple UHF receiver could find strike package frequencies and listen to everything pilots and controllers were saying. This made coalition aircraft vulnerable to Serbian communications jamming, which could have severed a critical command and control link.

Night Vision Goggles

If flying with degraded and jammed communications was risky, then flying at night without Night Vision Goggles (NVGs) was treacherous. The United States had fielded NVGs in fixed wing aircraft decades before in the Vietnam war and several coalition fighters were using the latest generation goggles during the Kosovo Air Campaign. In spite of attempts to field a night vision capability prior to Operation *ECHO*, CF-18s did not have the modified cockpit lighting necessary for NVGs. Canadian pilots flew lights out and

'blind' for almost half of their 678 combat sorties, leading the night crews to fittingly to often refer to themselves as the *Balkan Bats* instead of the *Balkan Rats*.



A pilot wearing night-vision goggles attached to his helmet - (CF Image - CX2005-0258-11d)

Navigation System

Canadian pilots flying at night without NVGs or jam resistant radios also had to overcome the CF-18's insidious navigational drift. The inertial navigation system drifted on average 900 metres/hour (0.5 nautical miles per hour) which made it very difficult to find tactical sized targets using the targeting pod. At a range of 16 kilometres (10 miles), the pilot's Forward Looking Infrared (FLIR) display would show approximately a quarter of a mile on either side of the cockpit screen's crosshairs, making it entirely possible for the actual target to be well outside the field of view of the display. The risk associated with this phenomenon was mitigated using navigation system updates and disciplined target search techniques. However, finding targets with this kind of navigational drift is like trying to find a star with a high powered telescope and no viewfinder. The lack of a GPS to centre aircraft sensors precisely at the target coordinates added complexity to an already complex mission. As a result, pilots returned to base on occasion with their full complement of bombs – a frustrating outcome after fighting their way through enemy defences.

War Stocks

Another critical component of a precision guided weapon system is the weapon itself – of which Canada possessed very limited numbers. Canada's war stocks of the 227 kilogram (500 pound) guided bomb units were exhausted within weeks of the first strikes, requiring bombs and guidance kits to also be requested in the "national emergency operational" requirement letter sent to the United States Air Force. The 907 kilogram (2,000 pound) laser guided bomb was also desperately needed to prevent multiple

passes over certain targets, but at the outset of the air campaign it had not yet been cleared for carriage and employment on the CF-18. It took a great deal of effort by engineers and staff officers to develop the needed stores clearance and authorize CF-18s to carry the heavier bomb. Ironically, after so much effort was made to create a PGM operational capability, the effectiveness of Canadian aircraft over Kosovo was limited by something out of anyone's control – the weather.

The Weather

Laser Guided Bomb (LGB) employment requires a clear line of sight between the aircraft and target for a significant amount of time. Pilots must acquire the desired point of impact and maintain an unobstructed line of sight to that point for the entire designation and guidance of the weapon. In Kosovo, more than 70% of the time there was at least 50% cloud cover which made LGB employment on many occasions a futile endeavour.



A USN F/A-18 Nighthawk FLIR laser designator pod - (USN Photo)

FLIR Pods

The lessons of *DESERT STORM* very clearly pointed to laser guided bombs as the future weapon of choice for combat aircraft. A critical component of a laser guided weapon system is the forward looking infrared sensor with an integrated laser designator for guidance and ranging. At the start of *ALLIED FORCE* Canada possessed only 13 *Nitehawk* FLIR pods for its fleet of more than 120 CF-18s. Just six

aircraft in the Balkan theatre were initially equipped with this critical piece of equipment, leaving limited pods available for spare parts and for training back in Canada. The fact that Canada possessed only a handful of pods for training new aircrew at home and not enough to equip all 18 aircraft in theatre limited the number of strike missions that could be conducted and to a degree the pilots' proficiency with the new system. A total of 12 out of 18 CF-18s were eventually equipped with FLIR pods as a result of a special request sent to the Royal Australian Air Force to "borrow" some of their pods. If Canada had not received extra pods from Australia, the majority of their, on average, 16 sorties per day would have been uneventful combat air patrols – a scenario similar to the one played out in Iraq.



CF-18 188733 from 416 Squadron after the Kosovo operation displays its mission markings - (Bill Upton Photos)

Epilogue - As a further cost-saving and personnel reduction measure, the CF-18 was further drawn-down after the Kosovo Air Campaign. The number of squadrons were reduced to just three: In Bagotville, 433 TFS was merged with 425 TFS and in Cold Lake, 416 TFS and 441 TFS were disbanded but were replaced with a reconstituted 409 TFS while the 410 OTU was retained.

LIBYA - OPERATION *MOBILE*

In February 2011, largely influenced by the successful uprisings in Tunisia and Egypt, the Libyan people began publicly demonstrating against Colonel Muammar Gaddafi's 42-year dictatorship and oppressive governance. Their demonstrations were met with violent opposition by Gaddafi's military forces, resulting in a civilian death toll which by some accounts has now surpassed 30,000 people. In Canada, politicians from all political parties voiced their abhorrence with the situation and called for the international community to take action. On 17 March 2011, the United Nations passed Resolution 1973 authorizing Member States "all necessary measures" to protect the civilian population from increasingly aggressive Gaddafi loyalists. With legal authority and a "moral obligation," Canadian Prime Minister Stephen Harper committed a frigate with a *Sea King* detachment, two CC-150 *Polaris* tankers, two CP-140 *Auroras*, and seven CF-18 *Hornets* to help enforce embargoes, a no-fly zone, and to help protect the Libyan people.

On very short notice, fighter aircraft from 425 Squadron deployed to Trapani, Italy and took part in the air campaign to prevent Gaddafi from acting on his promise to "burn all of Libya."

SEQUENCE OF EVENTS

Evacuating Canadians

The most pressing concern for the government at the outset of the Libyan crisis was the safety of hundreds of registered Canadian nationals living in Libya who sought to flee the ensuing violence. In the last week of February 2011, one CC-177 *Globemaster* and two CC-130J *Hercules* were put on standby in different European locations to transport Canadian citizens and those from other like-minded nations away from the increasingly dangerous environment. On 1 March 2011, Prime Minister Harper also announced that the *Halifax*-class frigate HMCS *Charlottetown* would depart to assist with the evacuation operations already underway. The government's number one priority was the safety of its citizens, but Harper also realized that a Non-combatant Evacuation Operation (NEO) could easily turn into a humanitarian intervention. Besides the immediate need for transport aircraft, the navy's high readiness and ability to operate in international waters made it again one of the first responders to provide a persistent military presence for a strategic benefit. The deployment of transport aircraft and a frigate marked the beginning of Operation *MOBILE*, a name well suited to the NEO theme and which foreshadowed the rapidity with which Canada's Fighter Force responded to Harper's official announcement that CF-18s would deploy.

Fighters Deploy Rapidly

A contingent of CF-18s and pilots had already been in the breach for an Icelandic "Air Policing" operation, making it possible to immediately redirect them to the Mediterranean. The "Air Policing" mission was to be conducted in the month of April, but as the Libyan situation escalated the 425 Squadron Commanding Officer, Lieutenant-Colonel Sylvain Ménard, started to see the "writing on the wall". He took it upon himself to discreetly ready eight of his aircraft and put together a list of pilots and ground crew who would be the first out the door if ordered to deploy. In the early morning hours of 17 March 2011, military

commanders predicted that Resolution 1973 would not be vetoed in the UN Security Council and put Lieutenant-Colonel Ménard and his squadron on 48 hours 'notice to move.' Because of 425 Squadron's high level of readiness, the 'notice to move' was reduced to 24 hours by 11:45 EST that day. Just a few hours after Harper made his announcement, seven CF-18s departed Bagotville, Québec and just three days later, Canadian CF-18 *Hornets* conducted their first mission in support of the UN-approved, US-led air campaign called Operation *ODYSSEY DAWN*. Four days from deployment notice to flying operational missions was an impressive accomplishment for an air force which had previously depended on contracted airlift and the United States Air Force air-to-air refuelling aircraft to get them anywhere. The use of the CC-177 *Globemaster* and the CC-150 *Polaris* air-to-air refuelling aircraft validated the importance of possessing these national capabilities. However, the first mission could have been conducted up to two days earlier if not for delays encountered securing a suitable base and establishing communications with the Combined Air Operations Centre (CAOC).

At the outset, the air force expressed interest in operating out of *Trapani-Birgi* Italian Air Force base in western Sicily, but had not yet received approval to do so on the day of their departure. The CF-18s deployed without knowing where their destination was, making a 24-hour stopover necessary in Prestwick, Scotland while diplomatic channels were being exercised between Canada and Italy. Final authorization to operate out of *Trapani* was received just two hours before the CF-18s landed at the Italian air base on 19 March 2011. Once they arrived at *Trapani* another day was required to set up the communication networks and establish a link with the command centre before they could accept any air tasking orders.

CF-18s Overall Performance

The CF-18s were first put into combat on 23 March 2011 when four aircraft bombed Libyan government targets. In total, the *Hornets* conducted 946 sorties, making up 10% of NATO strike sorties. Over the course of their sorties, 696 bombs were dropped including Laser Guided Bombs and Joint Direct Attack Munitions (JDAM). The RCAF ⁷ has dropped 495 of the 227 kg versions (500 lbs) and 188 of the 907 kg versions (2,000 lbs) *Paveway II* bombs. The RCAF also dropped 11 JDAMs of the 227 kg version and two of the 910 kg version.



The seven Hornets returned to 3 Wing in Bagotville, Canada, on 4 November 2011 after the end of the UN-approved NATO mission - (CF Image)

As with most coalition operations, Canada's aircraft in theatre made up only a small percentage of the forces at play; however, again they executed a disproportionate high number of the overall missions. They conducted strikes against ammunition storage facilities, artillery pieces, tanks, command and control headquarters, intelligence headquarters, radar sites, and surface-to-air missile sites. They also conducted strikes on Libyan forces engaged in offensive action against the rebels. They dropped a significant number of laser guided bombs on approved targets with

an impressive success rate and unlike previous air campaigns, not one of them was borrowed from Allies.



Above - CF188754 refueling using the probe and drogue system employed by the CC-150 tankers.

Below - seven CF-18 Hornets fly in formation with a CC-150 Polaris tanker over Parliament Hill after the Libyan mission - (CF Image CK2009-0254-02 & IS2011-6010-03)





A CF-18 lifting off for a night mission over Libya. It is carrying a laser-guided bomb on the outer wing station - (CF image - RE2011-M089-004)

LESSONS LEARNED



The Sniper FLIR Pod - (CF Image)

The performance of the CF-18 Task Force was not just a validation of the training and the professionalism of Canadian pilots; it was also a validation of recent and long overdue upgrades to the CF-18 itself and the modernization program overall. By the time the deployment was announced, the RCAF had taken delivery of the last of its fully modernized aircraft and had fully integrated a new FLIR pod which greatly enhanced situational awareness,

target identification, and laser guided weapons accuracy. The Sniper FLIR pod and the Joint Helmet Mounted Cueing System (JHMCS) were critical components in the fluid air campaign where pilots typically received their target brief while airborne. NVGs also gave CF-18 pilots a distinctive edge under the cover of dark while secure communications and data links were regularly employed.



Top Left - the new JHMCS helmet provides information and visual cueing to the pilot on the helmet visor. Top right - a CF-18 pilot in the cockpit before a night mission in Libya. Bottom -RCAF armorers preparing laser-guided GBU-10 two-thousand pound bombs in Trapani, Italy - (CF Images - IS2011-4028-7, IS2011-M089-002, IS2011-4028-2)

CF-18 HORNET FLEET UPGRADES ⁸

The need to upgrade the CF-18 had first been demonstrated during the 1991 Gulf War deployment and later during the 1998 Kosovo conflict as advances in technology had rendered some of the avionics on board the CF-18 obsolescent and incompatible with most NATO allies. In 2000, CF-18 upgrades became possible when the government increased the defence budget.

Consequently, in 2001, the Incremental Modernization Project (IMP) was initiated. The project was broken into two phases over a period of eight years and was designed to improve air-to-air and air-to-ground combat capabilities, upgrade sensors and the defensive suite, and to replace the data-links and

communications systems on board the CF-18 from the old F/A-18A and F/A-18B standard to the then current F/A-18C and D standard. Boeing (which had merged with McDonnell Douglas) the prime contractor and Bombardier Aerospace Defence Services (now L-3 Military Aircraft Systems), the prime Canadian subcontractor were issued a contract for the modernization project starting in 2002. A total of 80 CF-18s, consisting of 62 single-seat and 18 dual-seat models from the later production lots (7-10) were selected from the fleet for the upgrade program. The remaining aircraft in the fleet were progressively retired and reduced to spares or given to museums. The project was designed to extend the life of the CF-18 fleet to approximately 2020.

Incremental Modernization Project Phase I

This phase of the project included the following:

- Replacement of the Hughes AN/APG-65 radar with the new AN/APG-73 radar, which had triple the processing speed and memory capacity, while also incorporating Terrain Following and Terrain Avoidance modes for low-level, ground-attack missions. Furthermore, the new AN/APG-73 radar was also capable of guiding the modern AIM-120 Advanced-Medium-Range-Air-to-Air-Missile (AMRAAM);
- Addition of the AN/APX-111 Combined Interrogator and Transponder, otherwise known as an IFF (Identification Friend or Foe). The new IFF brought the CF-18 up to current NATO standards for combat identification;
- Replacement of the radios with the new AN/ARC-210, RT-1556/ARC VHF/UHF Radio. This radio, capable of line-of-sight communications on VHF/UHF frequencies as well as HAVE QUICK, HAVE QUICK II, and SIGCGARS waveforms, resolved the issues of compatibility with Allied forces, and were more resistant to jamming;
- Replacement of the mission computers with the General Dynamics Advanced Information Systems AN/AYK-14 XN-8 mission computer with increased memory and processing capabilities;
- Replacement of the Stores Management System with the Smith Aerospace AN/AYQ-9 Stores Management System. This made the CF-18 more compatible with the latest of PGMs and furthermore added the MIL-STD-1760 interface for use of the AIM-120 AMRAAM missile and the JDAM family of GPS-guided bombs; and
- Installation of a Global Positioning System/Inertial Navigation System (GPS/INS) capability, enhancing the CF-18's navigational capabilities.

Within the same time-frame, other non-IMP upgrades included:

- Installation of a new infrared sensor pod;
- Replacement of the old cathode ray tube cockpit instrument panels with new flat paneled, full-colour Liquid Crystal Displays from Litton Systems Canada (now Northrop Grumman Canada);
- Addition of a new night vision imaging system;
- Purchase of the AIM-120 AMRAAM medium-range missiles and other advanced air-to-air and air-to-ground munitions;



The new cockpit installation in the modernized CF-18 is fully night-vision compatible - (CF Image - CK00-0028-03)

- Application of a landing gear “get-well” program to reduce corrosion and improve gear retraction; and
- Replacement of the legacy CF-18 flight simulators with an Advanced Distributed Combat Training System.

The first completed "Phase I" CF-18 was delivered to the Canadian Forces on time in May 2003. Final delivery of all "Phase I" CF-18s was done at a ceremony on 31 Aug 2006 at L-3 Military Aircraft Systems in Mirabel, Quebec.

Incremental Modernization Project Phase II

Phase II of the CF-18 Incremental Modernization Project was awarded to Boeing on 22 February 2005. It consisted of the following upgrades:

- Addition of a Link-16 data net system to the aircraft, enhancing interoperability with major NATO allies;
- Integration of the Joint Helmet Mounted Cueing System (JHMCS);
- Addition of a crash survivable flight data recorder; and
- Upgrade of the electronic warfare suite.

Within the same time frame, other non-IMP upgrades included:

- A fuselage Centre Barrel Replacement Project (for up to 40 of the upgraded aircraft);
- An Air Combat Manoeuvring Instrumentation System;
- An Integrated Electronic Warfare Support Station; and
- An Electronic Warfare Test Equipment Project.

The first completed "Phase II" CF-18 was delivered to the Canadian Forces on 20 August 2007, at a ceremony in Mirabel, QC. The total cost of the entire CF-18 Incremental Modernization Project and concurrent *Hornet* upgrades was approximately C\$2.6 billion. The final upgraded aircraft was delivered in March 2010. The total program cost for the CF-188 purchase and subsequent upgrade programs was approximately \$20.21 billion including upgrades, in 2011 dollars. Additionally, the cost of maintenance for any 20-year period has been approximately \$5 billion, or \$250 million per year.



Externally the modernized CF-18 Hornet looks virtually identical to the older version. Extra blade antennas on the upper and lower fuselage and five IFF antennas on the nose of the aircraft are among the only visual clues. Internally, however, the aircraft is radically improved - (CF Image)

Ejection Seat Upgrade ⁹

As described in the RCAF publication *Flight Comment* magazine, the CF-18 fleet's original *Martin Baker* SJU-9/10 ejection seats (*Figure 1a*) were also replaced with the Navy Aircrew Common Ejection Seat (NACES) commencing in late 2008. The NACES offered a significant enhancement in safety margins over the previous ejection seats by providing greater seat stability, reduced parachute descent velocities, and an electronic mode selection for improved performance under high sink rate or low/adverse altitude ejection conditions. The NACES (*Figure 1b*) was developed by *Martin Baker* for the USN in the late 1980s to produce a common ejection seat compatible with multiple aircraft platforms.

This decision to acquire NACES was the expansion of a project originally designed to modify the SJU-9/10 seat to expand its weight envelope and to reduce the parachute descent rate. During this project, a high-speed ejection occurred (on CF188732) which resulted in fatal injuries to the pilot. This tragic accident provided further impetus to understand the risks during ejections and further improve the system.

In this same timeframe, the CF-18 fleet was also being modified to permit use of the previously mentioned JHMCS. The JHMCS required the use of a new helmet / visor system that has greater weight and profile therefore generated higher forces to be imparted to a pilot's neck and torso during ejections. An extensive test program of sled track ejections of instrumented mannequins was conducted during 2005 by the United States Navy (USN) to assess the higher neck loads while wearing a JHMCS helmet and ejecting

from a SJU-9/10 class ejection seat. This test program has led to a USN decision to retrofit NACES with their F/A-18 fleet currently flown by the United States Marine Corps. The Canadian Forces analysis of the data from the USN tests determined that the scope of possible modifications to the SJU-9/10 ejection seat could not solve the key risk issues identified by the USN test program with the JHMCS helmet. These facts supported the Canadian decision to procure a higher performance ejection seat.



Figure 1a: SJU-9/10 - (CF Image)



Figure 1b: NACES - (CF Image)

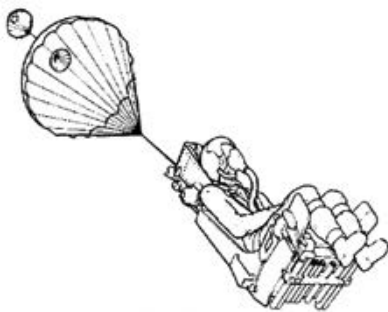


Figure 2a: SJU-9/10 single point drogue bridal attachment - (CF Image)

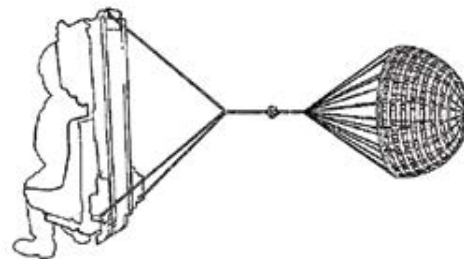


Figure 2b: NACES three-point bridal attachment - (CF Image)

The primary means of control for the seat system is a microprocessor-based electronic sequencer that regulates the deployment timings of the seat stabilizing drogue and main personnel parachutes. The sequencer is designed to receive airspeed and altitude data from a combination of seat-mounted sensors and determines one of five possible ejection modes for the seat. The modes cover ejection conditions from 0 - 1111 kph (0 – 600 knots equivalent airspeed (KEAS)) and 0 - 15,240 meters (0 – 50,000 feet),

ensuring that parachute deployment occurs only when the seat velocity and/or altitude are at acceptable values.

In contrast to the pilot chute- deployed, single-point attachment, cotton drogue stabilizer parachute utilized by the SJU-9/10 ejection seat, NACES employs a catapult-deployed, conical nylon ribbon drogue parachute connected to the seat by a three-point bridal attachment as shown in *Figure 2*. Once deployed, this three-point attachment provides for better control of the pitch and yaw movements of the seat, particularly at high ejection speeds, and further provides for an optimum alignment of force vectors on the crewman during deceleration. In addition, the NACES drogue is deployed earlier in the ejection sequence than that of the SJU- 9/10. These factors contribute to a significant advancement in stability over that offered by the single point attachment of the current SJU-9/10 seats.

Once the NACES is stabilized, a deployment rocket motor extracts the parachute deployment bag (*Figure 3a*) with main canopy out of the parachute head box enabling the main parachute to be deployed clear of seat entanglement and faster at lower speeds. NACES main parachutes are deployed as early as 0.45 seconds after initiation in low-speed modes and at a minimum of 1.3 seconds in high-speed modes. The SJU-9/10 seats (*Figure 3b*) have a fixed minimum time delay of 1.5 seconds and depend on the forces imparted by the drogue parachute to extract the main parachute.

The NACES main parachute system is comprised of a 6.4 meter (21-foot) GQ5000 “aeroconical” parachute compared to the 5.2 meter (17-foot) diameter GQ1000 “aeroconical” parachute employed in the SJU-9/10. The GQ5000’s larger canopy provides a reduced rate of descent for aircrew. The deployment bag keeps the mouth of the parachute closed until the parachute lines are fully extended (lines-first deployment) and then separates. This provides for reduced opening loads in comparison to the SJU-9/10’s GQ1000 parachute. A comparison of other key features that differ between the current and new ejection seat is provided in *Figure 4* and *Table 1*.



Figure 3a: SJU-9/10 Ejection Sequence - (CF Image)

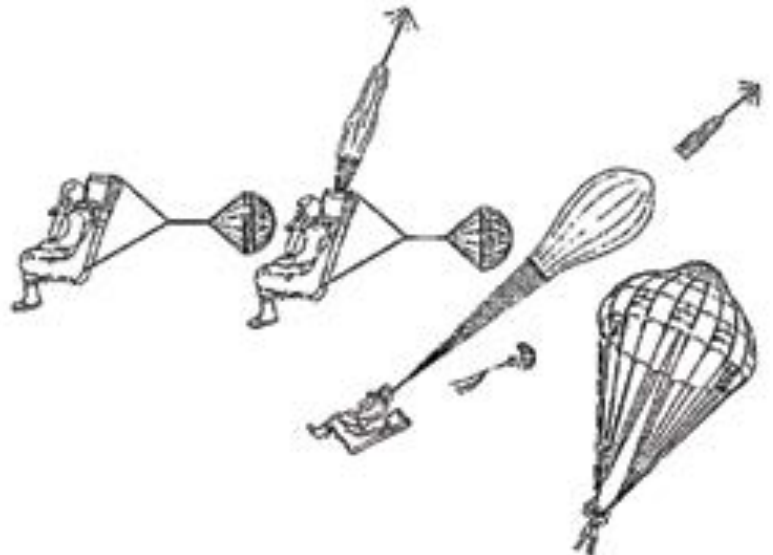


Figure 3b: NACES Ejection Sequence - (CF Image)

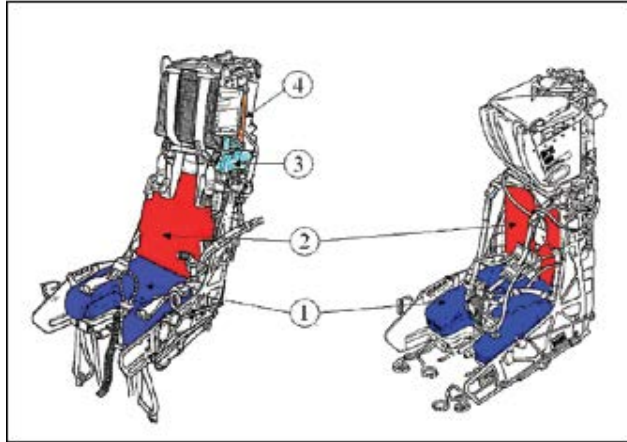


Figure 4: Comparison of NACES and SJU-9/10 - (CF Image)

NO.	COMPONENT	SJU-9A/10A	NACES
1	Seat Pack	Marginal comfort – intended for short duration missions	Ergonomic cushion for enhanced comfort during long missions
2	Back Rest	Fixed geometry	Fore and aft adjustable back rest to accommodate a wider range of aircrew
3	Sequencer	Mechanical –Time Release Mechanism	Microprocessor Controlled Mode Selection – Optimizes Parachute Deployment Timing for Ejection Conditions
4	Pitot-Static Tubes	N/A	2 deployable pitot-static tubes for active speed sensing

Table 1 : Comparison between the NACES and SJU-9/10



The effectiveness of the NACES seat is clearly demonstrated in this sequence from the crash of CF188738 in Lethbridge, Alberta on 22 July 2011. The pilot escaped with minor injuries after a low-level ejection - (CF Images)

Variants

- **CF-18A:** Single-seat fighter and ground attack aircraft. The CF / RCAF official designation is **CF-188A**.
- **CF-18B:** Two-seat training version. The CF / RCAF official designation is **CF-188B**. The dual aircraft is fully combat-capable and is used interchangeably with single-seat aircraft on missions.

As of 2012, the RCAF had a total of 77 modernized CF-18As and CF-18Bs remaining (of 138 originally acquired) in operational use as follows:

- 3 Wing CFB *Bagotville*, Quebec
No 425 (*Alouette*) Tactical Fighter Squadron
- 4 Wing CFB *Cold Lake*, Alberta
No 409 (*Nighthawks*) Tactical Fighter Squadron
No. 410 (*Cougars*) Operational Training Squadron
Aerospace Engineering Test Establishment (AETE)

Rotations from Cold Lake routinely occur from 4 Wing to CFB *Comox*, British Columbia, and from 3 Wing *Bagotville* to CFB *Trenton*, Ontario, CFB *Goose Bay*, Labrador, CFS *Gander*, Newfoundland, and, CFB *Greenwood*, Nova Scotia. Squadrons from both wings also deploy to various FOLs in the Canadian Arctic or internationally as required.

Accidents ¹⁰

Canada has lost / written-off a total of 19 CF-18s in accidents, incurring nine pilot deaths, as of November 2010:

- 12 April 1984: CF-18 188715 crashed at CFB *Cold Lake* during exercise; the pilot (Capt G.C. Milligan) was killed;
- 4 June 1985: CF-18 188737 crashed during formation take-off at CFB *Cold Lake*; the pilot (LCol G.D. Kenny) ejected safely;
- 24 May 1986: CF-18 188717 crashed after takeoff from CFB *Summerside*; the pilot (Capt T.P.R. DeKoninck) was killed;
- 4 May 1987: A CF-18 188919 crashed after a tail-spin during a test flight near Renchen, Germany; the pilots (Capt D.B. Beselt and Capt K.W. Gerhards) ejected safely;
- 21 September 1987: CF-18 188721 crashed at CFB *Bagotville* following a fire in the left engine; the pilot (Maj W.M. Stacey) ejected but incurred serious injuries;
- 20 October 1987; CF-18 188761 crashed on take-off from RAF *Alconbury*; the pilot (Capt D.A. Friedt) ejected safely; the aircraft was later restored to service;
- 5 April 1988: CF-18 188773 crashed in Brooks Peninsula near Vancouver Island; the pilot (Capt M.R. Erikson) was killed;
- 11 January 1989: CF-18 188704 crashed near CFB *Cold Lake*: the pilot (Capt W.W. Neimi) was killed;
- 21 January 1990: CF-18 188726 crashed on take-off from Inuvik; the pilot (Capt R.E. Cover) ejected safely;
- 4 April 1990: CF-18 188792 crashed on the Primrose Lake air weapons test range at CFB *Cold Lake*; the pilot (Capt P.L. Trottier) was killed;

- 17 April 1990: 2 x CF-18s collided in mid-air over Karlsruhe, Germany: 188765 was destroyed and the pilot (Capt T.K. Leuty) was killed; 188779 was destroyed and the pilot (Capt J.C.R. DeCoste ejected but suffered serious injuries upon landing);
- 22 April 1990: CF-18 188772 crashed off Vancouver Island; the pilot (Capt H.R. Tucker) was killed;
- 15 June 1995: CF-18 188713 crashed during training exercise near Klamath Falls, Oregon: the pilot (Capt A.R. Day) ejected safely but incurred serious back injuries;
- 5 July 1995: CF-18 188714 crashed on the weapons range at Cold Lake, Alberta: the pilot (Capt R.B. Bailey) was killed;
- 14 August 1996: A CF-18 188768 crashed on take-off from Iqualuit, Nunavut; the pilot (Capt K. Welch) ejected safely;
- 26 May 2003: A CF-18 188732 crashed on the Cold Lake Air Weapons Range during the annual international *MAPLE FLAG* training exercise; the pilot (Capt K.L. Naismith) was killed;
- 19 June 2004: CF-18 188761 crashed on landing at Yellowknife, NWT; the pilot (Capt J.E. Mullins) ejected safely but with injuries; the aircraft was once again restored to service (see 20 Oct 1987);
- 16 August 2005: A CF-18 188745 crashed during a training exercise near CFB *Bagotville*; the pilot (Capt C.J. Marks) ejected safely;
- 23 July 2010: A CF-18 188738 crashed while practicing an airshow routine at the Lethbridge County Airport. The pilot (Capt B.Bews) safely ejected but suffered back injuries upon landing; and
- 17 November 2010: A CF-18 188789 crashed on approach to CFB *Cold Lake*. The pilot (Capt D. Blakie) ejected safely. The aircraft crashed 13 kilometres from the base.

CF-18 DEMONSTRATION AIRCRAFT ¹¹

To demonstrate the capabilities of the *Hornet* aircraft to the public, a single specially-painted aircraft and demonstration pilot were appointed for various air displays as a solo aircraft demonstration. Eventually this was expanded to demo aircraft from each wing in Bagotville and Cold Lake. Starting in 2004, budget realities reduced this just a single demo aircraft alternating through the following years between these main operating bases. The solo team included a spare aircraft and a dedicated ground crew for the displays.

SOLO PILOTS:

(1983) Captain G. Liddiard (410 Sqn)	
(1984) Captain D. Erhart (410 Sqn)	Captain B.J. Ryan (410 Sqn)
(1985) Captain G. Dutil (410 Sqn)	Captain C. Caron (425 Sqn)
(1986) Captain B. Wade (410 Sqn)	Captain T. deKoninck (425 Sqn)
(1987) Captain N. Nowosad (410 Sqn)	Captain J Thibaudeau (425 Sqn)
(1988) Captain T.A. Short (410 Sqn)	Captain P. Blais (425 Sqn)
(1989) Captain R.A. Lancaster (410 Sqn)	Captain R. Duguay (433 Sqn)
	Major J. Thibaudeau (425 Sqn)
(1990) Major M. Holmes (410 Sqn)	Captain Y. Tessier (425 Sqn)
(1991) Captain L. DeGagne (410 Sqn)	Captain J. Graham (425 Sqn)
(1992) Captain J. Graham (425 Sqn)	
(1993) Captain K. Moore (410 Sqn)	Captain M. Charpentier (433 Sqn)
(1994) Captain K. Stewart (410 Sqn)	Captain M. Charpentier (433 Sqn)
	Captain G. Cossey (425 Sqn)
(1995) Captain M. Woodfield (410 Sqn)	Captain J. Bzrezinski (433 Sqn)
(1996) Captain D. Lecaine (410 Sqn)	Captain G. Morris (425 Sqn)
(1997) Captain D. Carter (410 Sqn)	Major N. Gagne (410 Sqn)
	Captain S. Langille (433 Sqn)
(1998) Captain S. Nierlich (410 Sqn)	Captain M. Bernard (410 Sqn)
	Captain B. Moffet (425 Sqn)
(1999) Captain R. Mitchell 410 Sqn	Captain M. Mirza (410 Sqn)

(2000) Captain S. Greenough (410 Sqn)	Captain P. Hervieux (433 Sqn)
(2001) Captain L. Vogan (410 Sqn)	Captain R. Williams (410 Sqn)
	Captain G. Schwindt (433 Sqn)
(2002) Captain D. Clements (410 Sqn)	Captain S. Shrubsole (425 Sqn)
(2003) Captain T. Brassington (410 Sqn)	Captain D. Belanger (433 Sqn)
(2004) Captain D. Pletz (425 Sqn)	
(2005) Captain J. Kettles (410 Sqn)	
(2006) Captain W. Radiff (425 Sqn)	
(2007) Captain Y. Gregoire (410 Sqn)	
(2008) Captain W. Mitchell (410 Sqn)	
(2009) Captain T. Woods (410 Sqn)	
(2010) Captain B. Bews (425 Sqn)	
(2011) Captain E. O'Connor (409 Sqn)	
(2012) Captain P. Gobeil (425 Sqn)	

Known Serials:

1992 - 188716 – 410 Sqn	
1993 - 188762 – 410 Sqn	
1994 - 188723 – 410 Sqn	188751 – 425 Sqn
1995 - 188710 – 410 Sqn	
1996 - 188746 – 410 Sqn	188784 – 425 Sqn
1997 - 188762 – 410 Sqn	188784 – 425 Sqn
1998 - 188710 – 410 Sqn	188784 – 425 Sqn
1999 - 188718 – 410 Sqn	
2000 - 188796 – 410 Sqn	
2001 - 188796 – 410 Sqn	188904 – 410 Sqn
188720 – 410 Sqn	188712 – 416 Sqn
188709 – 433 Sqn	
2002 - 188720 – 410 Sqn	188740 – 441 Sqn
188739 – 425 Sqn	
2003 - 188720 – 410 Sqn	188906 – 410 Sqn
188709 – 433 Sqn	
2004 - 188709 – 425 Sqn	188906 – 410 Sqn
2005 - 188719 – 410 Sqn	
2006 - 188711 – 425 Sqn	
2007 - 188719 – 410 Sqn	
2008 - 188703 – 410 Sqn	
2009 - 188719 – 410 Sqn	
2010 - 188738 – 425 Sqn	
2011 - 188796 – 409 Sqn	
2012 - 188781 – 425 Sqn	

The following images depict some of these air demonstration aircraft and their elaborate paint schemes:



Demonstration CF-18 #188720 provides a dramatic take-off - (CF Image)



Top to Bottom - CF-18 demo aircraft from 1993, 1994, 1995, 1996, 1997, 1999, and 2000 - (CF Images)



Top to Bottom - CF-18 demo aircraft from 2001, 2002, 2003, and 2004 - (CF Images)



Top to Bottom - CF-18 demo aircraft from 2003, 2005, 2006, 2007, 2008, 2009, 2010 and 2011 - (CF Images)



The CF-18 demo aircraft from the 2012 season - (CF Images)



Other CF-18 squadron aircraft have also occasionally received special paint schemes such as those depicted here from 410 Sqn (top left), 409 Sqn (top right) and 439 Sqn (bottom) - (CF Images)

AEROSPACE ENGINEERING TEST ESTABLISHMENT



The Aerospace Engineering Test Establishment in 4 Wing Cold Lake has maintained a small number of the CF-18s for various flight test purposes since the inception of the fleet. More recently, the unit's aircraft have also acquired an elaborate paint scheme unique to the unit.



CF188907 is only one of a number of CF-18 Hornets operated by AETE over the years - (CF Images - AE2004-0051-011a & AE2004-0051-003a)

THE MUSEUM'S AIRCRAFT - CF188901 ¹²

The Museum's aircraft (CF188901) is a dual-seat trainer from the initial batch of CF-18 *Hornet* aircraft. As previously mentioned, it was in fact the first-ever CF-18 delivered to Canada along with its sister-ship CF188902.



CF188901 at the roll-out ceremony in St Louis in July 1982 - (Bill Upton Collection)

But this particular aircraft had become famous even before landing in Canada as it was this airframe that was rolled out at the McDonnell Douglas plant in St Louis, Missouri on 28 July 1982 for the formal acceptance of the CF-18 fleet by the Canadian Armed Forces. On hand for the acceptance ceremony was Canada's Prime Minister, Pierre Elliot Trudeau. Later at CFB *Uplands* in Ottawa, the Prime Minister went for a flight in this same airframe.



Two views of Prime Minister Pierre Elliot Trudeau preparing for his flight in CF188901 - (CASM Collection)

CF188901 was then delivered to 410 Squadron in October of that year and it then spent the rest of its service life with this operational training unit. Many Canadian CF-18 *Hornet* pilots trained on this airframe. 188901 was, however, one of five aircraft built to the Lot # 5 production standard and, as such, the key structural bulkheads in the aircraft were one of the earliest design configurations. Consequently, the fatigue life of this airframe was less than half of the rest of the CF-18 fleet. While its remaining fatigue life was carefully managed, the aircraft's life ended before the bulk of the fleet and any further repair was deemed uneconomical.



CF188901 on its first flight - (Bill Upton Collection)



Above - CF188901 on its first flight - (Bill Upton Collection)

Below - CF188901 while in service with 410 Sqn carrying an AIS pod on the wing tip - (Bill Upton Collection)





CF188901 showing its underside - (Bill Upton Collection)

With its operational life ended after just 19 years of service, this important aircraft was offered to the Canada Aviation Museum. On 18 October 2001, the aircraft was flown for the last time to the museum sporting enhanced 410 “Cougar” markings from the squadron’s personnel. On its last ever flight, the aircraft was flown by LCol Gordon Zans, the squadron’s commanding officer. He was accompanied by LGen (retired) Al DeQuetteville, the former commander of the Air Force, and the former commanding officer of 410 Squadron when the CF-18 had first entered service at Cold Lake Alberta. Then LCol DeQuetteville had also been the first Canadian squadron pilot to fly aircraft 188901 in 1982.

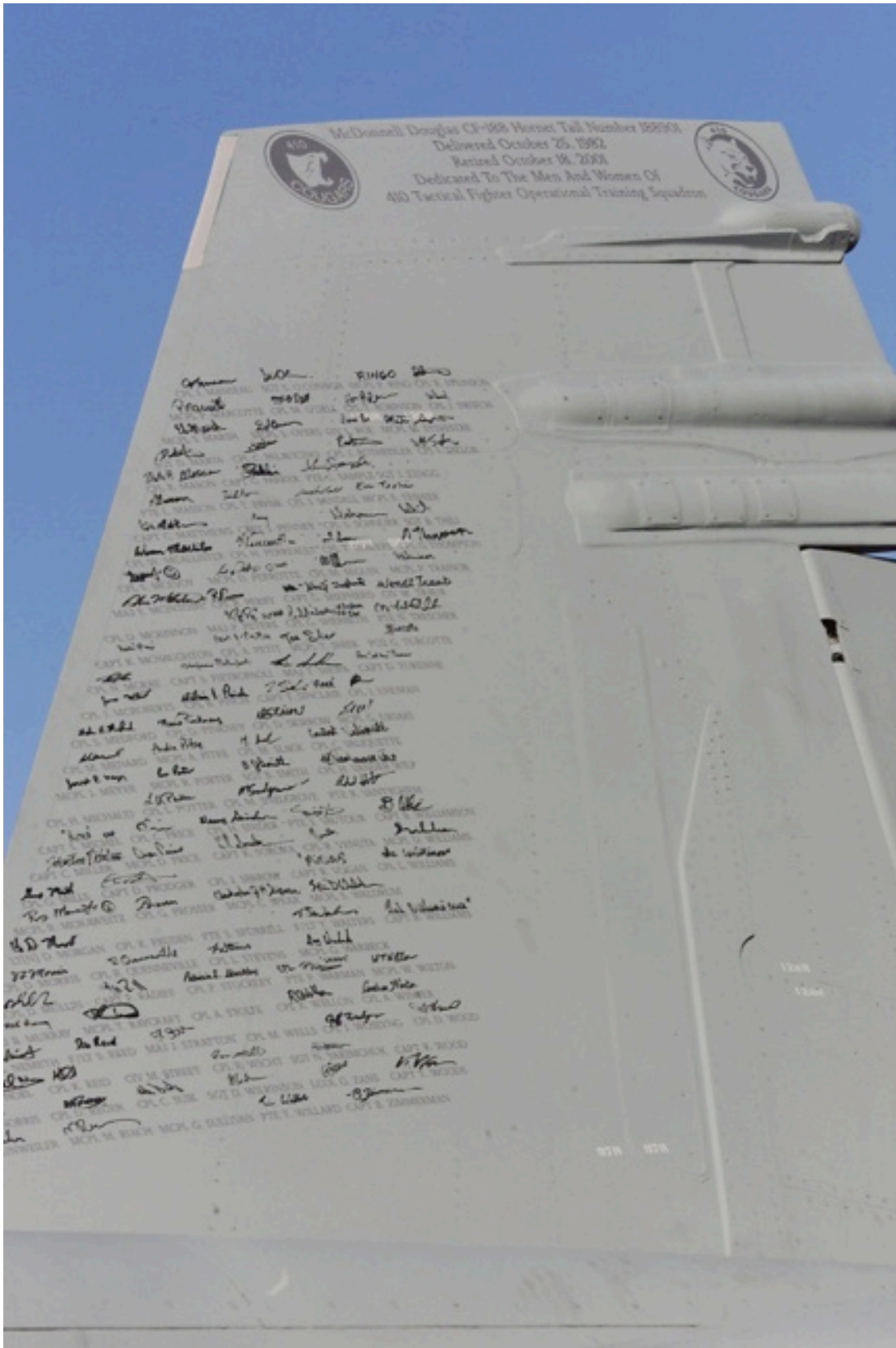
Landing the supersonic fighter on the short (1,006 meter / 3,300 foot) Rockcliffe runway necessitated the installation of a mobile arrestor gear prior to its arrival. LCol Zans therefore performed an “arrested” landing snagging the cable with the aircraft’s tail-hook. Formal ceremonies followed to officially hand over the aircraft to the museum.



A CF-18 performing an arrested landing - (CF Image - CK2007-0456-14)



CF188901 completing its delivery flight to then Canada Aviation Museum on 18 October 2001. At the controls were LCol Gordon Zans and LGen (Retired) Al DeQuetteville - (CF Images - ISD01-0301a & ISD01-0301b)



410 Squadron personnel immortalized their association with CF188901 on its tail before presentation to the Canada Aviation Museum - (CF Image ISD01-0303a)

Specifications (CF-18 Modernized) ¹³

General characteristics

- **Crew:** 1 or 2 pilots
- **Length:** 17.07 m / 56 ft 0 in
- **Wingspan:** 12.31 m / 40 ft 0 in with *Sidewinders*
- **Height:** 4.66 m / 15 ft 4 in
- **Wing area:** 37.16 m² / 400 ft²
- **Empty Weight:** 10,455 kg / 23,049 lbs
- **Loaded Weight:** 16,850 kg / 37,150 lbs
- **Maximum Take-off Weight:** 23,400 kg / 51,550 lbs
- **Powerplant:** 2 × General Electric F-404-GE-400 turbofans, 71.2 kN / 16,000 lb each

Performance

- **Maximum Speed:** Mach 1.8
- **Combat Radius:** 537 km / 330 mi (290 nmi) on a hi-lo-lo-hi mission
- **Ferry Range:** 3,330 km / 2,070 mi (1,800 nmi) (range without ordnance)
- **Service Ceiling:** 15,000 m / 50,000 ft
- **Rate of Climb:** 254 m/s / 50,000 ft/min
- **Thrust-to-Weight Ratio:** 0.89

Armament

- Nine Weapon/ Store Stations (5 pylons: 1 under-fuselage and 4 wing stations) (2 x LAU-116 launcher located on sides of fuselage: deploy AIM-7 *Sparrow* and AMRAAM missiles) + (2 x LAU-7 launchers located on the wing tips: deploy AIM-9 *Sidewinder* missiles), carrying up to 6,215 kg / 13,700 lbs of missiles, rockets, bombs, fuel tanks, and pods
- 1 × 20 mm M61A1 *Vulcan* internal gatling gun with 578 rounds, with a firing rate of 4,000 or 6,000 rounds per minute
- **Air-to-air Missiles:** AIM-9 *Sidewinder*, AIM-120 AMRAAM, or AIM-7 *Sparrow*
- **Air-to-ground Munitions:** AGM-65 *Maverick*, CRV-7 rockets
- **Bombs:** *Paveway* Mk 82, Mk 83, Mk 84, GBU-10, GBU-12, GBU-16 and GBU-24 laser-guided bombs.

Avionics

- Raytheon AN/APG-73 radar
- BAE Systems AN/APX-111 IFF
- Rockwell Collins AN/ARC-210 RT-1556/ARC VHF/UHF Radio
- General Dynamics Advanced Information Systems AN/AYK-14 XN-8 mission computer
- Smiths Aerospace AN/AYQ-9 Stores Management System



Dramatic images from the CF-18 flight-line - (CF Images - CKC98-041 & CK2004-1000-288d)



A modernized CF-18 ready for departure in Trapani, Italy - (CF Image - IS2011-6002-057)

LIST OF ABBREVIATIONS

AAA – Anti-Aircraft Artillery
AIM – Air Intercept Missile
CAOC – Combined Air Operations Centre
CAS – Close Air Support
CATGME – Canadian Air Task Group – Middle East
CDS – Chief of Defence Staff
CF – Canadian Forces
CFB - Canadian Forces Base
CFS - Canadian Forces Station
CRV-7 - Canadian Rocket Vehicle No. 7
DoD – Department of Defence
FLIR – Forward Looking Infrared
FOL - Forward Operating Location
GBU - Guided Bomb Unit
GE - General Electric
GPS – Global Positioning System
HMCS – Her Majesty’s Canadian Ship
IFF - Identification Friend or Foe
JDAM – Joint Direct Attack Munition
KLA – Kosovo Liberation Army
LGB – Laser Guided Bomb
NATO – North Atlantic Treaty Organization

NEO – Non-combatant Evacuation Operation
 NORAD – Northern American Air Defence (Command)
 NRC - National Research Council
 NVG – Night Vision Goggle
 OAF – Operation Allied Force
 OEF – Operation Enduring Freedom
 OTU - Operational Training Unit
 PGM – Precision Guided Munition
 RAAF - Royal Australian Air Force
 RCAF – Royal Canadian Air Force
 SAM – Surface-to-Air Missile
 TFA – Task Force Aviano
 TFS - Tactical Fighter Squadron
 UHF – Ultra-High Frequency
 UN – United Nations
 UNPROFOR – United Nations Protection Force
 US – United States
 USAF - United States Air Force
 USN - United States Navy
 VHF - Very High Frequency

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ENDNOTES

¹ This section is based heavily on two references: *Sting of the Hornet - McDonnell Douglas F/A-18 in Canadian Service* by David Bashow and the *F/A-18 Hornet - A Navy Success Story*, by Dennis Jenkins.

² In American aircraft nomenclature, the “Y” in front of an aircraft designation denotes a “prototype” aircraft as in “YF-17” or prototype F-17.

³ This section is also based heavily on two references: *Sting of the Hornet - McDonnell Douglas F/A-18 in Canadian Service*, by David Bashow and the *F/A-18 Hornet - A Navy Success Story*, by Dennis Jenkins.

⁴ This section is again based heavily on two references: *Sting of the Hornet - McDonnell Douglas F/A-18 in Canadian Service*, by David Bashow and the *F/A-18 Hornet - A Navy Success Story*, by Dennis Jenkins.

⁵ The author was an aerospace structural engineer in the RCAF on fighter and trainer fleets. This section is based upon a variety of unpublished / unclassified Canadian Forces references available to the author, from personal experiences and also upon information from an unpublished *CF188 Hornet Fleet Media Package* prepared by DND personnel in Nov 2002.

⁶ This entire section on international operations is based heavily on information drawn from the Master's Dissertation by LCol Darcy Molstad as listed in the references and is used with permission. As of 2012, LCol Mostad is the Commanding Officer of 425 Tactical Fighter Squadron in 3 Wing, Bagotville, Quebec.

⁷ The Royal Canadian Air Force (RCAF) had officially been reconstituted as a force on 16 August 2011.

⁸ This section is based upon an unpublished *CF188 Hornet Fleet Media Package* prepared by DND personnel in Nov 2002.

⁹ This section is an updated and further amended version of an article in the Canadian Forces *Flight Comment Magazine* - “NACES for the CF188 - A Higher Performance Ejection Seat for the Modernized Hornet”.

¹⁰ This section is an updated and further amended version of the information contained at the following website: www.ejection-history.org.uk/Aircraft_by_Type/CF-18/cf_18_hornet.htm with additional input by R.H. Smith on 07 May 2013

¹¹ This section is the author's material drawn from a wide variety of sources, images and references.

¹² This section is based on an article in *Airforce Magazine* by Vic Johnson entitled “*Supersonic Museum Piece*”.

¹³ This section is an updated and further amended version of information contained at the following website: http://en.wikipedia.org/wiki/McDonnell_Douglas_CF-18_Hornet