

The F-111C Aircraft for Australia

The F111 is the most significant aircraft in the RAAF's history. When it finally arrived in 1973, after ten years of controversy, it gave Australia for the first time a genuine, independent strategic strike capability. More than any other weapons system, the F111 has underwritten the notion of defence self-reliance and the strategy of controlling the air-sea gap¹.

The Requirement

Replacing the Canberra with a modern strike aircraft was a high priority for the RAAF for some years. Although the Canberra had been in operational service for some 10 years, it was a high altitude bomber which transitioned to a low level 'attack' aircraft and formed the mainstay of the RAAF's long range strike capability, with its well known limitations. Notwithstanding its outstanding achievements in Vietnam from 1967-71, its low attack speed, no powered flight controls, lack of electronic warfare systems and its overall survivability in a medium to high threat environment, made its replacement 'of paramount importance'. In 1959, the Air Board accorded re-equipment of the strike force, 'absolute precedence²'.

Offensive air operations are the *raison d'être* of a strike force, the primary role of the RAAF to destroy an enemy's air and maritime power before they pose a threat to Australia and its interests. These operations require highly capable strike aircraft designed to operate in all-weather, at long range, with accurate navigation bombing systems, suitable weapons load and survivable in high threat environments.

In 1963, a Department of Air Top Secret 'Report of the Evaluation on a Strike/Reconnaissance Aircraft for the Royal Australian Air Force', considered the F-4C Phantom, the RA-5C Vigilante (USA), the two seat French Mirage IV and the British TSR-2 (later cancelled) and the TFX (F111). The two aircraft that best met the RAAF requirements were the TFX and the TSR-2, both still on the drawing boards. However, because acquisition of an aircraft was urgent, the report recommended the Vigilante, mainly because none of the other contenders was suitable.

This decision did not appeal to many in the RAAF as early US jet strike aircraft were designed to different requirements and were not renowned by aircrew and technical crews for their performance.

The Vigilante was a nuclear strike aircraft, was approaching obsolescence and would have required many modifications to meet RAAF requirements. The USN retired their Vigilantes not long after.

The British were not happy with the recommendation; much diplomatic negotiation went on 'behind the scenes' on the virtues of the TSR-2 and the implications for RAAF/RAF interoperability.

The Government Announcement

However, Defence Minister Athol Townley excluded the CAS and the RAAF from further negotiations and on 24 October

1963, Prime Minister Menzies announced the decision to Parliament that his Government would acquire 24 TFX aircraft, now called the F111A, with deliveries starting in July 1968.

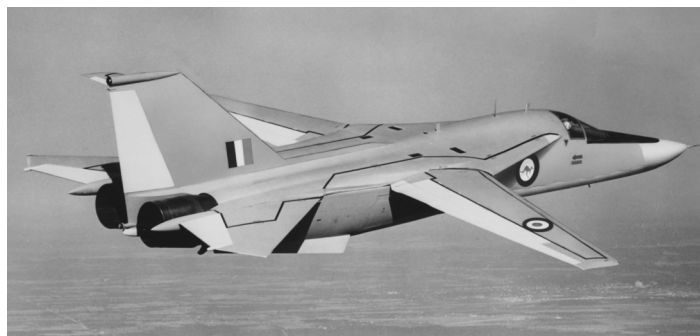
US Defense Secretary McNamara said one month after tooling began:

"This is the only time, to my knowledge, that a foreign Government has made a firm purchase commitment for a military aircraft before the plane has flown".

The F111 was McNamara's 'dream' of an all-purpose strike/fighter aircraft to suit both the USAF and USN, and with large degrees of commonality, would save money. McNamara rejected military advice on the many aspects of the aircraft, its contractors and capabilities. The F111 was called, more than once, the 'flying Edsel', a reference to the unsuccessful car that he pursued when a 'whizz kid' at Ford Motor Company.

As part of a political campaign and a public relations exercise for the Australian government, the USAF sent three B-47 aircraft to Amberley on a tour of 'goodwill'. Some 1SQN crews flew in two of the aircraft on a 2.5 hr demonstration flight; their observations told a lot: long takeoff roll, lumbering, slow at low level, captain and co-pilot seated behind each other, navigators down the nose (as distinct from the Canberra and the TSR-2, where navigators were in the 'black hole' behind the pilot) and a most important switch, water injection required for takeoff, only in the aircraft commander's cockpit – a story there!

When Cabinet approved the purchase of the F111, the cost was in the order of \$US125 million for 24 aircraft, spares, ground equipment and training. The cost was later confirmed at a fixed price of \$US5.95 per aircraft, plus the costs of RAAF modifications: extended wingtips and heavier landing gear. Because the aircraft experienced structural problems in its early days, these costs escalated. Much has been written on the cost escalations, mostly by commentators who knew little about the project. In addition, 'experts' questioned



The F111 for the RAAF, 3 November 1966
Photo: General Dynamics

¹ Alan Stephens, *Going Solo – the Royal Australian Air Force 1946-1971*, AGPS, 1995

² Air Board Agendum July 1959



First prototype F111A, 39766, ready for takeoff at Carswell AFB, Texas *Photo: GDFW*

the decision making process, the need for such an expensive aircraft, the planned roles, and so on. While some questions were valid, many weren't. All it proved was the infantile approach many critics exercised. However, the exclusion of the RAAF in the final selection was not justified.

The F111 rolled out of the General Dynamics Fort Worth factory, officially, on 15 October 1964, followed by the first flight on 21 December 1964. Early flight testing of the aircraft revealed that the range was 23% less than required by the RAAF. Whether this was combat range (or radius of action) or ferry range, was not stated. But, it was of concern to the RAAF. Longer wingtips, as fitted to the F111C and the FB111A, extended the range by about 350 n miles.

Production continued on 142 F111A models, 76 FB111A's and 24 F111Cs for the RAAF. The RAAF Project Director, Group Captain C H Spurgeon was the first Australian (and foreigner) to fly the aircraft in October 1965.

RAAF Training in USA

Two Australian instructor crews, plus an aircrew simulator specialist, completed conversion to the F111 late 1967- early 1968 before joining the USAF 4527 Combat Crew Training



The first course of crews for the F111 ferry flight

Back (L-R) SQNLDR Dave Marks, SQNLDR Jock Thomson, WGCDR Henry (Bill) Hughes, FLTLT Lance Halvorson, FLTLT Wally Walters, FLTLT Rob Montgomery

Front (L-R) FLTLT Errol McCormack, FLTLT Frank Burt, SQNLDR Tom Wright, FLTLT Peter Hackett, FLGOFF Chris Lake, FLTLT Len O'Neill

Squadron to assist in training the first RAAF crews, due to start their training in February 1968. In addition, an experienced test pilot, SQNLDR Ron Green, completed his conversion training and was based at Edwards AFB to provide research and analysis on the F111 performance. Concurrently, maintenance personnel were undergoing technical training at various USAF Bases and at General Dynamics Fort Worth (GDFW).

Following the RAAF 'instructor' group of aircrew, the first crews to be trained for the ferry had arrived in USA in February 1968 to start training in preparation for the planned ferry to Australia in Jul 1968.

As few of the RAAF air crews had experience with airborne radar systems, the training program involved a four-week introduction course to navigation/bombing systems (NBS) at Mather AFB in Sacramento, California. The course was held at the 3536th Navigator Training Squadron on B47 and B52 systems and involved radar scope interpretation and long navigation routes with simulated bombing.

Following the introductory radar training, crews underwent a 16 week weapons systems training phase, which included 16 simulator sessions, before starting the aircraft conversion. The pilots completed the same weapons systems training as navigators and flew the simulator missions, as a crew, before they had trained on the aircraft systems. In this way, pilots were introduced to the advanced integrated systems that the F111 employed. The training aimed to give crews a complete understanding of the navigation/weapons system and its operation and to develop the close crew co-ordination needed to effectively master the complex systems and their high level of integration in the F111.

Over the years, many thought that the training given was excessive. But, at the time, the introduction of the F111 was the most significant acquisition of an aircraft and weapons system ever implemented in the RAAF and not to train air and ground crews completely would have undermined the effective introduction and employment of such advanced capabilities in the ADF. The aircraft was often called, by the media and other commentators, the 'swing wing super bomber'. Initially it was, but as the RAAF gained experience with the aircraft, such claims were moderated. As experience was gained, training in later years was changed to meet contemporary requirements.

For the air and ground crews used to earlier RAAF aircraft, eg, the Vampire, Meteor, Canberra, Dakota, even the Sabre, the F111 was a dream. Crew comfort was exceptional: the ergonomic cockpit design, thanks to the 'human factors engineering' department at GDFW, was in another world after the Vampire and Canberra. Gone were the days of bizarre electrical systems, navcom equipment installed wherever, lights stuck all over, unhidden cables etc - enter the modern world of 110V AC systems, with the comprehensive electrical bus systems, forward equipment bays and good cockpit/instrument lighting. More importantly, crew co-ordination was paramount for the safe and effective operation of the aircraft and its systems.

With all this knowledge, crews started their 16 week conversion course onto the aircraft, where they flew in the order of 30-35 flying hours in the F111, with RAAF, USAF instructors and as a crew. Flying training covered all aspects of the aircraft operations: formation, air-to-air (limited), air-to-air refueling and low level bombing.

The flying was interesting and conducted in the Nellis training areas to the north and north-west, where the Red Flag exercises are now held. One of the RAAF crew missions planned by USAF included a night bombing exercise: downwind leg at 13,000 feet, then a descending right hand turn to 500 ft AGL, with an eight nautical mile run-in to the target at 1000ft elevation, followed by an afterburner climb after weapons release to climb over a 7000 feet mountain three miles past the target, then back up to 13000 feet on downwind followed by a rapid descent for the next pass. Adrenalin was prominent as the mission was the RAAF crews' first night crew 'ride' and there were four F111s in the range pattern at the same time. All this made for some first class crew co-ordination and the good aircraft spacing in the pattern.

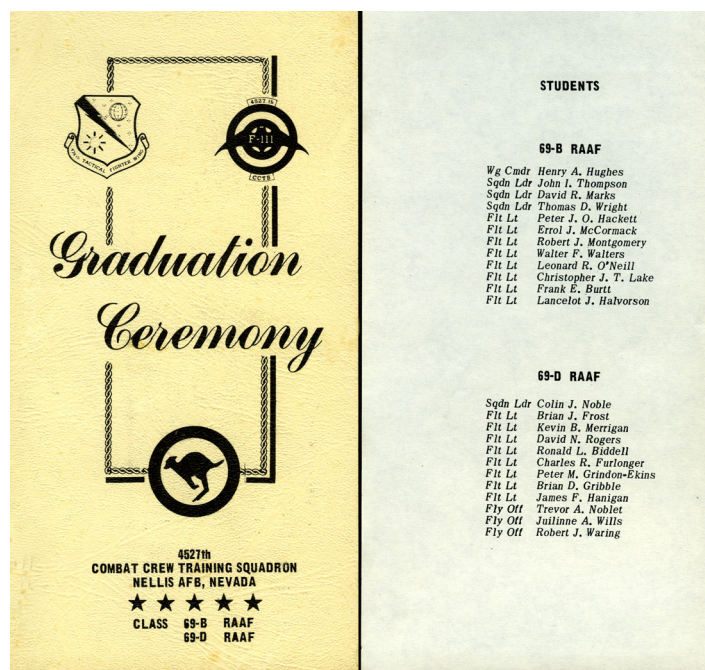
All USAF instructors attended the debrief after the mission, and after the Aussie crews expressed various views of the mission they had just completed, the USAF instructors were

asked how the USAF students handled the mission. The USAF CFI said "We haven't programmed that mission before, you are the first guys to have flown it! But, we don't think we'll put our guys in there". That the RAAF crews handled it well and came through with one or two 'tales', speaks well of the training involved and the background and experience of the crews.

The first crews graduated from their training and were then ready to pick up their aircraft at GDFW, ferry them to McClellan AFB in California, to conduct 'shake-down' flights in readiness for the ferry across the Pacific.

However, during the period of training, a series of USAF accidents in Vietnam during the Combat Lancer deployment and in the USA, put a dampener on F111 flying activities. The number of crashes and their causes are too detailed for this article, but the structural integrity of the F111 was of sufficient concern to the RAAF (and the USAF), that a technical team from the RAAF was sent to USA to investigate the status of the program.

After many visits to the USA, GDFW and technical assessments by the RAAF, the first F111 was handed over to the RAAF in a ceremony at Fort Worth on 4 September 1968. All RAAF air and ground crews attended, via USAF C-130, and were jubilant to see the aircraft in RAAF markings.



Graduation of RAAF F111 courses, May 1968



The sign on the Green Oaks Hotel, greeting RAAF crews for their overnight stay, September 1968 *Photo: Wally Walters*



Cover of the F111C Turnover Ceremony Program, September 1968 *Photo Lance Halvorson*



The F111C Handover ceremony at General Dynamics Fort Worth, 4 September 1968 Photo: Wally Walters

Defence Minister Sir Allen Fairhall caused a chuckle amongst RAAF crews, and few raised eyebrows from the USAF attendees, when in his speech he referred to the aircraft as the “F-one-double-one”; all crews used the term “F-one-eleven”, and still do today. The USAF General John Ryan replied in his speech, “...he had heard the aircraft called a lot of names, the TFX, F-one-eleven, the F-one hundred and eleven, and now the F-one-double-one. Whatever you call it, it’s a damn fine airplane”.

Over the years since, it has been called The Pig, Aardvark, but to many who know it & ‘love’ its capabilities, these were slang terms and not fitting names for such a great aircraft. It will always be known as the F-111.

Technical Problems

The RAAF test pilot, SQNLDR Ron Green and Harry Walton, a civilian from ARL, flew the first aircraft to Edwards AFB, soon after its acceptance on 4 September 1968, for flight trials. However, not long after, two more F111s crashed and inspection of the wreckage of one of them, a USN F111B, indicated a failure of a weld joint in the horizontal tail actuator. The F111s were grounded again after the eleventh crash, the USAF F111.

While not the cause of the latest crashes, engineers started to treat the wing-carry-through box (WCTB) with suspicion.

The WCTB was the ‘backbone’ of the wing pivot structure. A new steel, D6ac, was used in its construction and was also used for the wing pivot fitting, in which the wing pivot pin fitted. Numerous investigations and analyses were carried out by USAF, GDFW and RAAF engineers. As the future ferry to Australia slipped further ‘to the right’, crews were brought home before the end of December 1968.

Further crashes and a failure of the wing carry through box during testing put the RAAF acquisition in doubt. Much has been written about the political and engineering negotiations underway in both Australia and USA, and won’t be discussed in this article. Alan Stephens’ book, ‘*Going Solo*’, gives a comprehensive description of the processes that went on.

There were a number of F111 crashes, due to a variety of causes. The 16th in the list, an FB111A, which crashed in October 1970 was not caused by any structural failure; however the cause was not divulged at the time. Most of the widely publicised F111 accidents were not caused by structural failures and the accident rate, then in the order of 10.5 per 100,000 flying hours, was equal than most of the aircraft of the time, and better than most. Since the F111C has been in RAAF service, no accidents have been caused by structural failure.

Negotiations were still underway in February 1970 when Defence Minister Malcolm Fraser presented a submission to Cabinet which summarised the F111 project and the options available. The main point he made was that there was no other aircraft available, or under development, that could meet the RAAF requirements for a long range, all weather strike aircraft. The USAF maintained their requirements for the aircraft and they and the manufacturer, GDFW, believed the development problems could be overcome. Adverse media publicity in USA and Australia on the aircraft did little to maintain the reputation of the aircraft.

The F111 was a great advance in aircraft design: it can fly at M2.5 at altitude, M1.2 at 300 feet above ground (AGL), fly at very high speed at 200 feet AGL using the terrain following radar (TFR), in all weather and release bombs on a target, 1000 nautical miles from base and return without refuelling. These capabilities cost money to develop and operate.

On 12 May 1970, the then Defence Minister Fraser, announced to Parliament the results of the Fraser-Laird



F111Cs at GDFW, Fort Worth Photo: General Dynamics



RAAF F111Cs in open storage at GDFW factory, Fort Worth Photo: Dave Rogers

Agreement. Briefly, the main points were that a decision to accept or cancel the order had been postponed until late 1971 at the earliest, the F111C was most unlikely to enter RAAF service until 1974; the Government had the offer of an interim lease of 24 F4E Phantom aircraft and tankers and the alternative of transferring the Australian interest to the F111F was rejected.

The options in the Agreement were:

- Cancel the requirement - not acceptable
- Cancel now, replace with F4Es - would need 48 aircraft & 8 tankers
- Cancel now, wait for the F111F - not recommended (not a RAAF choice?)
- Store F111s pending IRAN - desirable course of action
- Acquire an interim aircraft - highly desirable

The last two options were agreed; the F111Cs would go through the USAF IRAN ('Inspect and Repair as Necessary') and the RAAF would acquire interim aircraft. The function of the IRAN program was to incorporate all the modifications necessary before the aircraft could carry out its full operational role.

The testing of the wing carry through box, pivot pin and assembly and the wings was a separate requirement and was carried out by RAAF and ARL engineers, in conjunction with USAF and GDFW. The Government insisted that full

testing was a requirement for acceptance of the aircraft. The strong position taken by the Government in dealings with the US Government, GDFW and USAF was provided by the engineering expertise and advice given by professional RAAF engineers.

The F111C aircraft went into storage at GDFW. It would be four years before RAAF crews acquired the aircraft. Other than the IRAN program, the fitment of the newly designed F111F wing carry through box and routine inhibiting maintenance, they sat in the hangar or in the open, as shown in the photos.

A RAAF evaluation team, headed by DCAS, left Australia on 10 May 1970 to examine and review the costs with the leasing of the F4E aircraft. The decision was made quickly; crews left for the USA in July 1970 for F4E training. The author was one of them. The F4E Phantom experience in Australia will be in a future Wings article.

Article by Lance Halvorson

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RAAF F111C stored in the GDFW factory, Fort Worth Photo: General Dynamics



What the RAAF was waiting for Photo: RAAF

The F-111C Aircraft for Australia

Article by Lance Halvorson

In February 1971, the most vexed question in defence re-equipment consideration was whether Australia would eventually accept delivery of the 24 F-111C strike aircraft ordered for the RAAF.

A decision on the acceptance was not made until after the F-111 had satisfactorily completed the USAF "Inspection and Repair As Necessary" program, which began in late 1972.

The Government decided to leave the aircraft in the United States until all the technical and scientific problems had been overcome and until the RAAF knew that the aircraft would reach the full performance requirements.

Testing of the Aircraft Structure

The USAF had developed a rigorous inspection and testing program for all versions of the F-111s and they, together with General Dynamics Fort Worth (GDFW), fully expected that all proving targets would be met. Cold Proof Load Tests (CPLT) and development of non-destructive inspection methods for in-service use were carried out. RAAF engineers were closely involved in these tests and closely monitored the testing of F-111Cs for the RAAF.

Defence Minister Fraser stated at the time, "Although a great deal of progress had been made with the proving of the Wing Carry-Through Box (WCTB), there remain some continuing uncertainties associated with the proving of the fatigue life of new WCTB designs. Difficulties were experienced in the use of D6AC steel, especially in the detection by non-destructive testing techniques of small cracks, which might become critical in service. Until these problems are solved, the aircraft will be unacceptable to Australia and to the Royal Australian Air Force as a result of shortfalls in performance and doubts about structural reliability. Assuming the F-111C meets our minimum operational and technical criteria, it will give the RAAF an outstanding strike capability superior to any other existing aircraft"

The successful completion of static, fatigue and flight tests was scheduled for the middle of 1971. The latest advice in mid 1970 was that fatigue testing program would not be completed before the end of 1971 and possibly later than that before it was established whether the aircraft would perform as required.

Australia was negotiating with US Defense Department, USAF and GDFW from a position of strength due to better knowledge of the program, the engineering expertise provided by RAAF engineers, the choices open to Australia in the acceptance, or not, of the F-111 and a sober detachment from past attitudes.

A degree of acrimony had arisen over the F-111 purchase, in both USA and Australia, in a number of areas of Government, Opposition, USAF, RAAF and bureaucracies. Australian Progress payments in USD were continuing and the Government was seeking options for deferring the purchase or not accepting the aircraft, ie, 'ways out' of the purchase, as USD were in short supply. The final decision on acceptance of the F-111 would hinge on RAAF engineering

assessments of the structural integrity of the aircraft and the life expected with the new re-designed wing-carry-through-box, following the tests to be carried out on the aircraft.

The status of the F-111 static test program, fatigue test program and the recovery program, including the cold proof test and non-destructive inspection (NDI) was covered in complete detail in the August 31 1970 report of Air Force Secretary Robert C. Seaman and USAF Chief of Staff, General John D. Ryan. At that stage the fatigue test program was about 75% complete, and the results indicated both "a sound basis for confidence in the structural adequacy of the system" and a "reasonable expectation" of a 15 year "life" for the wing-carry-through box (24,000 test hours, equaling 6000 flight hours), in testing to be completed by June 1972.

The F-111 underwent many tests, from the WCTB, NDI test on components, engine tests (with frozen chicken ingestion in the engine intakes) to high speed sled tests, again with chickens, to test the strength of the module transparencies (the front windshields). The NDI inspections required significant dismantling of the aircraft; following the inspections, the aircraft were reassembled and given thorough ground checkouts and five flight tests before the USAF acceptance flight. The F-111 was the most tested aircraft in USAF and RAAF history.

The complete details on the testing of the F-111 are outside the scope of this article. However, the RAAF engineering assessments that followed were obviously correct as the aircraft was accepted in 1972 and has flown in the RAAF for 37 years without any loss due to failure of the WCTB or structural components.

USAF Experience at the Time

Although criticised later as a risk that should not have been taken at the stage in the aircraft's development, six F-111As deployed from Nellis AFB in the US to the RTAF Base Takhli, 85 miles north of Bangkok, Thailand, early in March 1968. The aircraft flew their first combat sorties against targets in North Vietnam on 25 March. They completed 55 missions in the test of combat effectiveness before the loss of three stopped the operations. However, the testing proved to the USAF the benefits of the new interdiction concept, made possible by the F-111, night or bad weather low-level single aircraft penetration in a high threat environment.

Two F-111As disappeared with their crews, from causes unknown, but with no suggestion of enemy action. A third was lost (second of the three), attributed, at the time, to the jamming of the controls by some loose object. Officially, that remains the cause, but on 8 May 1968, another F-111 crash on a training flight near Las Vegas, was caused by fatigue failure of a weld on the actuator valve controlling the horizontal tail surface. Inspections of other F-111s showed development of a similar fault. A similar defect was thought to have caused the three that crashed in Vietnam - a defect that was, after the May 1968 accident, eliminated by a simple modification.

Following the Combat Lancer losses, a number of other crashes occurred, due to a variety of causes. While two of

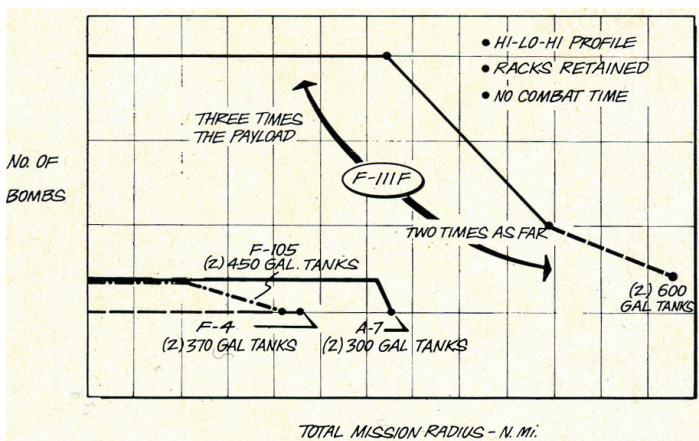
these were not structural failures of the WCTB, their failures were in the same area and the association was there. USAF General James Ferguson, in evidence before the US House of Representatives' Committee on Armed Services, when discussing the in-flight wing failure of a F-111 in December 1969, put the program in focus:

"This problem, like the others I have discussed, is not unique or mysterious in aircraft development programs. Demands for higher and higher aircraft performance have forced both the commercial and military aircraft designers to develop and employ higher strength materials. Each new material or new alloy of an existing material invariably has a few unique characteristics which must be ferreted out and understood. The exhaustive inspection techniques previously used in the manufacture of the part that failed did not disclose the presence of this particular flaw. The newly developed inspection techniques will positively detect them," said General Ferguson.

On October 8, 1970, there was a move in the United States House of Representatives to strike out \$US548,000,000 from the fiscal 1971 program for the F-111. It was defeated by 89 votes to 28. The chairman of the House Armed Services Committee, Mr Mendel Rivers, reporting on the conference with Senate representatives which restored the original House vote, added that "the House conferees in no way agree with the statement contained in the initial report of the Senate committee to the effect that this year's procurement will be the final buy for the F-111". He added: "We believe the Department of Defence should be prepared to ask for further aircraft if they are called for by military requirements. This is a truly unique aircraft. Even the Senate committee report says: 'No other aircraft in the Air Force inventory can compete with the F-111'. Pilots who fly this aircraft say they would rather fly the F-111 than any other aircraft in the world. If it is the best plane we can give them, then I think we should not permit substitution of a lesser aircraft".

The 20th Tactical Fighter Wing of the USAF was equipped with F-111E aircraft, operating at Upper Heyford, Oxfordshire in the United Kingdom as part of NATO defence in late 1969. The aircraft had flown 3000 miles across the Atlantic, from Pease AFB, New Hampshire, USA, to, England, un-refueled, in 6 hr 53 min.

Following North Vietnamese intransigence at the Paris Peace Talks and their decision to 'break-off' talks on 13



Comparison of F-111 range and payload Diagram: USAF

December 1972, Linebacker II bombing operations started on 18 December. The 11 day bombing campaign launched against targets that had not previously been attacked: rail yards, command and control facilities, power plants, bridges, POL supplies, MIG bases and SAM sites in and around Hanoi and Haiphong. Linebacker II used all-weather force of B-52s, F105, F4-E and F-111 attack aircraft to bomb these targets. The F-111s were employed at night on low level attacks against pin point targets, eg, POL supplies, power plants C2 facilities and SAM sites.

The F-111s excelled in the campaign and their effectiveness was proven beyond doubt.

Ferry to Australia – June 1973

In December 1971, the Defence Minister Mr Fairbairn announced the Cabinet decision to accept aircraft out of storage at General Dynamics, Fort Worth.

Australian aircrew and maintenance personnel were once again ready for training in the United States. Instructor aircrew were posted to the 474TFW in January 1972 for another F-111 conversion course; the two navigators were on the original 1968 F-111 courses and one, Alan Lockett, was also on the F-4E training and ferry in 1970.

By January 1973, ferry aircrew were once again at Nellis AFB for training. Four were trained in 1968, but the rest were new crews. The first six F-111Cs arrived at Amberley on 1 June 1973 from McClellan AFB, Ca via Honolulu and Pago Pago.

During the welcoming speech, Mr Barnard stated, "I'm sure this aircraft will be flying well into the 80s, and beyond". No-one present would have guessed that 'beyond' would be 2010, 37 years later. The aircraft were ordered in 1963, were due to be flown to Australia in 1968, but arrived five years late in 1973. A long period to wait for the best strike aircraft in the western world.



RAAF instructor crews and test pilot with the CMDR 442nd TFTS at the start of Class 72-U on 22 February 1972.

(L-R): FLTLT Chris Hancock, FLTLT Richard Kelloway, SQNLDR Gil Moore (Test pilot), LCOL Ken Frank, FLTLT Jules Wills and FLTLT Alan Lockett. Class scheduled to graduate 2 May 1972. Photo: 474th TFW Historian Jack Hays.

In-service

Once the aircraft were bedded down at Amberley, both squadrons started a comprehensive continuation training schedule and some flag flying around Australia. The first opportunity to wave the flag came four months after arrival



F-111C aircraft arrival ceremony at Amberley 1 June 1973 Photo: RAAF

with a nine aircraft flypast, the total number of aircraft in Australia at the time. After being called the 'Flying Opera House' by some in the Australian media, the F-111 force ironically overflew the real Opera House during the Royal Salute to Her Majesty, Queen Elizabeth II, when she opened the 'House' on 20 October 1973.¹

No 6 Squadron carried out its first conversion course in Jan 1974, closely followed by No 2 Conversion Course in August 1974, on which the author completed his 2nd F-111 conversion. Both squadrons engaged in Kangaroo 1 Exercise in the latter part of 1973 and a number of smaller exercises. No 6 Squadron deployed to New Zealand in November 1975 for Exercise Tasmanex, a maritime exercise with the RAN and RNZN.

Squadrons trained in maritime strike exercises and their primary role, low level strike, largely 'single ship', but working up to three and four aircraft strikes on land (co-ordinated at 30 sec intervals) and maritime 'targets'. On occasions, crews practised air-to-air intercepts, to maintain some of the skills they gained in the Phantom F-4E and on conversion course with the F-111. However, while the capability was maintained, it was accepted as a minor role. The same occurred with the 20mm M61A1 gun; it was fitted but not used, due mainly to the aircraft role, but also by the opposition of one or two senior members of the air staff, who considered firing the gun was the role of the fighter force. However, all of the guns were fired and proven in the F-111s before they were removed for fitment of the Pave Tack pod.

Most of the training involved bombing at the Evans Head Weapons Range where crews could practice radar and visual releases of 25lb practice bombs. To gain experience in operating the F-111 with 20 x 500lb (227Kg) high explosive (HE) bombs, ie, 'heavyweight', both squadrons deployed separately to RAAF Base East Sale and flew TFR sorties in Tasmania, mostly at night, before releasing the HE bombs at Dutson Range and recovering to East Sale.

Aircrew very quickly determined the limitations of the F-111 navigation and bombing system (NBS). As the system was integrated, navigation and bombing accuracy was dependent on an accurate inertial navigation platform and analogue nav/weapons computer, so that crews could find the pinpoint target/s in all-weather conditions. The navigation

system drift error was about 2 n miles per hour and while crews, more often than not, found their target/s, 'bomb damage' was dependent on the CEP² of the bombing system. The F-111's CEP, for similar attack conditions, was about 55 metres; inadequate to damage likely heavy structured pinpoint targets. While the accuracy was adequate for wide area targets where unguided bombs were suitable, eg, dispersed aircraft and 'soft skinned' targets in general, precision guided munitions were the obvious answer.

Possibly as important as the navigation and bombing accuracy, was the failure rate of the nav/bomb system. After a

few years in-service navigation computer units started to fail after 3 to 5 hours of operation, sometimes in flight. Availability of technical support and spare parts from the manufacturer were becoming problems also, as most US aircraft were fitted, or being fitted, with digital computer systems.

As procured, the F-111C had a PGM capability, albeit with Vietnam era weapons, eg, AGM45 Shrike anti-radiation missile (ARM), AGM65 Maverick and AGM62 Walleye missiles. Maybe Air Staff were involved in procuring the aircraft, against much bad publicity, and to pursue weapons as well may have pushed the procurement of both into the 'unobtainable' basket.

Whatever the reasons, the operational offensive capability of the F-111C, and the whole RAAF, was in a 'parlous state'. Following a paper on this unsatisfactory state by the new ARWPN, Peter Ekins, strategies were put in place to provide a graded operational capability for RAAF offensive aircraft. In addition, the activities of separate weapon acquisition, based on aircraft replacement, were changed to a weapons system philosophy. All air staff titles were changed to Operational Requirements to reflect this philosophy.

Attrition Aircraft

Provision for attrition aircraft was made in the original purchase agreement in 1964 and confirmed again in the Fraser/Laird Agreement in 1970. Chief of Air Force Operations, AVM David Evans, raised the subject of attrition aircraft with the USAF in 1977. Following Government approval, four F-111As were acquired from USAF operational squadrons in 1981. To maintain configuration control with the F-111Cs in the RAAF, the aircraft were selected from the same or near to, 'build block' as the 'C' models: 67109, 67112, 67113 and 67114, the last 'A' models built. In a departure from normal processes, Operational Requirements staff at the time, Alan Lockett and Lance Halvorson, recalled that they wrote the Air Staff Requirement (ASR) after the decision was made to acquire the aircraft, when the usual process was to write the ASR to justify the acquisition.

² CEP, (circular error probable) is a statistical figure of the radius in which 50% of the bombs will hit, under similar conditions. It also means that crews have a .5 probability of a bomb impacting within that radius. This figure is the basis for weapons effort planning, even with precision guided munitions (PGMs) which have a much lower CEP, and therefore a higher PK, ie, probability of kill.

¹ 'F-111C Formation', RAAF News, November 1973, p 3

The aircraft were stock standard F-111As which were modified to 'C' standard after procurement. An interesting fillip was that the original 'A' model WCTB's were retained. The fatigue life of these aircraft may have received closer monitoring than their 'C' model brothers. However, no problems were encountered when in-service.

RF-111C Modification

As early as December 1974, Defence Minister Barnard approved a Project Definition Study on the acquisition of a reconnaissance capability for the F-111C, the first project for the new aircraft. Air Staff Requirement 14, later Project 5014, was developed to modify four F-111C to provide a strategic and tactical reconnaissance capability. The team that visited GDFW and the sensor manufacturers agreed, predictably, that a reconnaissance pallet installed in the weapons bay was the best and only option.

The modification provided a comprehensive reconnaissance capability unmatched by other 'recce' aircraft at the time. An infra-red linescan system and various camera configurations were fitted and the prototype was completed in April 1979. A four month flight test program by SQNLDR Jack Lynch and FLTLT Marty Chalk verified the design and performance criteria. The remaining aircraft were converted at No 3 AD, Amberley. The avionics of the RF-111C were also upgraded as part of the AUP, later in 1996.

In addition, two Photographic Processing and Interpretation Facilities (PPIF) were established at Amberley to process the film and interpret the results, one for permanent installation and the other for deployment. Such facilities were essential to complete the intelligence sequence: acquire, process, interpret and disseminate.

Early Navigation System Upgrade

In 1978, USAF embarked on the Weapons Systems Improvement Program (WSIP) to upgrade their 'A' and 'E' models with a digital navigation and bombing system and to re-equip the aircraft with the Pave Tack system. USAF offered to include the F-111C aircraft in the program at about 10% of the total cost. However, when the costs escalated considerably, USAF cancelled the program. The RAAF was left with nowhere to go on the digital upgrade, the Pave Tack or Harpoon integration. It looked in danger of 'back to square one'.

Pave Tack & Guided Weapons

Following the cancellation of WSIP, there was little support in the certain areas of Air Office and DSTO to continue with the Pave Tack integration. Harpoon looked like a possible casualty too. However, Operational Requirements staff at the time, Alan Lockett, Peter Ekins and Lance Halvorson, knew that integration of Pave Tack and Harpoon in the F-111 would greatly enhance the capabilities of the strike force, even with retention of the analogue nav/bomb system. Without this integration, the F-111 would not progress into the world of precision guided munitions, essential for its future credibility as an offensive weapons system.

With considerable staff work by the officers above, and their technical services counterparts, the integration of Pave Tack on the F-111C was approved and the project became Air 65 Pave Tack and Guided Weapons. The guided weapons to be integrated were the AGM 84 Harpoon anti-shiping missile and the GBU-15, a 2000lb Mk84 glide bomb guided

by data link. Initially, the project included the dreaded 'fitted for but not with' concept that derived from the civilians in Defence who had little appreciation of modern weapons systems or strike operations. A weapon considered essential in any strike force was the AGM-88 high speed anti-radiation (HARM) missile; however, its inclusion in the project was not approved because of a 'trade-off', due to its cost, for other service projects.

Pave Tack was undoubtedly the start of the modern PGM capabilities in the F-111 aircraft in the RAAF.

The Pave Tack system gave the F-111Cs a much needed capability boost in weapons delivery precision. The system consisted of a forward looking infrared sensor (FLIR), a laser transmitter/receiver and target designator and the associated electronics, enclosed in a self-contained pod which could retract into the weapons bay when not in use. The turret could swivel to give a 180° arc forward, rear and to each side. A stabilised image in the navigator's display allowed the operator to switch between the radar and infra-red display and designate the desired bomb impact point on the FLIR, to which the laser was 'bore sighted'.



An F-111 fitted with Pave Tack and laser guided bombs, near Amberley Photo: RAAF

The RAAF Project Air 65 Pave Tack was approved in July 1980 when Minister for Defence Jim Killen announced a Letter of Offer and Acceptance for A\$160m. The letter allowed for conversion of the 18 remaining F-111C aircraft, but only ten weapons bay cradles and pods were to be acquired, although all 18 aircraft were modified to accept Pave Tack pods when available. The modifications started on the prototype in December 1983 and continued until January 1985, followed by flight testing.

The remaining aircraft were modified at Amberley from 4 March 1985 and the first locally modified aircraft was officially rolled out on 24 September 1985 to much fanfare and attended by the Minister for Defence, the Hon. Kim Beazley. In the end, all 20 F-111Cs were modified and fitted with pods once spares became available from ex-USAF F-111F stocks.

During the Pave Tack Preliminary Design Review of the Pave Tack project in August 1982, the author had the pleasure of flying his last F-111 mission in a USAF F-111F of the 48TFW, RAF Lakenheath, UK. The mission involved a transit up the east coast of UK, across Scotland, down Loch Ness to a run against a bridge 'target' using the Pave

Tack before heading to the Isle of Man for a quick bombing run, then back to Lakenheath. Pre-flight check-out on the 'F' was minimal and digital system and Pave Tack knowledge were from the checkout in the crew room; while not scoring a direct hit, the bomb was close to the target. The author was very impressed with the F-111F and its systems and Pave Tack; the sortie confirmed, in his view, that the RAAF decision on the project was correct. However, maybe the RAAF should have looked closer at the F-111F when the 'C' was having problems in 1968-1969 and all options were under consideration.

At the time, the LANTIRN (Low altitude navigation targeting infrared by night) pod developed for the F-15E Strike Eagle, or the Advanced Fire Control Pod developed for the F-18, deserved a closer look. The pods were much smaller than the Pave Tack, although the LANTIRN consisted of two pods. However, we were too far down the path on Pave Tack.

AGM-84 Harpoon

The RAAF became interested in Harpoon for the P-3C aircraft in 1977, and later, for the F-111C and F/A-18 Hornets. Harpoon was the only missile available to meet the maritime strike requirements; Exocet was not yet on the scene. The incorporation of Pave Tack in the F-111C gave the opportunity to also incorporate the AGM-84A Harpoon anti-ship missile control and launch system (HACLS) and essential interface with the navigation/bombing system.

Operational Requirements staff (Peter Ekins and Lance Halvorson) developed the operational design requirements before Halvorson attended a Harpoon Design Interface meeting at GDFW to develop the weapons control and interface design. As the F-111 Harpoon configuration was fully integrated with the nav/bomb system, target coordinates were continuously updated; immediately before launch, the navigator could program search patterns, way points and attack modes. The integration made the Australian F-111C the most lethal maritime strike platform in the world.

Harpoon is a 12.6 ft (3.8 m) long turbojet powered anti-ship 1145 lb (520 kg) missile with a high explosive blast warhead capable of inflicting significant damage to a vessel. Once fired, the missile flies autonomously to the target, turning on the active radar seeker head in the attack phase. The missile has a range in excess of 60 nautical miles (80kms), outside the target's missile engagement zone, thus providing a safe launch for the attacking F-111C.

AGM-88 HARM

After a failure in the late 1960s to acquire the AGM-45 Shrike or Standard anti-radiation missiles for the RAAF under Air Staff Target (Guided Weapons), the Operational Requirements Staff turned to the newer AGM-88 HARM or High Speed Anti-Radiation Missile. Anti-radiation missiles are designed to lock onto enemy radio or radar transmissions and then fly 'down the beam' to hit the target, or if the enemy becomes aware of the F-111C in the area with ARMs, force them to turn their radar off, denying them any tracking data of the F-111. Either way, the ARM is very useful, even indispensable, to the attacker in the defence suppression role.

On two occasions, procurement of anti-radiation missiles was denied for the F-111C. One wonders the rationale behind non-procurement of the anti-radiation missile; maybe it was viewed by the bureaucrats as too offensive and aggressive.

Well, they are and no apologies were offered for such a view. With wiring now being fitted to 12 F/A-18F Super Hornets, it may be third time lucky and ARMs will be fitted to upgrade the Super Hornet to the EA-18G Growler.

Modifications Along the Way

The F-111 has had a number of modifications in its service life, from engines and flight controls to avionics/weapons systems and electronic warfare (EW) equipment. However, details of the modifications are too detailed for this article; the major updates will be discussed briefly. Details can be found in Mark Lax's book on the history of the F-111, *From Controversy to Cutting Edge*, released on 3 December 2010. Books can be ordered from the Air Power Development Centre, www.raaf.gov.au/airpower

Engines

The F-111C/RF-111C aircraft were fitted with upgraded engines in the mid 1990s, procured from ex-USAF stocks of F-111D and F models that had been retired. These P109 engines were more reliable and had greater thrust than the P103 they replaced. The improved performance was welcome, achieved with little affect on fuel consumption or range and payload. The F-111G aircraft were fitted with a RAAF modified P107/109 (called the P108), to allow for the difference in engine and airframe structure.

Avionics Update Project (AUP)

Following a successful avionics modernization program carried out by the USAF on FB-111A and F-111A/E aircraft, the RAAF re-established the 1978 Air Staff Requirement to upgrade the avionics system of the F-111C. In addition, Operational Requirements staff, John Kennedy and Mark Lax, developed a 'position paper' on the options for the F-111 aircraft, which were considered by the Force Structure Committee. After Committee agreement, the Government approved the update of the avionics and a contract was signed with Rockwell International in August 1990, at a cost of \$480M. The choice was largely due to the company's experience with the USAF F-111F and F-111D Pacer Strike program which updated the USAF avionics system, 10 years after the original USAF WSIP program was cancelled.

Originally intended as a reliability and maintainability upgrade, the AUP continued the development of the F-111 to a modern and 'lethal' weapons system, a trend started with the Pave Tack and guided weapons provisions in the 1980's. Air Staff and Technical Services Division of the RAAF were aware of the tremendous capabilities that would be available with the upgrade to a digital system, so it was no great surprise when the operational advantages 'opened up' and a new era of PGMs became available to the F-111 fleet. As the capabilities and roles of the aircraft increased, so did the complexity and the level of training required for aircrew and groundcrew.

The digital update involved many major components: laser ring gyro inertial navigation system with GPS, digital stores management system, dual mission computers, digital flight controls, updated Terrain Following Radar (TFR) and new attack radar system. In addition to two multi-function displays in the cockpit for the navigator/weapons systems officer, secure HF and UHF radios were added. Greatly improved electronic warfare equipment was also installed.

Block Upgrade Program

In combination with the AUP, the RAAF incorporated a 'block upgrade' (BUP) of the F-111C/G fleet. The upgrades were to include new electronic warfare (EW) equipment and a number of other smaller upgrades to bring the aircraft to a common standard. Also included was the incorporation of a new stand-off weapon, the AGM-142.

In the event, the BUP for the F-111G did not proceed and the 'C' upgrade was curtailed. However, the EW equipment was upgraded on the F-111C, a much needed modification.

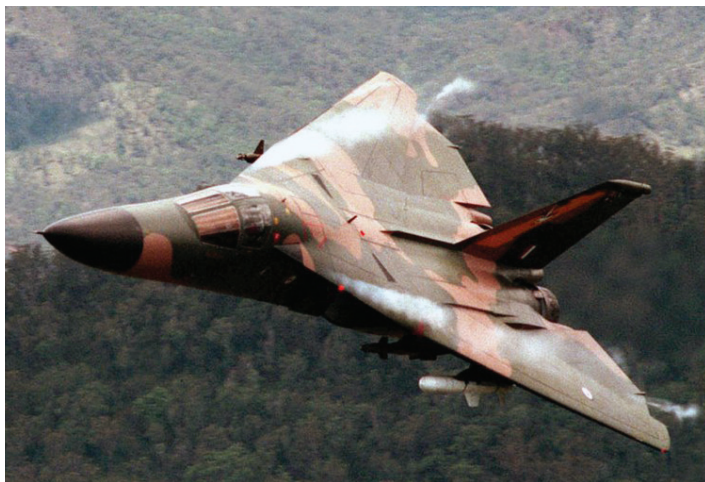
Precision Guided Munitions

Paveway Series Laser Guided Bombs

Paveway I and II series of bombs, standard Mk 82 (500lb, 227kg) and Mk 84 (2000lb, 900lb) bombs, fitted with laser guidance kits, have been employed as GBUs 10, 12, 22/24 for some years. These bombs are guided by laser energy reflected from the target/s by laser designators, usually Pave Tack equipped F-111C aircraft. The GBU series were developed with great success in Vietnam and refinements have resulted in increased accuracies, to less than 2 metres. F-111C aircraft released these GBUs in a 10 degree climb, (toss bombing profile) from low level (200-400ft) at high speed and the GBU would reach an apogee of about 3500-4000 feet before heading for the target. The aircraft laser would fire automatically at 10-15 seconds before weapons impact to provide terminal guidance. High level releases were also employed.

AGM-142

The AGM-142 is a rocket propelled air to surface standoff missile, with inertial midcourse guidance and a passive electro-optical (TV or IIR) terminal seeker which relays an image to the launch aircraft via a datalink. The WSO tracks the target aimpoint and command corrections are sent to the missile via a datalink carried in a weapon specific pod. The missile weighs about 3,000 lb and has an 800lb warhead,



F-111 with two Harpoon missiles and two laser guided bombs, at low level Photo: RAAF

twice the size of the Harpoon. The AGM142 is used for both land and anti-shipping targets, has similar range as Harpoon when launched at altitude, is supersonic and as it has a passive seeker head, provides no warning of its approach to the target.

As the principal intent of acquiring a standoff weapon was to improve F-111 survivability against high threat targets,

the RAAF procured the longer ranging AGM-142/Popeye weapon as it provided significantly better aircraft survivability than the AGM-130 weapon, which had a shorter range, while still capable of inflicting acceptable damage levels on the intended target types.

Procurement of the F-111G

After the USAF Strategic Air Command (SAC) received the B-1B Lancer in 1985, they transferred the FB-111A to the Tactical Air Command (TAC) in 1989, after the nuclear delivery equipment was removed and the nav/bomb system was upgraded. Operating in TAC as the F-111G, they were declared surplus in 1991. Procurement of additional F-111s by Australia offered the opportunity to extend the life



F-111 with AGM-142 fitted. Photo: RAAF

of the F-111Cs and the 'G' models seemed ideal as they had the same heavy landing gear and extended wingtips of the F-111C, but more powerful engines. Defence Minister Robert Ray announced the Government decision to acquire up to 18 F-111Gs in October 1992, to the surprise of many, including the RAAF.

The RAAF eventually acquired 15 'G' models, 14 from the 27 TFW at Cannon AFB, NM and one from the Aircraft Maintenance and Regeneration Center (AMARC), the 'boneyard', at Davis Monthan AFB, Arizona. The first two arrived in Australia in September 1993 and the rest arrived in 1994.

Operated by No 6 Squadron in the new grey paint scheme, eight of the aircraft were used in conversion training, training exercises and show-the-flag missions, preserving the fatigue life of the F-111C. They were retired on 3 September 2007.

Involvement in Exercises

The upgrades to the F-111C/RF-111C aircraft resulted in an outstanding offensive strike platform. The aircraft participated in many exercises in USA (Red Flag, Green Flag), IADS in SE Asia, Pitch Black in Australia and numerous others. In all, it proved its capabilities as one of the best strike aircraft in the world.

Lead -up To Retirement

The then CAF, AIRMSHL Angus Houston, and other senior Air Force members presented a paper on F-111 capability and the Joint Strike Fighter to the Joint Standing Committee on Foreign Affairs, Defence and Trade on 6 June 2004.

AIRMSHL Houston said the F-111 capability was "going great guns at the moment. We currently have a very good

strike capability built around the F-111. We have had a lot of problems in recent times, but I am very pleased to say that, with the assistance of the DSTO, industry partners and obviously the elements within the Air Force that are part of the F-111 community, we have remediated the capability fully after three major challenges ... the fuel leaks, the fuel tank implosion and the wing breakage.” He praised the “wonderful work” done to fix the problems.

DSTO scientist, Dr Graham Clark, said current testing of an F-model wing and other developments in DSTO could “push out” (the life of) the wings, with good results, to 2010. But the “overriding picture” was one of repeated problems which would present “very serious logistical and availability issues” for the Air Force. Already, flying hours has reduced from an average 5680 hours a year in the period 1974-1979 to an average 3060 for 1999-2003.

AIRMSHL Houston said the problems encountered had changed the ADF’s view of the cost of operating the F-111s and therefore the timetables for their retirement. “When I look at the amount of money that I have to plan with, through to 10 years, keeping the F-111 going really distorts the force structure of Air Force, given that we must transition to a networked Air Force for the future. Making the F-111 compatible with the networked system can be done, but it will be an expensive investment,” he said. The Government planned to spend about \$50 billion on capital investment across the ADF and about \$15 billion on air combat capability over 10 years.

AIRMSHL Houston said the upgrades of the Hornets would provide an enhanced strike capability. “We will have more lethality and a better survivability ... it is a strike capability that is better than the one the F-111 gives us now - and indeed it is one that will give us the capability we need through that period until the Joint Strike Fighter arrives”

Subsequent to the paper to the Standing Committee, the RAAF acquired F-18/F Super Hornets. See ‘The Super Hornet...A New Era’ in the Autumn 2010 issue of Wings.

Reflections

The evolution from a great modern weapons system in



An F-111 on its way to the RAAF Museum Photo: RAAF

1968, albeit with its limitations, to an even greater and very effective weapons system in the 2000’s, is evidence of the strength of the modern RAAF. The decisions of the RAAF air staff and their engineering and logistics advisers to acquire the F-111C, under such adversity, demonstrates the professionalism of the RAAF. The engineering expertise to overcome the earlier setbacks, to introduce the aircraft into service and to maintain the fleet to 2010, is very high. The F-111C’s employment for 37 years as an effective weapons platform is an outstanding achievement for the aircrew, the engineering/maintenance personnel, the logistics organisation and the administrative and support members in the RAAF, and to Boeing who maintained the F-111C to its retirement.

The F-111 Retires

At the time of writing, the F-111C Final Flight is scheduled to land at 1300, 3 December 2010. Wings will feature the retirement ceremonies and last flight in the Autumn 2011 issue of Wings.

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The Last Time – 4 F-111Cs in the Whitsunday Islands Photo: RAAF