Editorial Note: The proposed early retirement of the F-111 fleet in 2010 before the new Joint Strike Fighter (JSF) comes on line around 2012–2015 was briefly discussed in the Summer 2003–04 issue of *Defender*. The decision has attracted much comment and aroused some controversy. Several specialist aerospace and defence industry publications have published articles criticising the decision and some of its underlying reasoning. The case for the early retirement has not received the same degree of coverage. Articles outlining both arguments have not, to our knowledge, appeared together to assist in judging their respective merits.

The intention has been for this issue of The Sharp End to include short articles summarising both sides of the debate to allow *Defender* readers to make their own judgements on the implications, and especially on the degree of strategic risk involved, in not maintaining a dedicated and specialist strategic strike capability (and deterrent) for a period of five years or more. The ADA invited Dr Carlo Kopp from Monash University and the ADSC to present a case for retaining the F-111 aircraft in service until it could be replaced by the JSF. We also invited Air Force Headquarters to contribute an article explaining the decision to retire the F-111 fleet early.

Dr Kopp wrote his article first. In early February Air Force Headquarters were provided with a copy to assist in preparing a focused reply. Shortly before publication *Defender* was advised that the RAAF would not be providing an article at this time.

In analysing the new Defence Capability Plan the position of the ADA has been greatly reassured by the view of the CDF and Service Chiefs that the plan offers the best way forward given current constrained resourcing levels. More to the point the ADA notes that if the ADF had been, and in future is, appropriately funded then strategic risk management decisions which appear to be primarily driven by perceived comparative costs, such as the early retirement of the F-111 fleet, would not be necessary.

We regret that we are not able to provide *Defender* readers with the opportunity to easily compare the merits of the respective cases.

Stretching the F-111 past 2010

Carlo Kopp

Recent assertions by Defence arguing that the RAAF's F-111 fleet would present support problems and a high risk of 'loss of capability' post 2010 lack credibility under close scrutiny. Defence has argued that the F-111s should be retired due to their age, reasoning that the cost of maintaining the F-111 will become prohibitive over the next decade. This centres Defence's position in the technical domains of airframe fatigue and reliability engineering.

The thrust of the argument is very curious seeing that the US intend to fly their much older B-52H bomber fleet to 2040, and will most likely operate a good number of KC-135R tankers and C-5 heavy airlift aircraft into the same period. The US approach has been to extend the life-of-type of these aircraft by wing rebuilds, re-engining and ongoing avionic and systems upgrades — the B-52H and C-5 being the next likely candidates for engine refits. Statistics from USAF fleet operations indicate that engine hot-end maintenance accounts for up to 50 per cent of support costs on older aircraft.

The issue of airframe fatigue in the F-111 is complex in detail, but much simpler at a system level. The basic airframe was built for a service life of 10,000 hours and stressed for aircraft carrier operations. It is overbuilt and slightly overweight against the early 1960s specification. Thirty years of cumulative experience has shown that nearly all of the fatigue-limited load-bearing structure resides in the wings — the D6AC steel wing pivot fittings, and particular hotspots in the aluminium alloy wing structure and skins. The fuselage has never been a source of serious fatigue troubles, including the wing carry-through box which mounts the wing pivots.

The DSTO Sole Operator Program (SOP) focused on the wings, and modifications were devised to 'fatigue proof' the wing pivot fittings by changing the stress distribution in the part. Within the aluminium parts of the wings, the problems are well understood by DSTO and fixes could be applied to put additional hours into the wing structure. Stress relieving patches, skin panel replacements, selective structural component replacements, and reworking of the *Taperlok* fastener holes are all options. To date, the strategy has been much simpler - buy surplus wings from lower time F-111F and F-111D airframes mothballed at AMARC in the US, and refurbish and refit them. With around 200 F-111 aircraft in AMARC, there is an ample supply of additional wings to work with. In principle, between retrofits sourced from the large pool of spare wings and structural rebuilds of wing stocks, there are potentially decades of fatigue life available to an F-111 fleet of up to dozens of aircraft. Wing rebuilds have been successfully undertaken for the B-52, KC-135 and C-5 in the US and represent a means of adding 'fatigue life' almost indefinitely.

'... the problems are well understood by DSTO and fixes could be applied to put additional hours into the wing structure.'

Chief of Air Force, Air Marshal Angus Houston, commented in Hansard (03 June 2002): 'We were able to find some really good wings in the United States...Those wing sets have cost us next to nothing. In fact, most of the cost involved with getting them is to do with transportation and putting the wings through wing bay servicing at Boeing Australia at Amberley.'

The RAAF recently commissioned its Cold Proof Load Test facility, in which F-111s are chilled down and 'bent' with hydraulic rams to verify that the primary structure is safe to fly. No such guarantee exists to ensure structural safety on any other ADF aircraft.

The fuselage structure has not exhibited any critical fatigue problems, and a rework of the fuselage longeron *Taperlok* holes is an option to add further life to the fuselage. If need be, selective replacement of some specific machined alloy parts, or patching with boron epoxy, remain options.

Corrosion could prove to be an issue for some fuselage honeycomb skin panels in the future. To deal with this, DSTO devised a method for reverse engineering these panels and designing drop-in carbon fibre composite replacements. In principle, any problems which might arise could be handled by selectively replacing these with tougher and more durable carbon fibre replacements.

Other structural components, such as undercarriage, wheels and miscellaneous fuselage parts could simply be lifted from AMARC, or replaced with new parts manufactured in Australia or overseas, using the original, or more durable materials.

The cost of structural life extension would depend on the scope and scale of the effort, and how much extra life was sought. Public evidence in Hansard (08 June 2002) by former Vice Chief of the Defence Force, Lieutenant General Des Mueller, was that 'the airframe could be managed through to the period 2015–20'. Structural life extensions can be planned years ahead and scheduled into planned overhauls and upgrades. The airframe life of the aircraft could be extended seamlessly and typically with small funding increments over decades of use—as the US has done with many operational types regarded as too expensive to replace.

The Boeing Australia-operated Amberley Weapon

A 'what if' scenario

It is worth considering what impact would have been achieved in March 2003 if the RAAF had deployed F-111s rather than F/A-18As to Iraq. In terms of numbers let us assume that eight F-111s were stationed at Doha and integrated into the US-planned Air Tasking Order. In terms of weapons the F-111s would have delivered 2000lb GBU-10 bombs, 500lb GBU-12/22 laser-guided bombs (LGB), and 2000lb GBU-24 laser-guided bunker busters, as well as 500lb Mk 82 and 2000lb Mk 84 dumb bombs. Given the limited number of US aircraft capable of lifting the 5000lb GBU-28 laser-guided bunker buster, previously carried by the US F-111F, odds are that a special clearance would have been issued for the RAAF F-111s to carry this weapon as well. Borrowed USAF ALQ-131 jam pods would have been carried, with an EMC clearance done at Amberley before deployment.

Operationally, the F-111s would have been used instead of the smaller US F-15E and larger US B-52H and B-1B bombers, subject to immediate demand. The first week of the campaign would have seen primarily strikes on high-value targets using the GBU-10 and GBU-24, but as stocks of these were used up the aircraft would have been swung to medium altitude persistent 'killbox interdiction', armed primarily with GBU-12 or GBU-22 LGB, but also with mixes of Mk 82 and Mk 84 LGB. Sorties would vary in length between eight and 12 hours, with support provided by USAF KC-135R and KC-10A tankers, but with a much smaller total number of required refuellings compared to what our F/A-18A squadron needed.

While the total sortie count of the deployment would be lower in proportion to the smaller deployment size, per sortie the number of targets bombed would have been much higher, due to greater payloads lifted and a greater proportion of total sortie time spent over the target areas (rather than in transit to and from Doha). Statistically, the F-111s would have logged more hours airborne than the F/A-18As, spent more time over Iraq, destroyed more targets, and required a smaller number of aerial refuellings.

System Business Unit combines the depot facility and engineering design/software development capabilities to perform most of any structural life extension which might be sought to extend life past 2015-2020. DSTO would provide expert engineering support, while a robust pool of contractors exists now that could manufacture replacement structural parts should AMARC replacement parts of suitable condition cease to become available.

In terms of avionics and systems the F-111 is also in good shape. The Avionic Upgrade Program completed in late 1999 saw much of the C model's avionics and wiring replaced, and follow-on block upgrades have seen this process continue. At this time the only issues which might arise are in some cockpit instruments, some components in the *Pave Tack* targeting system, and possibly some radar components. While it is feasible to push all of these through to 2020, economically it would be cheaper to replace with more reliable and later generation technology. For instance, glass cockpits are around 100 times cheaper to maintain than conventional instruments, and usually pay for themselves in maintenance savings in 3–5 years. Modern AESA radars cost around $US 2–3 million each and are 5 to 10 times more reliable than older mechanically-steered radars.

'Replacement of the original TF30-P-103 engines with later model TF30-P-108/09 engines with the addition of further durability fixes would see engine time between overhauls grow from around 1000 hours to in excess of 2000 hours.'

Avionics have historically not been an issue in long-lived combat aircraft, since their replacement is driven by capability factors rather than old age. While Boeing Australia at Amberley can provide all of the required design, software and integration capabilities, there is a larger pool of players across the Australian aerospace industry able to support or design avionic and electro-optical sub-systems. These include BAE Systems Australia, Thales/ADI, Honeywell, Daronmont, CEA Technologies, OEA and others. Given available numbers, unique parts such as digital flight controls can be sourced from AMARC stock to cover decades of fleet life.

Whether imported components or domestic ones are used, avionics are simply not a long-term issue, both up to and beyond 2020. The aircraft's hydraulic system is supported by Rosebank Engineering in Victoria, which provide precision machining and engineering capabilities. The F-111's TF30 engines are currently supported by the RAAF-operated Engine Business Unit (EBU) with expert assistance from DSTO. Replacement of the original TF30-P-103 engines with later model TF30-P-108/109 engines and the addition of further durability fixes would see engine time between overhauls grow from around 1000 hours to in excess of 2000 hours, a remarkable improvement for a 1960s turbofan.

While the existing pool of engines is expected to last past 2020, there are additional TF30 engines available in AMARC from later-build F-111Fs, and now increasingly US Navy F-14As. While this stock of engines could no doubt be used to push into the 2030 timescale, economically it would be better for a post 2020 fleet to retrofit a newer engine. The F-16C's F110 engine ($US 4-5 million unit price) would be first choice, as a retrofit kit exists for TF30 replacement, designed for the F-14B/D and almost adopted for the USAF F-111 fleet in the early 1990s. The F-111's engine bays are large enough to fit the F/A-22A's new F119 series turbofan as well, although this would require more engineering to adapt.

From an engineering perspective many good and quite economical solutions exist to enable our F-111s to push well past the original 2020 withdrawal date. If the required work was scheduled over a two-decade period under a rolling technology insertion program, the annual funding impact would be quite low. A 2040 withdrawal date similar to the B-52H, B-1B and KC-135R is technically feasible for the RAAF's F-111s.

The issue of annual running costs of the F-111 fleet is also worth scrutinising, given the assertions by Defence on this matter. Currently, the annual cost of engineering support by Boeing Australia, the RAAF's EBU and other local contractors sits somewhere between $A80 and $A100 million. This is a modest slice of the approximately $A800 million reported in DAR 99 for the total capability, itself between three per cent and four per cent of the total annual defence budget.

Defence claims the cost increased by six per cent annually over recent years, itself a curious finding given that RAAF's total costs over that same period grew by around 18 per cent. Based on this, the F-111 fleet showed much slower cost growth than other RAAF platforms.

On the basis of a five per cent annual compounding cost model, Defence insists that the F-111 will become uneconomical by the end of the decade. This claim is not one which Defence can easily support. The costing model they used is designed for aircraft supported with a different maintenance regime, and one not subjected to an 'ageing aircraft engineering program' of the ilk instituted two years ago by Boeing Australia, the F-111 SPO and DSTO. Such programs identify components approaching wear-out and systematically depopulate the fleet of these parts, so that the aircraft never climbs the 'bathtub curve' of age-related failure rate and cost increases. Within two years the Boeing Australia depot cleared a large backlog of accrued maintenance, replaced most wings in the fleet, fixed endemic fuel leaks (related to sealant choice in manufacture, not age) and also identified and corrected a host of problems previously attributed to age, but actually resulting from incorrect prior maintenance regimes.

Even were the F-111 fleet maintained using bathtub curve-prone airline maintenance techniques, the unusual burst of repairs and maintenance over the last two years makes these unsuitable as a costing baseline for a compounding cost model. It is known that engine support costs have reduced by about 50 per cent since 1990, and are projected to further decline as DSTO-devised fixes are incorporated. The technical evidence indicates that annual engineering support costs for the fleet are apt to remain similar to current levels, and likely to decline over time if avionic and other technology insertion programs are undertaken. Claims by Defence of significant cost increases, not unlike their claims of a high risk of 'loss of capability', cannot be supported by the available evidence or US case studies. It is worth noting that in 1996 US Air Force F-111s cost less to own than US Navy F/A-18Cs. There is little evidence to support the case for early retirement of the F-111 fleet and much evidence to make a case for postponing the withdrawal until well after 2020. ◆

'It is worth noting that in 1996 US Air Force F-111s cost less to own than US Navy F/A-18Cs.'

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Hard facts

The F-111 provides around 50 per cent of the RAAF's punch, whatever conventional measures of effectiveness might be employed to calculate this. The aircraft carries about three times the internal fuel of an F/A-18A, or about twice the internal fuel of the new Joint Strike Fighter (JSF). The F-111 can also lift around twice the weapons payload of the F/A-18A or JSF.

In terms of deliverable combat effect, depending on the operational scenario involved, replacing a single F-111 sortie typically requires two or more sorties by a smaller fighter type and 50 per cent of an available tanker sortie. Loaded with 250 kg dumb or smart bombs, an F-111 can lift about half the bombload of a US Air Force B-52H bomber - or more than half if additional fixed pylons are fitted. The current digital avionics system, fitted during the 1990s, supports a wide range of laser-guided and dumb bombs, and the Harpoon anti-shipping missile. The Block C-4 upgrade, currently in progress, will add the latest technology VME computer hardware, a Military Standard 1760 digital weapons bus and the AGM-142 Stand-Off Weapon. Previously planned follow-on upgrades would permit addition, at the cost of software and clearance testing, of the satellite aided GBU-31/38 JDAM bomb, the AGM-158 JASSM cruise missile, the ASRAAM air-air missile, and the new 130 kg GBU-39/B Small Diameter Bomb (SDB). An ARDU F-111G was used as trials platform for testing supersonic drops of the SDB demonstrators. The F-111 also boasts prodigious speed. In a region where the principal air defence capabilities reside in fighters rather than dense surface-to-air missile (SAM) and anti-aircraft artillery systems, speed presents an important advantage in the survivability game. The F-111 remains the fastest combat aircraft in Western service, making it extremely difficult to intercept at any altitude. Assertions by Defence that the F-111 is not particularly survivable do not stack up to close scrutiny, as results from multinational Exercise 'Red Flag' deployments will confirm.

The contentious issue of survivability is really dependent on how the F-111 is operated and how it is armed. The US Air Force plans to fly far less survivable B-52H and B-1B bombers to about 2040 — protecting them with F/A-22A escorts to deter fighters and suppress or destroy SAM launchers. There are no fundamental reasons why the RAAF could not employ the same operational doctrine for the F-111—using its F/A-18 fighters and then the JSF for escort. The reality is that strike-tasked F/A-18A and JSF aircraft will usually need escorting in any event.

In strategic terms the value of the F-111 has quietly grown over the last three years. During this period Malaysia and Indonesia signed on for long-range Russian Su-30 strike fighters, a type already bought in the hundreds by China and India. Equivalent to the US F-15E, the Su-30 can, with buddy refuelling or available CIS standoff missiles, strike across the sea-air-land gap to the north of Australia. Losing the F-111 drives Australia in the direction of eventual 'strike capability parity' with the region. Another no less important development has been the rapid shift in bombing techniques away from traditional pre-briefed tactical strike profiles, to the new 'persistent strike' model of orbiting the battlefield to rapidly pounce on highly mobile ground targets. Persistent techniques demand large weapon payloads and large fuel payloads to permit a maximum of time on station. While generous use of tanker aircraft stretches the latter, it does not stretch the former. Over Iraq last year, typical fighter sorties grew from 4-6 hrs out to 6-12 hours airborne, pushing a huge burden on the US F-15Es and the badly overstretched US tanker fleet. The F-111 is ideal for this style of combat.