by Dr Carlo Kopp

HOW DEFENCE MISCALCULATED F-111 COSTS

The Joint Standing Committee on Foreign Affairs, Defence and Trade's public hearing in Federal Parliament on December 15 2003 covering the Defence Annual Report for 2002/2003 saw a remarkable disclosure by the Defence bureaucracy.

In testimony the Department stated that it employed a 5% compounding cost model to estimate future costs for operating the F-111 fleet. In a single statement Defence effectively destroyed its fiscal case for early retirement of the F-111 fleet.

The compounding cost model is used to approximate the classical reliability engineering 'bathtub curve' which describes the effect of cumulative old age wearout in a large population of parts – in this instance the components from which the F-111 fleet is made up. Historically this model has been used most frequently to describe the statistical behaviour of older airliners in operational service.

For this model to have mathematical validity two key conditions must be satisfied. The first condition is that a period of stability in the aircraft's configuration and maintenance regimes must exist, preferably for several years, to establish a costing 'baseline'. The second condition is that the fleet must be maintained using an 'on condition' policy in which parts are replaced when they fail, or if inspected just prior to failure. The effect of a population of parts which are approaching wearout if replaced in this fashion is that the failure rate, and resulting maintenance costs, will follow the 'bathtub curve' or technically speaking, a normal distribution function.

These conditions are usually true for airline operators, who 'burn out' their fleets in the knowledge that shifting markets and newer, more economical designs, are just around the corner. Airliners very seldom receive mid-life airframe upgrades, the notion of rewiring, re-engining and replacing avionics wholesale is uncommon in the airline industry.

The use of this model for any military aircraft is questionable since through life upgrades result in well mixed age populations of components in a fleet. The avionics might be 20 years younger than the airframe, portions of the engines might be 20 years younger, etc.

The use of this model for the F-111 is technically quite wrong. The F-111 does not meet the two basic preconditions for the use of the compounding cost approximation – while genuine problems arise with determining a suitable 'baseline' cost for projecting forward to a future cost.

In terms of determining a period of stable configuration and costs, the last four years are simply unusable. During this period the maintenance regime on the aircraft changed, with Boeing taking over depot support, a revised fuel tank sealing technique was adopted, the fleet was subjected to a wing replacement and rewiring program, and a large backlog of deeper maintenance tasks accrued during the late 1990s including Cold Proof Load Tests had to be cleared.

As a result the last several years were not a period of stability in the aircraft's configuration, or indeed in its maintenance regime. Consequently any compounding cost or uncorrected 'bathtub curve' model would overestimate the cost of operating the aircraft due to an unsuitable baseline – assuming the F-111s were maintained in the manner of an airliner.

However, the compounding cost model collapses completely once the aircraft is subjected to an 'ageing aircraft' engineering program in which components approaching wearout are wholly removed from the fleet, in scheduled block replacements. The effect of this is illustrated in Figure 1, which compares a 5% compounding cost model, a corresponding 'bathtub curve' wearout model, and a 'bathtub curve' model adjusted to account for block replacements of worn out part populations in the fleet at five year intervals – a reasonable number in this case since the Amberley Block Upgrade Program sits at depot cycles of similar duration.

In terms of applying basic reliability theory, the Defence bureaucracy misused the compounding cost model, evidently by failing to understand the mathematics underpinning it.

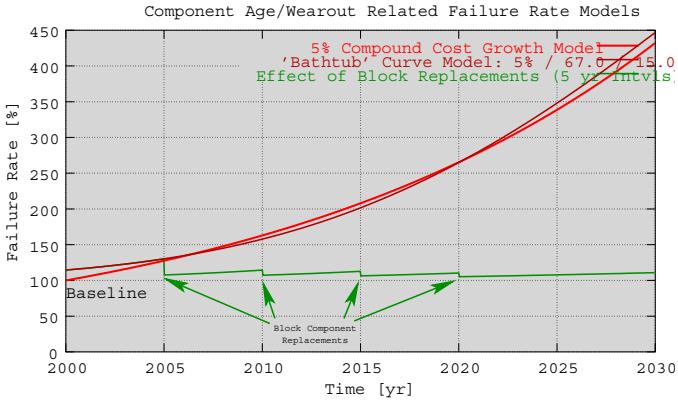
The miscalculation however runs much deeper, since the policy adopted in recent years at Amberley has been to replace where possible worn out components using parts with better basic reliability and often durability. Therefore the actual reliability will over time improve relative to the 'sawtooth' curve of the block replacement model – and engineering costs will reduce.

The existing program of block upgrades also sees older avionics progressively replaced with more reliable new hardware, further driving down support costs. As the Defence bureaucracy has not published any hard numbers for its projected future costs, we do not know how far its estimates departed from observable reality – we can presume that departure was great enough to compel the Defence leadership to push for early retirement.

It is not widely known that the basic annual cost of supporting the airframe and systems is only a modest fraction of the total cost to operate 82WG and the Amberley base. Boeing's WSBU contract is of the order of $50m annually, and the RAAF Engine Business Unit (EBU) costs around $20m annually. With the other contractors supporting avionics and other components, the total annual engineering costs sit around the $100m mark on published data. Even a doubling of this annual cost is not a dominant fraction of the annual cost of operating and maintaining the fleet, itself around 3% to 4% of the annual Defence budget. These numbers fit reasonably closely with statistical data gathered in the US over recent years – the cost of engine maintenance in older aircraft is often up to 50% of the total bill.

In this respect, the work done by the Amberley EBU and DSTO on improving TF30 engine durability and reliability has been remarkable. From an annual operating cost around $30m pre-1990, the current annual cost of around $20m is a 50% improvement, and forward projections are close to $13-15m annually in the 2010-2015 timescale. Given that engine support cost

This chart compares failure rates corresponding to the 5% compounded cost growth model against a raw 'bathtub curve' model, and a 'bathtub curve' model adjusted to account for block replacements of worn out parts – the maintenance model used on the F-111 in recent times. The 5% compounded cost model grossly overstates long term costs against the characteristic 'sawtooth curve' seen with block replacements. (Author)



growth has dominated US operational aircraft fleet operating cost increases, the DSTO/EBU effort is world class. Clearly engine operating costs for the F-111 are steadily declining.

Last August's F-111 Ageing Aircraft Forum detailed the now well established trend to a reduction in aircraft support costs longer term. Evidently the findings of this F-111 engineering conference were not read in Russell, as the public admission on the use of the compounding cost model demonstrates.

What is abundantly clear is that the advice to Cabinet predicting a significant rise in F-111 operating costs post 2010 is not supportable by fact, and certainly not supportable by the compounding cost model used last year.

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F-111 READER LETTERS

Last issue we asked our readers for their opinions on the Defence Department's decision to retire the F-111s early. Here are some representative responses:

I read with interest Recce, Analysis, and Defence Update in the Jan/Feb 2004 edition of AA. Carlo Kopp's writings and analysis makes sense and poses, to date, many unanswered questions that the Department of Defence needs to address and publicly reply to. Whether it will or not remains to be seen, particularly given the endless behind the scenes attempts to ground the F-111 that have dogged this aircraft for decades.

As a taxpayer I want to know why assets that I have a financial interest in may not be being utilised to best advantage, and worst of all are going to be retired prematurely and possibly leaving gaps in our defence capability. To draw analogies from the USAF's retiring of its F-111 fleet and applying this to the RAAF's situation is shear folly. The RAAF is not the USAF any more than Australia is the USA. The USA has a totally different fiscal base to work from and can arguably afford to retire defence assets early as they have other aircraft, in this case, that can perform the same or similar roles with commensurate capability and outcomes. The RAAF, in this instance, does not.

The F/A-18 is not an F-111 replacement any more than it is a B-1, B-2, or B-52 replacement. If the matter was so simple the USAF may well do away with its strategic strike fleet and replace that capability with F-15Es, F-117s, et al. I will not get into the AP-3C debate as in this context it appears to be window dressing and a band-aid solution at best.

Do we want our military to be strategically and tactically impotent, of little relevance internationally, and hard pressed to be able to perform anything more than domestic flood and fire relief, let alone defend its homeland or effectively participate in an international war or peace keeping force?

Bruce R Kendall
Ballan, Victoria

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I was impressed with the pro F-111 arguments in the article 'Taking the Force out of Air Force?' However it is apparent that the motives behind the decision to retire the aircraft early are best summarised in the article's closing paragraph – that the RAAF will become an organisation "suited primarily for second tier support roles..."

I would imagine that to the bureaucrats and several senior military officers, having a second tier capability is an excellent 'low risk/high profit' scenario. The Iraq war showed how the RAAF's second tier role could be seen by some as a 'win-win' result; the RAAF crews excelled at their assigned taskings (a morale boost for the troops), no casualties were sustained in any high risk endeavours (casualties are almost inevitable with sustained F-111 missions and are bad for public morale), and the government got significant brownie points with our powerful allies, which are now being used in trade talks and strategic foreign policy initiatives (not to mention a visit to Australia by the US President).

Why bother having a 'strategically capable' Air Force if a 'second tier' option will do, especially when the government seems to have made the decision that Australia will never be required to undertake a strategic air campaign independently of American capability?

History will tell if it is the right decision or not.

Jason Byrnes
Canberra

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I am seriously disappointed in the ADF for its lamentable lack of foresight in deciding to withdraw the F-111s. They remain, without exception, the best tactical strike aircraft in the world. Carlo Kopp's article in the Jan/Feb issue pointed this out quite clearly.

Over the last few years I have seen several decisions which I believe were the wrong choice – mainly, decided using the wrong criteria. To see such important matters decided on such short term and changeable issues is really disappointing.

If such matters continue, Australia will simply cease to be a relevant force in the region. Already the ADF is having terrible troubles with manpower. If we have inferior equipment as well, what is left? We will end up relying on other countries for our defence. I for one would be loath to see that happen.

Michael Angelico
Melbourne

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I fully agree with the comments made by Carlo Kopp in his articles in the last issue of *Australian Aviation*.

In an uncertain world, can someone please explain to me how on earth Australia stands to benefit by retiring about half of it's Air Force's strike capability?

I would have thought the Royal Australian Air Force would want to at least maintain or preferably advance its capabilities, not significantly reduce them. The assertion that arming the F/A-18 Hornets and AP-3C Orions with a standoff missiles and the introduction of the new aerial tankers will restore the firepower lost when the F-111s go does not stand up to scrutiny.

The point of view that appears to have made the difference with the retirement is that the F-111 is old and may fall apart. This clearly is not the case and as pointed out in your article, there are plenty of reasons to believe the F-111 can be maintained for a long time yet.

It is also quite obvious that the F-111 is a cheaper aircraft to operate in many scenarios than the F/A-18 Hornet or any other light fighter/attack aircraft. I would be very interested to see figures of how much it cost for each bomb dropped by our Hornets over Iraq, factoring in inflight refuelling and all other costs, compared to an F-111 tasked with doing the same job. Can we get these figures?

I am reminded of the photographs I have seen of our F/A-18 Hornets during the Iraq campaign. They are loaded primarily with drop tanks for extra fuel as their range on internal fuel is very poor compared to the F-111's. The Hornet's ability to carry weaponry pales in comparison with the F-111's ability.

The F-111 is a unique aircraft and we should be keeping this plane and updating it as required for as long as possible. The F-111 has the range and payload that no other aircraft available to us has.

Wayne Charters
Baulkham Hills, NSW