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RAAF Aerial Refuelling Where To Next?

This year will see a decision to purchase aerial refuelling tankers as replacements for the RAAF's four decidedly aged Boeing 707-338C tankers.

While senior defence personnel have made much of the value of project Air 5402 in various public comments of late, particularly in reference to new tanker's ability to help bridge the gap following the early retirement of the F-111, the reality is that aerial refuelling will remain as perhaps the greatest single capability gap in the RAAF force structure. With the now stated intent to retire early the long range/long endurance F-111s without replacement, Defence's lack of serious investment in an operational aerial refuelling capability is perplexing – it raises genuine concerns about the future of air power in Australia.

On the global scene we are seeing the initial steps in what is termed the 'recapitalisation' of aerial refuelling fleets in leading western air forces. The US Air Force has taken the first step with its plan to lease 100 KC-767A tankers as interim replacements for the oldest KC-135Es, a plan subsequently bent into a split hire/purchase deal by legislators unhappy with the leasing model (but currently on hold due to a US DoD investigation into ethics at Boeing). Britain is looking at a large scale replacement of its fleet of well used VC10s and TriStars, while Italy and Japan have ordered KC-767 variants to rebuild their force structures. These developments are taking place during a period of a significant downturn in airline activity, and an unprecedented glut in cheap used airliner airframes, which even the growing air freight market cannot absorb.

The Iraq campaign of March 2003, was a somewhat rude surprise for all western air forces, insofar as the shift to persistent strike operations, often termed 'killbox interdiction', saw the demand for aerial refuelling soar well above any previous air campaign. Typical fighter sortie lengths grew from two to four hours during the Cold War era to much longer six to 12 hour sorties. In turn, the demand for tanking almost doubled – clearly evident in the CENTAF report statistics published after the campaign. The rule of thumb ratios for fighter to tanker numbers in force structures were effectively halved. In campaigns where persistent strike against mobile targets dominates operations, typically one KC-135R sized tanker is required to support two to three fighters in combat.

Regionally, we are seeing 800nm (1480km) class Su-30 fighters being purchased in respectable numbers by Malaysia, Indonesia, India and China, most of these aircraft are equipped with retractable aerial refuelling probes. India has taken the lead in regional tanker acquisitions, with the de-

The four Boeing 707-338C tankers were acquired to provide a 'training and limited operational capability'. The planned replacement fleet of similar sized 767 or A330 aircraft will provide only an incremental gain in total fleet fuel offload capability, yet is now seen to be a full operational capability. (RAAF)

The regional strategic environment is shifting, with the first Ilyushin Il-78MKI Midas tankers delivered to the Indian Air Force. India has been the 'trend setter' for Asian buys of Russian equipment, and we can expect a series of copycat regional buys over the coming decade, as observed with Su-30s and AEW&C aircraft. (Indian Air Force)

livery of its first batch of Ilyushin Il-78MKI Midas tankers from Russia. Historically China has followed India by acquiring like Russian aircraft to match capabilities, and the saga of regional 'me too' Sukhoi and A-50 AEW&C buys indicates that more Ilyushins are likely to appear across the region over the coming decade. The only constraint to regional growth in fighter, AEW&C and tanker numbers will be funding.

In the face of these global and regional developments, Defence's adherence to buying just four or five tankers is peculiar, but not surprising given the arguments put forth to support the case for RAAF combat fleet downsizing by early F-111 retirement. What is clear is that the current plan for the RAAF will see it progressively sink in relative force capability against the region.

How Many Tankers are Enough?

A question recently raised by a Parliamentary Committee in Canberra, and not answered by the Defence attendees on the day, is that of how many tanker aircraft the RAAF should be operating. This issue has been argued repeatedly, sadly to no avail given statements emanating from the Department in recent years. Evidently four to five tankers is the 'correct' number and the surrounding strategic environment must be made to fit this number.

How should we best estimate what number, and indeed what size of tanker aircraft the RAAF should be operating? Several models can be applied, and not surprisingly, none of these models say four to five medium sized aircraft.

The baseline for most force structure sizing models is the basic 'medium size' tanker typified by the Boeing KC-135R. The aircraft has a design payload just under 40 tonnes, and is essentially a dedicated narrowbody 'fast tanker'.

Rule of thumb sizing models are valuable since they are derived from gross air campaign statistics. Therefore they factor in the realities of aerial warfare – fighters burning more gas than planned for, fighters arriving late on station, tankers being diverted to cover unplanned for offload demands, airborne 'hot spare' tankers and the reality of chaos in the battlespace, whereby unanticipated enemy actions force unplanned changes to operations with all of the consequences this has for operational planning.

Not surprisingly, taking a set of fuel offload curves for a tanker and cruise fuel burn figures for a fighter always yield optimistic numbers against the rule of thumb estimate. This will become apparent to any observer who performs operational analysis modelling of tanker demand – the basic analytical method sets a lower bound on demand.

Prior to the advent of the persistent strike techniques, the gross statistics available from Desert Storm and Allied Force indicated that a single medium sized tanker was required to support four fighters, regardless of fighter type. This should not come as a big surprise since the cruise fuel burn of most fighters averages out around 2.7 tonnes (6000lb)/hr – dominated by drag, the additional external tanks carried by small fighters tend to drive their fuel burn up into the same bracket as the F-15 and Su-27/30 series – or indeed the F-111. The statistics for Allied Force were most interesting as the ratio was almost exactly 4:1, and this campaign saw limited refuelling of heavy aircraft as the ranges to targets from European NATO bases were very modest.

Applying this metric to the current RAAF force structure with around 100 combat aircraft, we end up with about two squadrons of 12 to 13 KC-135R sized tankers. This is not an unreasonable number insofar as it accords well with the results of offload simulations performed in 1999 to establish how many tankers were required to cover regional targets from northern Australia, using a strike force of around 60 aircraft – and with no persistence over the target.

The CENTAF report detailing statistics from Operation Iraqi Freedom graphically illustrates the growing demand for aerial refuelling which results from persistence over the battlespace. Crunching these numbers down shows a ratio closer to 2.5:1 between fighters and tankers. The doubling of typical fighter sortie durations, with most fighters loitering with draggy payloads of bombs, accords well with the gross statistics. Twice as much time on station demands twice as much offload from the available tankers. Unlike the 'classical' model during which fighters spend roughly equal time outbound and inbound to targets, burning more fuel due to stores drag outbound, the current persistent strike model sees perhaps 2/3 to 3/4 of the fighter sortie duration spent in a higher fuel burn regime due to loiter with yet to be expended stores.

Applying this raw metric to the current RAAF force structure model indicates that around 40 tankers would be required – or three overstrength squadrons each with 14 tankers. The implicit assumption is that all RAAF fighters would be applied to combat ops, and all would be flown in a persistent regime of operations. In practice, such persistent strike operations would only be localised, so the actual ratio would fall in between two and three squadrons.

The statistics from recent US led campaigns are directly applicable to Australia's strategic environment as the key factor – distance between basing and targets – is similar. The statistical distribution of distances from Darwin/Tindal to major regional airfields shows peaks at 1200 and 2200nm (4075km). While Learmonth provides a useful range advantage into the region, against Darwin/Tindal, its remoteness currently presents issues for resupply of fuel and other stores in sustaining high intensity operations.

The RAAF is now well on track to a force structure of 70 combat aircraft rather than 100 – the prospects are very good that the removal of the F-111 will see the future JSF fleet buy numbers adjusted down to match then current fleet numbers. If we scale down the number of tankers required, what we get is between 17.5 and 28 medium sized tankers.

What other models can we apply to estimating a proper size for the RAAF's tanker fleet?

If we look at putting up a strike package to 2000nm (3700km), with 24 F/A-18A or JSF aircraft (12 bombers, six strike escorts, and six to cover the Wedgetails and tankers), using tanker offload curves we end up with around seven tankers including an airborne 'hot spare' and no allowance for on station loiter. Two packages drives this up to 14 tankers. If we want to maintain a reserve of tankers at Darwin/Tindal and Learmonth to support defensive fighter CAPs at these bases, on demand only, we end up with at least four more tankers, as a spare will be required at each of these bases. The total comes in at 18 tankers. If we plan around having defensive CAPs airborne at Learmonth and Darwin/Tindal, or any significant loiter over the target, then we can start adding additional tankers into the model.

It takes very little to show that the rule of thumb tanker fleet sizing models hold up quite well against a basic operational analysis model using hard numbers for tanker offload performance and fighter cruise fuel burn. If we relax the striking radius distance numbers, and add commensurate loiter time over the target, the numbers change very little.

Can we apply scenarios other than strike operations into the region? One example scenario is placing continuous fighter patrols over the North West Shelf, Timor Sea and Darwin/Tindal areas to defend against a cruise missile strike. While JORN will provide excellent early warning of an outbound strike performed with fighters/bombers carrying cruise missiles, it cannot warn effectively against submarine launched cruise missiles. Even with JORN early warning, the reality is that successful intercepts will require early engagement of inbound cruise missile shooters – launching interceptors, Wedgetails and tankers on initial early warning becomes a race against time to get to the inbound shooter before it can release its missiles.

If we take 1000nm (1850km) as the baseline distance for this 'high noon' cruise missile shooting/interception game, the interceptor/AEW&C/tanker package travelling at similar speed to a Sukhoi Su-30 heading in the opposite direction needs to launch at exactly the same time to meet in the middle. Since targets of interest such as gas/oil platforms and onshore processing plants sit in between Learmonth/Darwin/Tindal and regional airbases, and there will be an implicit delay in identifying a JORN track as an inbound shooter, the reality is that standing airborne CAPs will be required. Lets assume the CAP orbits around 450nm (830km) out from an RAAF runway, and let's assume four hours on station and two hours for transit. Four fighters and a medium sized tanker will together burn around 16.3 tonnes (36,000lb)/hr on station, in four hours burning off around 65 tonnes) (144,000lb) of fuel – leaving a typical medium sized tanker with about nine to 14.5 tonnes (20,000 to 32,000lb) of spare gas to cover for combat burn by fighters.

To do this will require at least three tankers per CAP station – one spare on the ground and two swapping stations to support the CAP. In practice the three tankers would be continuously rotated through the CAP station. If we assume three CAP stations to cover the three most target rich sectors in the deep north, we end up with a bare bones minimum of nine tankers. Upping the size of the CAPs scales tanker numbers proportionately – CAPs of eight fighters each pushes tanker numbers up to 18 aircraft. If the RAAF is to concurrently fly any long range strikes of useful magnitude, the numbers again push out to 24 or more tanker aircraft.

Another scenario which is not unreasonable is the US 'Noble Eagle' model of providing CAP cover over major cities to defend against hijacked kamikaze airliners. While the risk of a domestic hijacking is relatively low due to good security in Australia, the same is hardly true of regional nations. Therefore a September 11 event in Australia is not outside the bounds of possibility.

Assuming that an airliner is hijacked and flown south to hit a target in Australia, there is a finite time window for an intercept determined by the fuel payload of the hijacked aircraft. This indicates that CAPs need only be airborne for several hours. However, if we make the assumption that all capitals need to be covered, and one each spare tanker is kept on the ground, the baseline number ends up being yet again of the order of 15 tanker aircraft.

The F-111 has in many respects been a critical asset for the RAAF as strike profiles to 1000nm (1850km) would see tanking used primarily by the F/A-18A escorts supporting the aircraft. Analysis (refer Jan/Feb AA) indicates that removing the F-111 from the force structure requires of the order of 15 tankers alone to make up the difference in aggregate fleet payload/radius performance, or 'throw weight'. It is worth noting that using the F-111 (which can carry the AIM-9 Sidewinder) rather than the F/A-18A in the 'Noble Eagle' model permits defensive CAPs to be flown without tanker support.

What is the impact of tanker size in this equation? The two current Air 5402 candidates, the KC-767 and A330-MRTT, are both medium sized tankers, the 767 providing around 10% more offload than the KC-135R, and the A330 around 20% more, making reasonable assumptions about the profile. The only other credible current production widebody airframe with a prior tanker conversion design is the 747-400, which comes in at around twice the offload of the medium class tankers, or more with lower deck auxiliary fuel. With around twice the cruise fuel burn of the medium class candidates, the 747-400 would roughly halve crew and airframe numbers to meet the same offload requirements.

In the balance, the faster and larger 747-400 works better for scenarios biased toward long range strike profiles, whereas the smaller and slower 767/A330 options work better for scenarios biased toward the 400-500nm (740-925km) CAP station orbit model. This is because the 747-400 has more gas to offload at long range, and its higher cruise

By far the best bang for buck offering in the used airliner market, Special Freighter conversions of used 747-400 passenger transports are now selling in the $US50 to 60m price bracket. A tanker conversion of the 747-400 using either the KC-767A or A330 MRTT refuelling packages could deliver more than twice the offload of the twin engine bids.(Boeing)

The A330 MRTT (above) and KC-767A (below) are conversions of the current late production variants of the A330 and 767 commercial airliners. With a range of configurations possible, including booms, fuselage hose drum units, and wing mounted pods, these aircraft are direct equivalents to the established KC-135R/T Stratotankers. While slower than the KC-135R, the newer widebodies are much more capable in the supplementary airlift role, and cheaper to operate with only two engines. While the Boeing offering has the advantage of a much more mature aerial refuelling package design, the Airbus offering can offload slightly more fuel, runways permitting. (EADS & Boeing)

speed does not impose speed restrictions on a strike package – the slowest aircraft in a package limiting its transit speed. As a result slower tankers on long range profiles keep the whole package airborne longer, which statistically impairs force productivity. In shorter ranging scenarios with smaller numbers of fighters, the higher fuel burn of the 747-400 favours the smaller tankers.

What does this all tell us? No matter what models we apply, it is clear that four to five medium sized tankers is not enough, and is not supportable by any type of analysis. It covers perhaps 20% of what would be required in any ‘real world’ defence of Australia scenario.

Tellingly, the Defence Materiel Organisation’s website tacitly admits that the tanker project does not aim to purchase enough tankers to meet the number that would be required for real operational scenarios. “Since the early 1990s, the Royal Australian Air Force (RAAF) has operated four Boeing 707s as tanker aircraft to provide *a training and limited operational capability*,” says the website’s brief on Air 5402. “The aircraft were modified for air to air refuelling under Project Air 5080 by fitting two wing-tip mounted refuelling pods to refuel probe equipped aircraft such as the F/A-18. Due to issues associated with continuing to support the ageing B707 fleet, Air 5402 seeks to *replace and enhance* the air to air refuelling capabilities of the Australian Defence Force (ADF).”

So Air 5402 only aims to “replace and enhance” the RAAF’s current “training and limited operational capability”.

Assessing Air 5402

Air 5402 has had a long and somewhat convoluted history. Initiated during the late 1990s, the program started out essentially as a tradeoff study between the choice of extending and reengining the existing 707s, or acquiring used 767 or A330 airliners for conversion into tankers. Considerable effort and investment was made into these studies in the 1998 to 2000 period. Part of this study included a survey of ageing aircraft issues, and a detailed corrosion and fatigue study of the 707 fleet (refer AA March/April 2001 – also http://F-111.net/CarloKopp/).

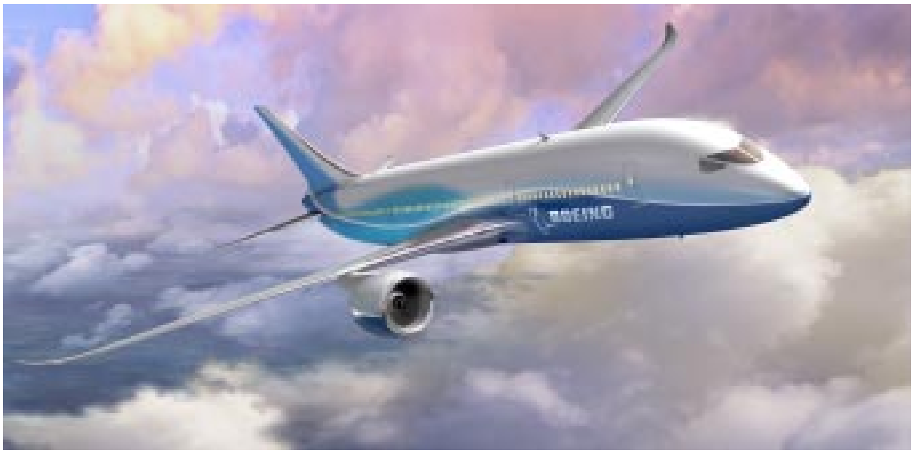
The findings of this effort were most interesting. Used airliners of seven to 10 years of age were identified as being the most economical basis for tanker conversion, compared to new build aircraft. Tankers were typically found to run out of airframe corrosion life well before they ran out of airframe fatigue life, reflecting the relatively low flight hours of tankers against their airline operated siblings. The corrosion problems seen with the US Air Force KC-135 fleet and the RAAF’s 707s, while in part attributable to the absence of ageing aircraft programs in their earlier service histories, reflect the reality that airliner class airframes not subjected to the kind of deep overhauls done on tactical airframe tend to get into difficulties at around the 30 to 35 years of airframe age mark. With a proper ageing aircraft program introduced early enough in the life of the airframe, to pre-empt and/or manage corrosion, significantly greater airframe service life could be achieved – evidenced by US Air Force plans to fly B-52H and B-1B bombers into the 2040 timeframe.

The economics of tanker fleet operation are not driven by airframe maintenance alone. Recent studies into ageing aircraft problems carried out in the US by the Air Force and Navy indicate that the single biggest cost factors in older aircraft are engine maintenance costs and obsolescence of unique parts. The US KC-135 fleet rode on the back of the retiring 707 fleet, seeing large numbers of common components and JT3D engines cannibalised. The exhaustion of this pool of cheap spares is in part driving the current plans to replace the JT3D powered KC-135Es. The KC-135 is an interesting case study in that it has spent much of its service life to date feeding off the commercial 707 fleet, which resulted in exceptional economies of scale in spare parts.

After 2001 the Air 5402 program shifted into the acquisition phase, and primary responsibility moved to the Defence Materiel Organisation. During this period Air 5402 changed fundamentally, abandoning the model of buying cheap used airframes for conversion to tankers, and firmly espousing the idea of new or near new build tankers. The two principal contenders are bidding new aircraft. During this period the allocated budget for Air 5402 nearly doubled.

The histories of the US KC-135 and KC-10A raise some very interesting questions about the economics of new build 767 or A330 tankers over their life cycle. We can assume that the RAAF will exploit much of the ageing aircraft expertise gained on the F-111 program and apply this to the new tankers. It is reasonable to surmise these aircraft will remain in service for 40 to 50 years post delivery. At some point, perhaps 20 to 25 years into their life cycle, they would be re-engined to avoid obsolescence and improve operational economics.

Experience in the US with both the 20 year old KC-10 and 40 year old KC-135 suggests that the collapse of the parallel commercial fleets has had a large impact on operating costs, especially due to the rapid increase in the prices of high consumption spares. Commercial airliner fleets typically begin to contract around 15 years after the cessation of production for a type, reflecting largely the economics of operation. This should come as no surprise, as the economies of scale in 'cottage industry' manufacture of consumable spares cannot compete with full scale production operations, unless consumables are ordered in large batches.



Planned as a higher performance successor to the 767, the 7E7 Dreamliner is a much better fit to the tanking role than the 767 is, as it is faster and longer ranging. If the aim of the Air 5402 program is to maximise the longevity of the investment, holding off a few years until a 'KC-7E7' or its Airbus equivalent could be bid makes sense. (Boeing)

Were the 767 and A330 at the beginning of their respective production life cycles, the RAAF could be assured of production lives of 20 to 30 years and commercial fleet lives of around 35 to 45 years. During these parallel tanker and commercial fleet life cycles the RAAF could repeatedly borrow avionics, engine and system upgrades designed for the commercial fleets, at very economical costs. Pushing an engine upgrade into the 25+ years of life period would ensure that the fleet would remain relatively economical to operate past the 40 year mark (as evidenced by the almost 100 CFM56 re-engined DC-8-70 freighters).

However, the 767 in particular is in the twilight of its production life cycle (witness Boeing's decision last year to axe the concurrently developed 757). Boeing's new 7E7 Dreamliner – actually a better design for a medium tanker transport as it is faster, more fuel efficient and more voluminous – is apt to displace the 767 in commercial fleets from the end of this decade. To remain competitive in this niche, Airbus may have little choice other than to replace the A330 early in the next decade with a 7E7 clone, again faster and more fuel efficient than the A330.

As a result the commercial fleets of 767s and A330s are likely to start contracting after 2020-2025, driving up costs for all remaining operators of 767 and A330 fleets. The US Air Force KC-767A build may be the last large block of 767s made. As a result the cost advantages in operating new build KC-767s may drop off quickly in the 2020-2025 period, and A330s five to 10 years later, which would start to nullify the additional investment in new build jets.

The rationale is much better supportable were the basic airframe a new 7E7 or its yet to be defined Airbus equivalent – both would be better tanker airframes than the current Boeing and Airbus offerings. While this would necessitate stretching the 707 fleet a little further, or leasing gap fillers, the cost penalty is trivial against the very long term impact of a repeat tanker fleet replacement cycle in the 2025 timeframe.

Other interesting questions arise from the abundance of used widebody airframes. In November 2003 there were no fewer than 28 747-400s and 69 767s in storage, many of which are late build variants suitable for conversion. Freighter conversions of used 747-400s are now being sold for a mere $US50m-60m, making for a tanker transport at around $US80m to 90m each – compared to the order of magnitude $US100m+ unit cost of new build and much smaller KC-767 and A330 tankers.

Were the original Air 5402 plan to have been followed and used airliners converted to tankers, significantly more aircraft could be bought for the same total investment. While Boeing or EADS would have to forgo profit margin on the new airframes, the odds are this would be made up on aerial refuelling equipment and conversion/refurbishment costs. But this now won't happen as the Department has committed to new build airframes. If bang for buck really mattered in the Defence bureaucracy, used and relatively young 747-400s with over twice the fuel offload each compared to twin engine medium tankers would be at the top of the Air 5402 shopping list.

What is clear is that Air 5402 is not structured around strategic needs for aerial refuelling capacity, or tanker fleet longevity/economics, or even short term acquisition costs.

If maximising fuel offload out of the current budget came first, we would see used 747-400s being bought up and tenders out for conversion of these into tankers, fitting as many systems into the available budget as possible. Were acquisition cost minimisation the aim, then the tender would have been for the conversion of used 767s or A330s into tankers. Were fleet longevity the aim, then Air 5402 delivery would be deferred and the shortlist based on a KC-7E7 and its future Airbus sibling.

Where does this leave the Australian taxpayer? Much less bang for buck will be the direct consequence of the Air 5402 program being implemented in its current form.

An issue which is yet to be addressed in planning for tanker operations is provision of a sustainable fuel supply infrastructure for replenishing our northern bases. A single medium sized tanker will use around 90 or more tonnes of avtur per sortie – at any reasonable intensity of operations hundreds of tonnes would be consumed daily. Attempting to resupply by tanker truck is simply not feasible. While Tindal now has a nearby rail connection, Learmonth (pictured) does not. A future Analysis will explore this issue in further detail.