HUG at the core of RAAF ‘capability gap’ concerns?

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Confidence within the RAAF of its ability to sustain the schedule for its extensive program to upgrade the air combat capability of the current F/A-18A ‘Hornet’ fleet suffered a blow last November, with the announcement that efforts to advance an indigenous electronic warfare (EW) upgrade to the aircraft based on the BAE Systems ALR-2002B had been cancelled, and instead, the Air Force would move forward to acquire an imported, off-the-shelf solution - via Raytheon’s ALR-67(v)3 radar warning receiver – for fitment to the F/A-18A fleet from 2008 under phase 2.3 of project Air 5376.

Trevor J Thomas/CANBERRA

More critical to the ‘Hornet’ life extension program, however, is the effective management of the aircraft’s structural fatigue. The Hornets were originally designed and manufactured by McDonnell Douglas (since acquired by The Boeing Company), to a US Navy specification with a structural fatigue Safe Life of 6,000 airframe hours of US Navy usage.

Similar to other fighter aircraft, the ‘Hornet’ has since been found to suffer from fatigue cracks that increase in size and numbers as load stresses are applied during flying operations.

The Royal Australian Air Force’s (RAAF) current Hornets began service in 1985, under an interim structural Safe Life pending an assessment of the RAAF operational environment. Early assessments by Air Force and the Defence Science & Technology Organisation (DSTO) identified significant differences in usage type and severity between RAAF and US Navy ‘Hornet’ operations.

Consequently, in the mid-1990s, Australia and Canada commenced an International Follow-On Structural Test (IFOST) program, with the aim of achieving improved Safe Life management of their ‘Hornet’ fleets.

The IFOST results, based on centre fuselage, aft fuselage and wing structural fatigue tests and evaluations, confirmed that the RAAF’s Hornets would require major mid-life structural refurbishment and modifications to maintain safe operations until their planned withdrawal date of 2012 to 2015.

The investigations also confirmed the need for careful management of Fatigue Life Accrual Rates and Fatigue Life Expended Indices for each RAAF ‘Hornet’ aircraft. A methodology known as the Fatigue Life Expended Index (FLEI) is used by Defence to measure the proportion of the certified structural Safe Life of the aircraft which has been consumed.

A FLEI of 1.0 normally indicates that an aircraft has accumulated fatigue at the outer limit of its Safe Life range, where modelling fatigue testing and associated analysis deem the aircraft to be airworthy. FLEI consumption greater than 1.0 may require an aircraft to transition to a ‘Safety by Inspection’ program or be withdrawn from service.

Key Points

- **The Royal Australian Air Force’s problems** with sustaining its air combat capabilities through to Joint Strike Fighter introduction have not all been solved with a move to acquire 24 ‘Super Hornets’.
- **Behind the scenes, a series of issues** with the current F/A-18 ‘Hornet’ upgrade (HUG), including a very tight schedule for centre barrel replacements, has Defence planners concerned about overall fleet sustainability.
- **A decision last November to cut its losses** - in terms of the development of an indigenous radar warning receiver project as part of the current HUG - has dented Government confidence in such projects, when compared to off-the-shelf purchases of new aircraft.
- **Any significant difficulties with phase 3 of the HUG** over the next five years - due to cost, schedule or technical reasons - might see the Government in a similar situation to that in which it has just found itself with the F-111, and opting to order additional Super Hornets.

Since 1985, the Department of Defence has engaged contractors to produce monthly and quarterly ‘Hornet’ fleet fatigue consumption reports for the RAAF’s Air Combat Group (ACG) and Directorate General Technical Airworthiness which, amongst other things, provide an analysis of each aircraft’s structural fatigue accrual.

The reports are used by the ACG to ensure ‘Hornet’ fleet Fatigue Life Accrual Rates are maintained within agreed limits. Each ‘Hornet’ has a data recording system which measures both flight parameters and loads on the aircraft continuously throughout its life, with the RAAF maintaining it holds valid records for each of its ‘Hornet’ aircraft from their introduction into service to the present day.

A recent Australian National Audit Office (ANAO) report looking into the ‘Management of Air Combat Fleet In-Service Support’ tabulated the Hornet fleet’s FLEI as at June 2006, and found (on average) 0.536 FLEI of each aircraft’s structural Safe Life has been consumed.

The ANAO’s investigations also illustrated the FLEI limits beyond which certain structural modifications or refurbishments need to have occurred. Clearly, if such modifications or refurbishments were not carried out, the aircraft would need to be withdrawn from service – a position that would be unacceptable to the Government in the period running up to first introduction of the Joint Strike Fighter (JSF) after 2013.

Structural integrity issues identified and assessed by the 'Hornet' structural integrity management process, combined with an annual 2-3% fatigue life expenditure rate across the 'Hornet' fleet, has led to Government approval of phase 3 of project Air 5376 – more commonly referred to as the Hornet Upgrade (HUG).

This phase is an integral part of the three-phase and $2.92 billion HUG project (involving avionics, radar and other upgrades), which is now scheduled for completion by 2012.

Phase 3 of the HUG aims to provide the RAAF (and ultimately the Government) with assurance that the Hornets will remain serviceable until their planned withdrawal date. The project has two parts: Phase 3.1, which is in its early production phase; and Phase 3.2, which is in its prototype phase. Defence's Tactical Fighter Systems Program Office (SPO) and supporting contractors are also looking to embed in the Australian project lessons learnt from similar US Navy and Canadian Air Force projects, which are currently in various stages of revision or suspension - the former having reduced 2009 CBRs from 45 to 23.

The ANAO says authorities are also seeking to manage the project's risks by using proto-typing and a Low Rate Initial Production (LRIP) approach to acquiring knowledge and industrial capacity to effectively deliver the intended outcomes. Officials have further conceded that Phase 3.2, which is the largest and most complicated phase, faces a highly ambitious production schedule.

The $123m phase 3.1 of the HUG aims to deliver a wide range of safety inspections and some 22 discrete structural modifications to all 71 Hornets. The phase is required to be conducted between 0.53 and 0.60 FLEI on

CASE STUDY: Tapping into the 'sting' of the Super Hornet's tail

Despite selecting rival systems in its quest to upgrade the McDonnell Douglas (now Boeing) F/A-18A/B 'Hornet' to extend its operational life-time through to 2015, a risk mitigation strategy associated with the Government's decision to buy 24 Block 2 F-model Super Hornets brings them readily packed with a whole range of weapons not previously preferred for the Royal Australian Air Force.

Canberra Bureau Report

In the aftermath of Defence Minister Nelson's announcements regarding Australia's 'Super Hornet' purchase, the Department of Defence – under phase 2 of Project Air 5349 - will now proceed to acquire Raytheon's AIM-9X 'Sidewinder' air-to-air missile, which originally lost out to the MBDA AIM-132 Advanced Short Range Air-to-Air Missile (ASRAAM) in the earlier concluded project Air 5400.

Also coming on-board the new F/A-18F Block 2 (B2F) is Raytheon's ASQ-228 Advanced Targeting forward looking infra-red pod (ATFLIR), which similarly lost to the Northrop Grumman/Rafael AAQ-28(V) 'Litening AT' in phase 2.4 of Project Air 5376.

Yet another Raytheon weapon capability in-built on US Navy Super Hornets is the AGM-154 Joint Stand Off Weapon (JSOW), which although not in the bidding for project Air 5418 (due to non-compliance with RAAF range requirements), is now the subject of a range extension program that will ultimately make it competitive with the successful Air 5418 tenderer - Lockheed Martin's AGM-158A Joint Air-to-Surface Stand-off Missile (JASSM).

All these weapons, when combined with the ATFLIR advanced targeting pods, will provide a substantive improvement to the combat effectiveness of the Australian B2F fleet (*see story page 9*), which by 2010 will constitute the Royal Australian Air Force's (RAAF) Bridging Air Combat Capability (or BACC) solution.

According to officials, and in order to mitigate project risk, the selectionof weapons for the RAAF's Super Hornet's has necessarily had to mirror exactly the existing capabilities of the US Navy to ensure there are no cost over-runs or schedule slippages associated with the controversial acquisition.

Customising the B2F with standard Australian systems would nevertheless have been possible, but in reality, would consume valuable time (as well as increase risk) that is just not available if Boeing is to meet the stated RAAF requirement of an in-service, fully operational squadron by end-2010.

Walking hand in hand with the US Navy's weapons strategy will further allow the RAAF to acquire some additional capabilities developed for the 'war against terror', such as the variable warhead options in the JSOW and its stand-off glide bomb capability.

Some of these weapons will also have potential for migration to any latter Lockheed Martin F-35A 'Lightning II' Joint Strike Fighter (JSF) acquisition, particularly the JSOW, which is suitably sized for stealthy internal carriage on the F-35A (JASSM must be carried externally), and the AIM-9X, which will compete with the ASRAAM in the Within Visual Range (WVR) air-to-air missile role given both missiles will be integrated within the F-35A.

The AIM-9X component should only comprise about 2% of overall project Air 5349 expenses, if based on a similar (late-2005) order by Finland for 150 war-shot missiles and 51 training missiles (11 dummy/40 captive), valued at US$100m.

The JSOW weapon provides the newest capability for the RAAF (via its four warhead options and two guidance packages), when combined with the 'gap filling' 126km (70 nautical mile) gliding range. Such capability will provide the RAAF with a viable stand-off attack capability against long-range Ground >30




BACK WITH A BANG - PROJECT LOSERS TO ARM THE B2F: Despite losing to MBDA's ASRAAM and Northrop Grumman's 'Litening AT' respectively in previous ADF competitions to upgrade the A/B Hornets, Raytheon's AIM-9X (far L) and ATFLIR targeting pod (L centre) will equip the RAAF's new F/A-18F Block 2 Super Hornets, as part of a strategy to assure low risk entry of the overall B2F weapon system into Australian service given their already operational status with US Navy systems. Also entering the RAAF's arsenal by stealth as a result of the Air 5349 decision, and due to US Navy commonality, is the modular payload and targeted Raytheon AGM-154 Joint Stand-off Weapon (centre R), now entering a process of evolution to compete with Lockheed Martin's AGM-158 JASSM selected for the RAAF via Air 5418. Facing replacement by the Joint Strike Fighter at mid-life, the ability to morph into an EA-18G 'Growler' electronic attack platform perhaps illustrates the B2F's most lethal potential in terms of its overall impact on the future structure of the Royal Australian Air Force. VENDOR AND US NAVY PHOTOS each aircraft, and its goal is to enable safe operations to 0.72 FLEI. Several additional work packages, known as the HUG 3.2 Delta modifications, are to be incorporated in select aircraft to extend their structural airworthiness through to 0.78 FLEI.

The outcomes of this activity will delay or possibly avoid the need for the major Centre Barrel Replacement (CBR) program proposed for Phase 3.2 of the HUG – an important consideration in regard to project Air 6000 – the mooted selection in 2008 of Lockheed Martin's F-35 JSF to ultimately replace the A/B 'Hornet' fleet.

According to the Auditor-General, Phase 3.1 of the HUG was originally approved in July 2001, at a cost of $45.34m, with implementation to occur between January 2003 and January 2005.

Since then, revised cost estimates and increased work scope have resulted in the Government approving a real cost increase of $69m, thus taking funding approval to $114.34m. Production and installation of the modifications commenced in April 2004, and this is now expected to be completed by August 2011, with project closure expected in 2012. As at July 2006, the Tactical Fighter SPO had spent $87.57m on Phase 3.1, and the project's scheduled completion had been extended from 2008 to 2011. This extension seeks to accommodate other elements of the HUG program (Phase 2.2 and 2.3), whilst maintaining aircraft availability targets.

The Defence Materiel Organisation (DMO) sole sourced HUG Phase 3.1 design, prototype, low rate initial production and modification kit manufacture from L-3 Communications Military Aviation Services Canada (L-3 MAS).

The production installation program has been sole sourced from the Hornet Industry Coalition (Boeing, BAE Systems and Bombardier). The work is planned to be undertaken at RAAF Base 'Williamtown' (NSW), with the exception of the prototype modification installation on one aircraft, which was completed in January 2004 by L-3 MAS in Mirabel, Canada.

The $856m HUG Phase 3.2 involves additional 'Hornet' structural modifications and replacement of each aircraft's centre barrel structure. The centre barrel is the primary load bearing structure in the fuselage, in that it withstands the loads induced by the wings and the main undercarriage. Replacement centre barrels are required to extend the service life of 'Hornet' aircraft beyond 0.72 FLEI, or beyond 0.78 FLEI in the case of aircraft that have received the HUG 3.2 Delta modifications.

The RAAF's lead 'Hornet' aircraft are expected to reach an FLEI of 0.72 in November 2007, and an FLEI of 0.78 in July 2012, at their current Fleet Fatigue Life consumption rate. Aircraft having an FLEI of 0.78 will require centre barrel replacements (or will need to be withdrawn from service), as a safety-by-inspection program involving the

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Based Air Defence (GBAD) missile systems, and without having to expend the more expensive and powered JASSM.

JSOW is a modular weapon made up of three assemblies, which can be joined up as required. Initial guidance is via a highly integrated Global Positioning System/Inertial Measurement System (GPS/IMS) that directs the gliding weapon directly onto the target, or into a nominated target area based on either pre-planned information or in-flight via aircraft sensors or a third-party targeting asset.

To engage moving or complex targets, the AGM-154C guidance system adds an uncooled Imaging Infra Red (IIR) package for precision, autonomous guidance in the terminal phase. Further, a current US developmental program – the JSOW Block III (AGM-154C-1) – will see the addition of a data link in the aft section of the weapon to provide targeting information after launch, and is scheduled for production from 2009. Warhead options include the AGM-154A package of 145 BLU-97 combined effects bomblet submunitions, that have the effect of covering a large area to destroy a widespread target, such as a convoy of soft-skin vehicles.

Even in an age of precision strike, military strategists argue there remains a need for so called "carpet" bombing options, and submunitions which cover larger areas more efficiently than the large-scale use of 'dumb' bombs. Another more sophisticated submunition option is available with the AGM-154B, with its two BLU-108 sensor-fused bomblets for engaging armoured vehicles.

The AGM-154A-1 provides a unitary BLU-111 blast/fragmentation warhead for engaging conventional targets, while the AGM-154C boasts the powerful BROACH warhead that features a 100kg augmenting charge which has the effect of creating a breach in up to 1.5 metres of steel-reinforced concrete for a follow-through 146kg bomb to detonate inside the protected structure.

In a recent development, Raytheon confirmed 21 February that they had tested the engine for a new Joint Stand-off Weapon – Extended Range (JSOW-ER) aft unit. Fitted with a data link and a flush inlet design (to retain radar low observability) to a Hamilton Sundstrand 150-pound thrust engine, the new JSOW-ER is expected to provide at least 540km (300 nm) of range, based on combination with the JSOW's legacy gliding characteristics.

ADBR understands the JSOW-ER could enter production in 2011, and if it secures an initial order, would provide to the RAAF a 45% range increase over the JASSM, at 55% of the unit cost, whilst retaining an internal carriage option in the F-35A.

The most transformational weapons capability aboard the B2F, however, is not kinetic (physical impact), but the Electronic Attack (EA) capability of its Raytheon APG-79 Active Electronically Scanned Array (AESA) radar, when combined with its integrated Electronic Counter Measures systems (ie: fuelled by a high-speed fibre optic data bus), Open Architecture software/hardware integration principles, and ruggedised Commercial Off The Shelf computer hardware.

Recent US Navy reports indicate that the F/A-18F B2 will be capable of "extremely significant tactical ranges" in EA utilising the AESA radar to defeat enemy sensors well beyond the ranges of kinetic effectors, such as air-to-air and GBAD missiles (>160km).

This electronic attack capability will give the RAAF its first ever highly aggressive Electronic Warfare (EW) capability, given the previous focus on intelligence gathering and self-defence (ie: Project Air 5077) platforms.

ADBR understands that Boeing Australia is considering next making a case to the RAAF that introduction into service of the the F/A-18F in Australian livery is a natural first step towards acquisition of the EA-18G 'Growler' – a dedicated EA platform shortly to enter service with the US Navy. Australian B2Fs could be relatively simply and cost effectively upgraded to an EA-18G capability, as this aircraft is simply a production Block 2 with additional features.

The EA-18G adds the Northrop Grumman ALQ-218 Improved Capability III (ICAP III) Advanced Electronic Attack system installed on a pallet replacing the gun and two wingtip pods, and wired into to the baseline B2F avionics. The ICAP III system also provides selective-reactive and pre-emptive jamming capability, and electronic suppression/attack against opposition communications.

Fitted with added jamming pods and Suppression of Enemy Air Defence (SEAD) weapons, the EA-18G can carry out stand-off jamming, escort jamming, time critical strike, communications countermeasures, along with conventional kinetic strike and air-to-air missions when functioning as a conventional F/A-18F B2 'Super Hornet'. ADBR

'Bolide' missile as the RBS 70. ASRAD-R can be mounted on just about any vehicle (or as a stand-alone container), and can be remotely operated up to 100m away from the system. Each ASRAD-R system includes four ready fire 'Bolide' missiles, integrated sighting and a search and acquisition system; all gyro-stabilised allowing target search and engagement while moving.

The standard search and acquisition system is the HARD 3-D radar with a 20km range, and ability to track 20 targets and five jammers, and classify helicopters. HARD can, however, be replaced with infrared search systems or another radar like the PSTAR system currently used by Australian Army GBAD troops. Acquiring ASRAD-R as part of an enhancement of existing RBS 70 capability would be one low cost option for Land 19/7. 'Bolide' missiles are designed for a shelf life of 15 years, and this can be boosted to 30 years with a mid-life overhaul.

While the 'Bolide' missile can provide effective air defence, it is nevertheless limited by maximum engagement altitude. Tactical fighters and strike aircraft now conduct air operations from above an altitude of 6.5-km (20,000 feet) to avoid GBAD fires like RBS 70, anti-aircraft guns and other Very Short Range Air Defences (VSHORAD). To engage above this 'trash fire' ceiling (as it is called by the US Air Force), Saab Bofors Dynamics have developed the RBS 70 concept into the RBS 23 or 'Bamse' (Swedish for 'Teddybear' and 'Giant', a popular children's cartoon character).

GIANT TEDDYBEAR SOLUTION: 'Bamse' comprises a radar guided 'Bolide' missile mounted on a booster rocket with an effective engagement range of 20km and up to an altitude of 15km (45,000 feet). The two-stage system provides the high altitude capability and ensures high kinematic manoeuvrability towards the end of flight when the target is engaged. Firing units consist of a Surveillance and Control Centre (SCC), and as many as six (though three is typical) Missile Control Centres (MCC).

The SCC has a 3-D radar mounted on an 9m or 13m high elevating mast to provide long range target detection (up to 100km in range and 20km in altitude) and engagement management. Each MCC can be located up to 20km from the SCC and presents as a towed, armoured, Chemical Biological, Radiological (CBR) sealed, firing unit with fire control system, two operators, embedded simulators and up to six ready fire missiles.

The MCC can be brought into action from movement in under 10 minutes, and all six ready fire missiles reloaded in under four minutes. The Ka-Band fire control radar, supported by a thermal imager and IFF, is on an 8m high mast and can acquire and track targets on its own out to 30km. 'Bamse' is currently being delivered to the Swedish Armed Forces.

One of the other recent GBAD developments, in terms of ADF requirements, is the shift to surface launching of formerly air-to-air missiles like Raytheon's AIM-120 Advanced Medium Range Air to Air Missile (AMRAAM). In such a construct, Lockheed Martin's Network Activated Short Range Air Defence System (NASRAD) combines the AMRAAM missile with a PSTAR radar and an S-Band 3-D Multi-Mission Radar, with a detection range of over 110-km and ceiling of 10-km (30,000 feet) with a command post and network system.

Raytheon's surface launched AMRAAM (SLAMRAAM) combines the missile with the MPQ-64 'Sentinel' 3-D surveillance radar with 75km range, and an Integrated Fire Control Shelter. SLAMRAAM passed its US Army and USMC system Critical Design Review (CDR) stage in June 2006, and is now progressing towards adoption by these services. Utilising AMRAAM for GBAD would provide obvious synergies for the ADF, as the missile is identical to the air launched missile with a slightly different software load.

One drawback is that the engagement range of an AMRAAM missile when fired from a stationary launcher at ground level, is considerably less than air launching. Relative speed to target from a ground launch (compared to an air launch) is also another concern. USMC tests indicate that at a slant range of over 15km, the missile will be coasting in its terminal phase, and may not have enough kinematic performance at high altitude to successfully intercept maneuvering targets. ADBR

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centre barrel is not considered practical.

Phase 3.2 was first approved in October 2003. Subsequently, this phase has been expanded to include more CBRs needed to accommodate possible extensions to the 'Hornet' planned withdrawal date should, for example, the Government not proceed with early acquisition of JSFs, for whatever reason.

In August 2006, the expanded Phase 3.2 received Government approval, thus bringing its estimated cost to between $600m and $856m. The project's final cost, therefore, depends on the extent the CBR program needs to be fully advanced in order to extend the 'Hornet' fleet through to its planned withdrawal date, or any extensions beyond that date.

As of November 2006, Tactical Fighter SPO had spent $58m on HUG 3.2. The CBRs, combined with the other structural refurbishments specified in HUG Phase 3.1, are expected to provide the 'Hornet' fleet with approximately seven additional years of life.

Phase 3.2 modification design, prototype, and discrete modification kit manufacture have also been sole sourced from L-3 MAS. Prototype modification activities commenced in April 2006, and are expected to be completed by July 2007. CBR installations are expected to commence in Australia in October 2007, and to be completed in 2014.

The relatively even distribution of fatigue consumption throughout the 'Hornet' fleet that was illustrated from ANAO analysis, combined with a likely CBR implementation schedule of approximately 13 months per aircraft (during the mature rate production program), suggests the Phase 3.2 program will face extremely demanding implementation schedules, with little capacity to absorb unplanned delays or work scope increases.

Political-level governmental nervousness with the project is, therefore, understandable, and perhaps put the decision to purchase an initial 24 F/A-18F Block 2 Super Hornets in a different light. The Tactical Fighter SPO's first response to such unease has involved mitigation of schedule risks by aligning the Phase 3.2 modifications with Deeper Maintenance service schedules, and by prioritising individual aircraft modifications according to their fatigue consumption.

At the same time, any major (or perhaps wholesale failure due to cost, schedule or technical reasons) of phase 3.2 of the HUG might also leave the Government in a similar situation to that in which it has just found itself with the F-111, and citing uncertainty with the RAAF's confidence in being continually able to fly the aircraft under a comfortable cost and risk profile, has justified the putting into place of a bridging air combat capability solution that is capable of addressing risks with both the F-111 and F/A-18 'Hornet' fleets. ADBR

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