# Submission No 29

**Inquiry into Australian Defence Force Regional Air Superiority**


**Organisation:** **Air Power Australia**

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Joint Standing Committee on Foreign Affairs, Defence and Trade
Defence Sub-Committee

**The.Firm**

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**Sent:** Friday, 17 February 2006 10:57 AM
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**Subject:** AIR POWER AUSTRALIA SUBMISSION - APA-SUB-2006-3

To:

The Hon Bruce Scott
Chair, Defence Sub Committee
Joint Standing Committee on Foreign Affairs, Defence and Trade

Dear Mr Scott,

Air Power Australia is pleased to provide our second submission to the Inquiry into ADF Regional Air Superiority, entitled 'Attaining Air Superiority in the Region: Testing the Evidence'.

This submission encompasses a review of recent developments in Joint Strike Fighter costings, which have driven the cost of early production aircraft above the cost of the F-22A Raptor in the period during which Australia is to purchase replacement aircraft.

The submission also responds in detail to questions on notice from Committee members.

Finally, it contains a comprehensive analysis and rebuttal of the evidence provided by Defence to the Committee.

On balance, we have found the evidence provided by Defence to be of much poorer quality than that provided to the Committee in 2004. The evidence is so poor that we strongly recommend the advice from senior Defence officials and their barrackers in these matters should be independently tested if Government and the people of Australia are not to become exposed to resulting risks.

We wish the Committee every success in its endeavours and stand willing to assist should our services be needed.

Yours sincerely,

14 May 2006

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***"Air Power Australia - Defining the Future"***
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***Attachments*:** This document employs a number of charts, plots and diagrams. These have been implemented in full colour to improve readability. While we have invested a lot of effort into ensuring best possible contrast when printed in black and white, in general colour rendering still reads better. We strongly recommend that any hard copy distributed to the committee be printed in colour.

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# Inquiry Into Australian Defence Force Regional Air Superiority: Attaining Air Superiority In the Region

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# Attaining Air Superiority in the Region: Testing the Evidence

# Inquiry into Australian Defence Force Regional Air Superiority

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Figure 1: *F-22A Raptor assigned to the 27th Fighter Squadron of the 1st Fighter Wing, Langley, Virginia, the first operational unit to fly the F-22A, releasing a GBU-32 JDAM satellite/inertial smart bomb. The US Air Force intends to replace the F-117A Nighthawk stealth fighter with the F-22A providing a precision strike capability against the most heavily defended targets. Two F-22A squadrons are to be assigned to the 49th Fighter Wing at Holloman, New Mexico, replacing all existing F-117A aircraft (US Air Force).*

# Executive Summary

This Submission comprises three main sections. The first of these addresses issues of increasing cost in the Joint Strike Fighter, the second responds to questions on notice by Committee members, and the third tests evidence provided to the Committee by Defence and its supporters.

Fourteen principal observations arise, mostly as a result of evidence provided by Defence.

**Observation §1:** Within Australia's time window of interest for replacing the F/A-18A fleet, the Joint Strike Fighter will be more expensive to acquire than an identical number of much superior F-22A Raptor fighters.

**Observation §2:** The opportunity to procure or otherwise acquire F-22A Raptor fighters earlier than the Joint Strike Fighter allows Australia to avoid the very expensive, high risk and low payoff elements of the F/A-18 HUG Program including the Fuselage Centre Barrel Replacement Program, the integration of additional guided munitions, and the further enhancement of avionics.

**Observation §3:** If Australia opts for the Joint Strike Fighter rather than the production F-22A Raptor, it will have to accept progressively increasing costs over time. For all intents and purposes, this is an 'open chequebook' with no certainty in terms of an upper ceiling in costs. This will represent a high risk to the Australian taxpayer, but also a political risk for every Federal Government in office between now and the delivery of the final Joint Strike Fighter aircraft.

**Observation §4:** The evidence provided by senior Defence officials excludes the import of strategic changes to the region and strategic changes in future United States' capabilities, and the impact of these strategic changes upon Australia. Consequently, there is no evidence to support the proposition that senior Defence officials provided sound advice to Government on these matters.

**Observation §5:** Testimony provided by senior Defence officials, and the Kokoda Foundation, concerning the performance and capabilities of the F-22A Raptor multirole air dominance fighter, and the manner in which the US Air Force will use this aircraft, does not reflect what is publicly known about the F-22A. Multiple claims made by senior Defence officials directly contradict public statements by the US Air Force on these matters.

**Observation §6:** Evidence provided by senior Defence officials on the cost structures which apply to the acquisition of military aircraft from the US is not accurate, and repeatedly understates the resulting acquisition costs in the Joint Strike Fighter, and mostly overstates the resulting acquisition costs in the F-22A Raptor.

**Observation §7:** The evidence provided by senior Defence officials concerning risks in the support of older aircraft is predicated on the use of improper technique. Techniques which should be used in the reduction of technical risk are not understood, and the adoption of modern engineering planning techniques which can be used to reduce risks is rejected. The adverse consequences of this lack of understanding and rejection of appropriate planning technique are then erroneously attributed by Defence to the calendar age of the military aircraft in question.

**Observation §8:** Testimony provided by senior Defence officials on the risks inherent in the retention of the F-111 departs from fact. The testimony inflated the cost of F-111 life extension upgrades **tenfold**, to a magnitude similar to the cost of developing an entirely new fighter design. No justification was provided to explain this inflation. For comparison, evidence provided in 2004 by Defence inflated F-111 upgrade cost figures only twofold.

**Observation §9:** Evidence provided by senior Defence officials on Australian Industry capabilities, in the design and development of upgrades, or support of military aircraft systems, is in error, including cost structures and reasoning on how to approach risks inherent in such activities. Australian Industry experience and lessons learned overseas in such programs, for estimation of risks and costs, and establishment of viable, sustainable outcomes, are absent in this evidence.

**Observation §10:** Testimony provided by senior Defence officials ignores the limitations of networking equipment in hostile jamming environments and the risks that arise as a result. Consequently greater robustness is attributed, than historical experience and expert advice indicates to be safe.

**Observation §11:** There are no less than sixteen well established technical reasons why the adoption of Network Centric Capabilities will not provide the military effect Defence claim it will. While networking capabilities are essential for the future of the ADF, they are not a substitute for the firepower delivery capabilities of platforms, and cannot be used as a justification for force structure downsizing or the acquisition of inferior platforms.

**Observation §12:** Given the poor quality of evidence provided by senior Defence officials across a wide range of areas, when responding to reasonable questions by the Committee, it is evident that all advice tendered to Government in these areas should be tested independently to ensure that Government and the Australian community are not exposed to the risks which result from defective advice.

**Observation §13:** The absence of cogent argument, supported by hard data and traceable evidence, in the testimony provided by senior Defence officials, is proof of a failure to perform 'due diligence' in capability development and acquisition, including the application of formal Test and Evaluation philosophies and techniques. This is demonstrably so in the decisions to pursue the Joint Strike Fighter, F/A-18 life extension, early retirement of the F-111, and in the rejection of the F-22A Raptor. The systemic nature of this failure can also be seen in the recently tabled ANAO Report on the management failures in the Air 87 Tiger Armed Reconnaissance Helicopter Project, the primary cause being clearly identified in Table 1.1 of the report[1].

**Observation §14:** The evidence presented by senior Defence officials to this Inquiry demonstrates a much higher frequency in errors of fact, non sequitur conclusions and lack of rigour, compared to the evidence presented in 2004 in relation to these matters. There is a remarkable consistency of misunderstanding, non sequitur conclusions and errors of fact, a rejection of alternatives and risks, selective bias in analysis, absence of contingency plans, and poor definition of objectives. This is no different from that observed in recent and well documented overseas decision failures[2].

# 1 Why the JSF is an Open Chequebook

Recent developments in the United States, following the compilation of Submission 20 to this Inquiry, clearly illustrate that the budgetary and risk analyses provided in Submission 20 were correct.

> Within Australia's time window of interest for replacing the F/A-18A fleet, the Joint Strike Fighter will be more expensive to acquire than an identical number of much superior F-22A Raptor fighters.

This represents a 'cost differential inversion' or situation where declining cost of F-22A unit production falls into the same time frame as early Joint Strike Fighter production, when the cost of the Joint Strike Fighter unit production is highest.

Air Power Australia's analysis performed as part of the Evolved F-111 Option Proposal provided to Defence in 2001/02, updated late last year, and included this February in Submission 20 stated:

**Page 14, Para 5**

**5.** The results of an independent, parametric cost projection of an Australian buy of 100 Production Block 2 and/or Block 3 JSF aircraft in 2012 were provided to Defence in 2003 and again in 2005. This analysis assumes the development and production schedules being advised by Defence can be maintained. The analysis estimates the unit procurement cost will be somewhere between $US112 million and $US120 million per aircraft in FY2012 dollars.

**Page 22, Para 26**

**26.** Finally, the JSF Program Office is reporting the milestone for Defense Acquisition Board approval into Full Rate Production (FRP) as currently scheduled for the first QTR of CY2014. Analysis in FY2004 dollars indicates that the Average Unit Procurement Cost (UPC) for a buy of 100 x JSF aircraft at the beginning of CY2014 could be in the order of $US100.0 million (FY2004). Estimating when delivery could start and at what rate is somewhat problematic but as a Level 3 Team Member, Australia is behind Italy, Netherlands, Turkey and, possibly, Canada in the priority pecking order for full rate production CTOL aircraft. Acquiring earlier build LRIP (low rate initial production) units has always been the intention of the Director, NACC Project Office. However, these units, traditionally, would cost more (≈$US110 million per unit) and require additional expenditure to upgrade to the full rate production configuration.

**Boxed Text, Page 23 - Point Note 6**

**6.** The total procurement cost for a fleet of 55 x F-22A aircraft is estimated at $US6,930.0 million (FY2004 dollars) and delivery could begin in 2010 and possibly earlier, subject to how well Australia is able to negotiate on both price and delivery.

Publicly available data from the United States now supports the analysis performed by Air Power

Australia.

The US **Selected Acquisition Report December 2005 (Public Release - 07 April 2006)** states "... due primarily to a quantity increase of 4 aircraft from 172 to 176 (+$506.6 million) ...". This means that for the additional 4 aircraft approved for production (#172 to #176), the increase in the overall procurement budget is +$US506.6 million. This puts the average unit procurement cost across these four aircraft at $US126.65 million.

Therefore, the unit procurement cost at the end of the currently planned production of, overall, 185 aircraft (which includes test aircraft), "will be about $US126.0 million", or exactly the estimate produced by Air Power Australia.

What this also means is that for less than half of the currently planned Joint Strike Fighter procurement budget (which does not include the budget for the SDD as this comes out of the DoD RDTE budget), the USAF could procure an additional 1,000+ F-22A Raptor aircraft.

Joint Strike Fighter cost figures released in **GAO Report No GAO-06-356, dated 15 March 2006** indicate that creeping cost growth has now driven the cost of Low Rate Initial Production (LRIP) aircraft above the cost of the F-22A during the same period.

The following analysis is based on the data from Figure 1 on page 9 of this GAO report. Data have been adjusted to correctly reflect the currently planned achieved position at the start of each calendar year. For example, CTOL aircraft No A-1 will not be available to commence the flight test program till the beginning of 2007. On current plans, 1% of the flight test program should have been achieved by the beginning of 2008. It should be noted that CTOL A-1 is not representative of the production design, having been well advanced in major sub assembly build prior to initiation of the weight reduction program. The actual representative CTOL flight test will have to wait until the second aircraft, CTOL (Opt) A-2, comes on line some time in 2007-08. A summary of this data is presented in Figure 2.

For Australia to get Joint Strike Fighter aircraft delivered by 2012, we will have to order them some 3 years ahead, according to Tom Burbage of LM[3]. This would mean Australia would have to place its order in 2010, at the latest, to get delivery in 2012 out of LRIP Phase 4, as currently planned by the NACC Project Office. The unit procurement cost for LRIP Phase 4 aircraft is currently estimated, from US DoD budgetary figures, to be somewhere between $US114.1 million and $US136.8 million. On current planning, LRIP Phase 4 aircraft will most likely be at the Block 1 configuration, at best Block 2. To bring these aircraft up to the end of LRIP Block 3 configuration, a number of upgrade modifications will be required. These are likely to include a new central processor computer and a new complete software load, as well as any modifications/changes that result from the developmental (DT&E) and operational (OT&E) flight test programs. The total combined flight test program is slated to take 7 years and some 7,000 flying hours, starting in 2007.

In relation to Figure 2, there are a number of observations of a 'due diligence' nature that can be made.

| Beginning of Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| **LRIP Phase - Planned End Point** | | | | 1 | 2 | 3 | 4 | 5 | 6 [1] |
| **Cumulative Production Investment ($US Billions)** | | $0.2 | $1.5 | $4.9 | $11.7 | $18.7 | $26 | $36.9 | $49.3 |
| **Cumulative LRIP Aircraft (Does not include early test units funded by SDD/RDTE budget.)** | | 0 | 5 | 23 | 70 | 126 | 190 | 291 | 424 |
| **Cumulative Average Procurement Cost ($US Millions)** | | | $340 | $213 | $167.1 | $148.4 | $136.8 | $126.8 | $116.3 |
| **Target Descalation % per Phase** | | | | 37.3% | 21.5% | 11.2% | 7.8% | 7.3% | 8.3% |
| **LRIP Phase Budget** | | | $1.7 | $3.2 | $6.8 | $7.0 | $7.3 | $10.9 | $12.4 |
| **Nos of Aircraft per LRIP Phase** | | | 5 | 18 | 47 | 56 | 64 | 101 | 133 |
| **LRIP Phase Average Procurement Cost ($US Millions)** | | | $340 | $177.8 | $144.7 | $125 | $114.1 | $107.9 | $93.2 |
| **Target Descalation % per Phase** | | | | 47.7% | 18.6% | 13.6% | 8.7% | 5.4% | 13.6% |
| **Descalation % on 2009 UPC** | | | | | 18.6% | 29.7% | 35.8% | 39.3% | 47.6% |
| **Flight Test Program** | ~ 7 Years/7,000 Flying Hours | | | | | | | | |
| **Percentage of Flight Test Program Complete at Year's Start.** | | 0 | 1% | 3% | 13% | 35% | 56% | 77% | 98% |

Figure 2: *Data Summary: JSF Low Rate Initial Production (LRIP) Program vs Flight Test Program ([1] LRIP Phase 7, currently planned for Year 2015, not shown as beyond scope of source GAO report, the primary purpose of this report being to highlight the number of aircraft scheduled to be built before testing has been completed.).*

Firstly, the ‘target descalation factors’ (ie. that rate at which the average procurement cost is planned to be reduced from one LRIP Phase to the next) are quite aggressive and exceed both the planned and achieved ‘descalation factors’ of any other known programs by some degree.

Secondly, between LRIP Phase 5 and 6, the ‘descalation factor’ trend actually reverses, with an increased rate in the target cost reduction of some 8.2% in Phase 6 over that achieved in Phase 5. Now, there may be perfectly reasonable reasons for these variances, particularly as the budgetary figures upon which the source GAO report is based are Procurement Budget figures, resulting in Unit Procurement Cost being the basis for comparison. However, from a due diligence perspective, such variances should be tested and explained. To do otherwise would put into question the due diligence process.

Rather than rely on inferences derived from GAO and Congressional Budgetary Reports, the more appropriate way to perform due diligence would be to go to the source data, in this case the actual costing model for the Joint Strike Fighter Program. As a Tier 3 Partner, Australia, through its Department of Defence, should have access to such data. Defence, in turn, and, should be able to make such data available to the oversight level of governance of the Parliament and the people of Australia who are funding Australia’s involvement in the Joint Strike Fighter Program. Any claim that such data, particularly at the upper level of interest, is somehow ‘classified’ or ‘commercially sensitive’ should be viewed with some scepticism since, firstly, costing information is not sensitive from a military or national strategic sense. Secondly, the Joint Strike Fighter Program has been sole sourced to the Lockheed Martin Team so there is no commercial advantage to be gained by third parties other than if the data does not support what has been represented through the program’s marketing and public releaseable briefing material.

In summary, Australia has the choice of acquiring F-22A Raptor aircraft during this period with a Unit Procurement Cost no greater than $US126.0 million, or Joint Strike Fighter aircraft with a Unit Procurement Cost at best of $US114.1 million, but more likely closer to $US136.8 million, according to the data contained in GAO reports.

If Australia opts to acquire the Joint Strike Fighter rather than the F-22A Raptor, it will be buying a much less capable and less mature aircraft, yet paying a price, best case, somewhere in the range of 90.5% to 109% of the Unit Procurement Cost of the F-22A Raptor.

This analysis is focussed on matters of relative cost between the F-22A Raptor and the Joint Strike Fighter. It is no less important to consider that the F-22A Raptor is a significantly more capable aircraft than the Joint Strike Fighter is intended to be.

The noted disparity in performance and capabilities between the F-22A Raptor and the Joint Strike Fighter is prominent. With supersonic cruise capability the F-22A Raptor has for many key roles twice the productivity of the Joint Strike Fighter. The F-22A Raptor also offers twice the radar footprint, greater passive detection footprint, significantly greater external payload capacity, more internal fuel, the redundancy of a twin engine design for overwater operations, and much better stealth performance, compared to the Joint Strike Fighter. The internal payload of new Small Diameter Bombs is identical for both aircraft.

Of the eight non-US partner nations in the Joint Strike Fighter program, all but Australia are NATO nations which since the fall of the Soviet Union, exist in a benign strategic environment. Australia, conversely, exists in the Asia-Pacific-Indian region which has seen the greatest aggregate investment in modern military aircraft and weapons since the end of the Cold War, mostly systems of Russian origin. The disparity in strategic circumstances between Australia and NATO nations has never been greater. As a result the capability advantages of the F-22A Raptor over the Joint Strike Fighter do matter for Australia, even if they do not matter for European NATO nations.

There is every reason to believe that the F-22A Raptor will be even cheaper relative to the Joint Strike Fighter, than indicated by the **Selected Acquisition Report December 2005** and **GAO Report No GAO-06-356** figures indicate.

Last August US Deputy Secretary of Defense Gordon England commissioned the Virginia consultancy Whitney, Bradley & Brown to perform a study, intended to identify opportunities to reduce expenditures on new fighter aircraft. A previous study by this consultancy resulted in a reduction of the US Navy Joint Strike Fighter buy by 400 aircraft.

US analyst Loren Thompson, cited by Reuters on the 24th April, 2006, disclosed that the Whitney, Bradley & Brown study concluded that the US should be acquiring between 220 and 260 F-22A Raptor aircraft, rather than the 183 aircraft provided for in the current budget.

> If the conclusions of this study are accepted and the US Air Force is funded to acquire an additional 40 to 80 F-22A Raptor aircraft, then the Unit Procurement Cost of these aircraft will be well below $US126.0 million.

> If we assume the established cost descalation observed in previous builds of the F-22A is sustained, then aircraft #220 will be supplied with a Unit Procurement Cost of $US109.6 million, and aircraft #260 for $US95 million. These figures represent 96% and 83% of the estimated best case Unit Procurement Costs of the Joint Strike Fighter during the period of interest.

This differential in Unit Procurement Costs decisively favours the F-22A Raptor over the Joint Strike Fighter, regardless of the much better performance and capability of the F-22A Raptor. It is however predicated on the assumption that the Joint Strike Fighter will not experience further cost growth between now and 2010, as the analysis uses best case Joint Strike Fighter Unit Procurement Costs.

There are many reasons to believe that the Unit Procurement Costs of the Joint Strike Fighter will further increase, progressively, as the program enters the latter stages of development, and Low Rate Initial Production.

The first reason is historical experience. Until an aircraft enters Full Rate Production, it is in the development, test and production shakedown phase, and problems requiring design modifications will inevitably be discovered. Every program in recent history has experienced this effect, with creeping cost increases until the design is stable and volume production is established. The established track record of the Joint Strike Fighter has followed this pattern consistently, and there is no reason to believe that it will depart dramatically from a proven trend across the industry, and a proven trend within the Joint Strike Fighter program itself.

The latest increase, reported in April this year, has seen the program cost increase by about $US20 billion to US $276.5 billion, against estimates produced January 2004, and by around $US45.5 billion (+34.5%) since the start of the SDD Program in 2002, with the percentage change being adjusted for the reduction in the planned number of aircraft to be produced by 408 units, from 2,866 to 2,458 aircraft.

The second reason lies in the matter of how many Joint Strike Fighter aircraft the US will build for its own services. It is clear that over the longer term the numbers will be smaller than those cited for the Joint Strike Fighter program to date.

The recent US Quadrennial Defense Review (QDR) report did not mention or describe the Joint Strike Fighter. It was neither named nor referred to directly once in the 113 page document. Given the originally planned $US221.4 billion plus program budget, its absence in the QDR document is remarkable to say the least. Media reports in Australia falsely claimed the QDR endorsed continuation of the Joint Strike Fighter program in its current form. The QDR simply avoided the Joint Strike Fighter issue completely.

The central question arising from the planned QDR force structure growth measures is that of how the US will fund the intended and ambitious expansion of strike capabilities, be they US Air Force capabilities or the new long range US Navy J-UCAS (unmanned aircraft), which for all intents and purposes is filling the vacant niche left by the A-12A Avenger II aircraft, cancelled 15 years ago. This expansion must compete with the F-22A, the Joint Strike Fighter and recapitalisation of the US aerial refuelling tanker fleet.

The Joint Strike Fighter will now be confronted with pressures on two fronts. In capability terms the Joint Strike Fighter is not a good fit for the range/payload/persistence intensive environment which is driving the new QDR strategy and resulting force structure planning.

Designed and sized around Cold War era and immediate post Cold War strategic constraints, the Joint Strike Fighter is put simply too small for the emerging strategic environment (refer `http://www.ausairpower.net/APA-2005-04.html`).

On the funding front, the Joint Strike Fighter will have to directly compete in its own "strike capability" niche against the J-UCAS and the new strategic bomber fleet planned for in the QDR document, while it must indirectly compete with new tankers for funding.

Since its inception, the Joint Strike Fighter program has seen steady encroachment into its capability niche. The Block 20 and proposed Block 30 and 40 upgrades to the F-22 have seen Joint Strike

Fighter hardware directly transplanted into the F-22, entering production well before any Joint Strike Fighter aircraft come off the production line. A Block 30/40 configuration F-22 will outperform the Joint Strike Fighter in all strike roles of interest to Australia.

Further encroachment has arisen as US heavy bombers are increasingly used for close air support and persistent "killbox interdiction" of battlefield targets. This shift has seen investments in laser targeting pods for the B-52H, B-1B, and the intended retrofit of the Joint Strike Fighter Electro-Optical Targeting System (EOTS) in the B-2A. Spirit bomber. The steady forward capability creep of the unmanned J-UCAS toward more persistence and payload has pushed it into the size and weight class of the Joint Strike Fighter, and into a bracket of superior payload/radius performance.

While the Marine Corps / UK STOVL Joint Strike Fighter remains unchallenged in its core capability niche, the US Navy CV Joint Strike Fighter variant will compete for deck space and budgets with the F/A-18E/F and J-UCAS. The US Air Force CTOL Joint Strike Fighter variant will have to compete in budgets, roles and missions against the F-22A, the J-UCAS and the heavy bomber fleet. In high threat scenarios the Joint Strike Fighter competes at a disadvantage, and in long range or highly persistent scenarios it also competes at a disadvantage.

Prior to the release of the QDR, reports emerged in the US that the Joint Strike Fighter had survived last year's DoD fighter review, but that Joint Strike Fighter CTOL variant numbers were expected to be chopped from around 1700 to 1000-1200 for US Air Force. This proposed reduction in numbers may not free up sufficient funds for competing needs, and may not be final as yet.

The alternative F136 engine program for the Joint Strike Fighter, to be built by GE and Rolls-Royce in the UK, was axed from the US DoD's fiscal year 2007 budget proposal earlier this year as part of the moves to save monies over the Future Years Defense Plan. This would have saved over $US7 billion in the program budget. However, the US Congress House Armed Services Committee has recently vetoed this recommendation, insisting the second engine program continue. This still has to pass three more committees before the F136 program can be considered for funding in the 2007 budget which will be signed later this year and it is likely the exact position will not be know till sometime in September/October this year. If the decision is in the affirmative for the F136 engine program, this will require putting an additional $US7 billion+ back into the Joint Strike Fighter Program Budget.

In terms of the overall number of Joint Strike Fighters that are to be built, Gordon England, Deputy Secretary of Defence, was quoted recently stating that Joint Strike Fighter numbers "will come down" over time.

Other important questions arise from US Air Force planning for one of the two aircraft the Joint Strike Fighter is intended to replace in US service, the Fairchild-Republic A-10 Thunderbolt II.

The A-10 fleet was mostly built during the 1970s, making it similar in age to the F-111s, but the A-10 was designed as a specialised tank busting, close air support and battlefield interdiction aircraft, dedicated to supporting ground troops. It has proven to be remarkably successful in this role. The US Air Force owns around 350 of these aircraft, and have used it extensively in Afghanistan and Iraq, as well as Yugoslavia in 1999 and the Gulf War in 1991.

When the Joint Strike Fighter was conceived during the 1990s, it was expected that US air power would be used mostly in high intensity battlefields such as encountered in 1991, where the survivability of the A-10 would be challenged, with advanced post Soviet air defence missile systems in the market. With much of the A-10 fleet expected to run out of wing structure fatigue life by 2015, the Joint Strike Fighter was expected to provide a more survivable replacement.

Since then, several important developments have taken place:

1. The cost of the Joint Strike Fighter has crept upward, and the delivery timelines for full production aircraft have slipped.
2. The US has become embroiled in the Global War On Terror, in which the Cold War era A-10 have proven exceptionally useful in supporting ground troops.
3. The US have adopted Network Centric Warfare which favours aircraft which have large payloads and good persistence over the battlefield. The legacy A-10 has better payload and persistence performance than the Joint Strike Fighter has.

As a result, the US Air Force has recently embarked on an extensive program to extend the life of the Fairchild-Republic A-10 Thunderbolt II fleet, rebuilding these aircraft to the A-10C 'Borg Hawg' configuration.

This upgrade includes a new glass cockpit, hands on throttle and stick controls (HOTAS), a revised digital weapon system, capability for delivering the same Mil-Std-1760C late generation smart munitions to be carried by the Joint Strike Fighter, integration of capability for carriage of Sniper and LITENING pods, doubling the DC Power available onboard, and integrating a new low terrain/targeting system. The reported budget for upgrading some 350 aircraft to the A-10C configuration is $US300million. As an aside, one of the technology insertion programs contained in the Evolved F-111 Proposal of 2001/02 would see 36 x F-111s fitted out with a later generation glass cockpit and HOTAS capability.

Importantly, a large proportion of the A-10 fleet, the oldest by construction, will be fitted with rebuilt wings. These new wings are expected to add up to 30 years of additional fatigue life to these aircraft, permitting their operation until the 2040 timeframe.

The US Air Force will thus have the option of keeping the A-10 Thunderbolt II in service well past 2030, rather than replacing them with the Joint Strike Fighter. The investment to provide the A-10C avionics upgrade and wing replacement is a tiny fraction of the cost of replacement using the Joint Strike Fighter, and given projected budgetary pressures, indicates a large risk that the aggregate US Air Force build of the Joint Strike Fighter will be reduced by the number of retained A-10C aircraft.

In summary, there is extensive evidence to support the expectation that production numbers of the Joint Strike Fighter for US services will be reduced in coming years:

1. Ongoing upward cost creep in the Joint Strike Fighter program as a result of development and design issues. Progressive slippages in delivery timelines for full production aircraft.
2. The adoption of Network Centric Warfare which favours aircraft which have large payloads and good persistence over the battlefield, unlike the Joint Strike Fighter.
3. Budgetary competition against the more capable F-22A Raptor, Unmanned Aerial Vehicles, aerial refuelling tanker recapitalisation, and the new strategic bomber planned for in the Quadrennial Defense Review.
4. Competition in roles and missions against the legacy A-10C Thunderbolt II, the legacy B-52H/B-1B heavy bomber fleet, the new strategic bomber planned for in the Quadrennial Defense Review, Unmanned Aerial Vehicles and the more capable F-22A Raptor.
5. Life extension by structural rebuilding and avionics upgrades of the legacy A-10C Thunderbolt II, with operation until 2040.
6. Public statements and media leaks by US defence officials suggesting future reductions in Joint Strike Fighter production numbers.

At this point in time it is abundantly clear that the Joint Strike Fighter will be at best similar in Unit Procurement Costs to the better F-22A Raptor, in the timescales of interest for Australia, but more likely it will be significantly more expensive, possibly by as much as 20% or more of the cost of the F-22A Raptor.

There is an overwhelming volume of evidence now available which shows that there is no advantage in acquisition costs, in Australia purchasing the Joint Strike Fighter rather than the better F-22A Raptor. From the perspective of raw budgets and basic risks, the F-22A Raptor is now demonstrably cheaper to acquire, in equal numbers, in the timeframe of interest, and it carries none of the risks carried by the Joint Strike Fighter. Even if the superior capability of F-22A Raptor were irrelevant, which it is not, the F-22A Raptor is the cheaper and smarter buy for Australia.

For the purpose of argument, let us consider the implications of the Government accepting the proposition by Defence that the Joint Strike Fighter should be purchased instead of the now cheaper and more capable F-22A Raptor. What are the other implications of this, from a budgetary and risk perspective?

If the Government accepts the proposition by Defence that the Joint Strike Fighter should be purchased instead of the now cheaper and more capable F-22A Raptor, Australia will have to accept that future reductions in Joint Strike Fighter numbers, and cost creep during the latter phase of development will result in progressively increasing costs to the Australian taxpayer between now and the delivery of the Joint Strike Fighter buy. For all intents and purposes, this is a 'open chequebook' with no certainty in terms of an upper ceiling in costs. This will represent a high risk to the Australian taxpayer, but also a political risk for every Federal Government in office between now and the delivery of the final Joint Strike Fighter aircraft to Australia.

For the purpose of argument, let us also consider the implications of the Government accepting the 2001/2002 Australian Industry proposal to acquire the more capable F-22A Raptor rather than the Joint Strike Fighter, and retain the F-111 fleet. What are the implications of this, from a budgetary and risk perspective?

If the Government accepts the 2001/2002 Australian Industry proposal to acquire the more capable F-22A Raptor rather than the Joint Strike Fighter, and retain the F-111 fleet, the implementation risks in the fighter replacement program largely vanish. From a budgetary perspective, the F-22A Raptor will exhibit stable or declining procurement costs over the whole period of interest. As the F-22A Raptor can be supplied earlier than the Joint Strike Fighter could, the need to perform risky and expensive rebarrelling of the F/A-18A Hornets vanishes. The aggregate savings to the taxpayer are of the order of $4.5 billion over the period of interest, and budgetary predictions can be made with a high level of confidence.

This difference in costs between the force structure plan presented by Defence and the more affordable model presented by Australian Industry in 2001/02, is in the order of $4,500 million in 2004 discounted present value dollars, which at current interest rates over the next nine years aggregates to a value of the order of $7,600 million. If we assume a nominal taxation rate of 30%, Australian taxpayers would have to generate over $25 billion of taxable income to generate the tax revenue to cover the additional costs of the Defence proposal. This is of the order of 3% of Australia's annual GDP, and well in excess of an annual Defence budget.

# 2 Questions on Notice

**Senator JOHNSTON:** *I am trying to learn. I want to put to you some of the issues that we need to establish before we get into the technical debate. He [Dr Alan Stephens] goes on to say: Furthermore, and most significantly, Airborne Early Warning & Control has since been added to the matrix, thus introducing an information network dimension which has fundamentally changed the nature of air combat. And in the next few years, a handful of advanced defence forces, including the ADF, will integrate data from even more networked control and/or information sources (satellites, unmanned aerial vehicles, ground radars, navy ships, army formations, etc) into the total system. The end result will be an unequalled degree of situational awareness, which historically has represented a combat advantage of the highest order. Do you accept that?*

**Dr Kopp:** I believe that is basically a very optimistic assessment of what the technology can achieve in the next 20, perhaps even 30, years. I would be happy to take the technical detail of why this is on notice, because we could spend two hours drilling into it.

**Response by Dr Carlo Kopp:**[4]

The notion of a Network Centric Warfare based warfighting system which can connect all sources of information and all consumers of information to provide 'universal network connectivity' and thus provide complete situational awareness is a popular and recurring theme in some of the literature dealing with military networking. The aim underpinning this idea is that such a system can provide an overwhelming advantage in knowledge of the battlespace and almost complete understanding of an opponent's actions. Dr Stephens is effectively restating the 'grand vision' which has been presented by some of the most vociferous overseas advocates of networking, and the very same vision which permeates statements and public documents produced by Defence.

The difficulty with 'grand visions' is that they are driven much more by fervent belief than by hard technological and scientific fact. As a result, real practical limitations are not accounted for and unrealistic expectations are elevated as a future reality.

The case study is Duncan Sandys' 'grand vision' of nearly fifty years ago, in which Sandys envisaged a future where manned aircraft were wholly displaced by guided missile systems. The reality proved to be that missiles were never good enough to displace aircraft, and real operational needs proved very different from those envisaged by Sandys and his followers. With nearly half a century of hindsight, missiles are now vitally important tools used in every facet of warfare, immeasurably more capable than the technology of Sandys' era, but are still no nearer to wholly replacing aircraft.

Sandys' 'grand vision' gutted the Royal Air Force and wrecked much of Britain's aerospace and avionics industry, and bears testament to the enormous damage which can be wrought by misguided visionaries, when their visions are accepted as fact and acted upon, without first being tested.

Network Centric Warfare is a vital prerequisite for combat in the information age, but it is not a replacement for more fundamental military capabilities.

The 'grand vision' of wholly dispelling the 'fog of war' by constructing a networked system connecting all sources and consumers of information is unimplementable for a number of very good reasons. These reasons fall into two broad categories:

1. Hard limits imposed by the physics of radio signal propagation and the mathematics of networked systems.
2. Impairments resulting from hostile actions.

The notion that the 'grand vision' can be implemented is predicated on the idea that reasons why it cannot be implemented either do not apply, or will be overcome by some non-existent or yet to be developed technological advances.

The reasons why the 'grand vision' cannot be implemented can be summarised thus:

**The Power Aperture Problem:** The amount of data per second which can be sent over any wireless radio link is limited by the amount of radio frequency power, available radio spectrum, and size of the antennas used, for any given distance between stations. To achieve link data transfer speed performance competitive against even legacy technology optical fibre cable links, over distances of tens to hundreds of kilometres, requires the use of power levels, antenna sizes and receiver performance comparable to that of a radar on a fighter aircraft. To provide an aircraft, warship or vehicle with 360° very high speed link coverage with such performance thus requires three to four such antenna/transceiver systems, which at the cost of current phased array radar antenna technology *would be of the order of $US5 million per platform*. For many military platforms such installations are not feasible for reasons of size and weight, regardless of cost. The notion that the miniaturisation seen in computer hardware will apply to high speed wireless computer network hardware is a fallacy which assumes that the physics of radio propagation do not apply[5].

**The Propagation Physics Problem:** The amount of data per second which can be sent over any wireless radio link with given transmitter power, receiver performance, bandwidth and distance will be limited by the impairments experienced in propagating the radio signal through the atmosphere. In the microwave bands of interest and relevance to military networking, rain, cloud, fog, haze, atmospheric gas molecules, reflections from terrain, solar noise, unintended interference by commercial equipment can all impair transmission. In the upper microwave bands these impairments can be severe enough to make connections unusable. The propagation conditions best suited to high speed wireless networking may be absent due to weather conditions for much of the year in equatorial or tropical geography of most interest to the ADF. The notion that the propagation environment will permit round the clock all seasons high speed long range network connectivity is predicated on the assumption that radio propagation conditions will always be ideal, and physics of radio propagation impairment mostly do not apply. Lasers suffer even more severe impairments than microwave links suffer[6].

**The Radio Spectrum Problem:** The available radio spectrum for military networking is limited by severe and worsening global congestion of the radio spectrum. This congestion has arisen as a result of unrestricted growth in satellite communications, broadcast usage, mobile telephony and networking, and dedicated commercial radio link usage. Moreover, the radio frequency bands which are least impaired by natural radio propagation impairments are by far the most heavily congested. The reality of this century will be increasing pressure upon the radio spectrum, with declining availability of spectrum which is well suited for miliary networking applications[7] [8].

**The Footprint Problem:** High speed radio networking requires that line of sight exist between platforms carrying networking equipment, as microwave links (or laser links) cannot propagate through the earth or water. The curvature of the Earth sets hard limits on what is achievable. Whether the platform is an aircraft, Unmanned Aerial Vehicle, warship, land vehicle, fixed ground station or satellite, the two stations at either end of the link must be connected by direct line of sight. For an aircraft at typical cruise altitude and surface based station communicating, this distance is at best of the order of 200 nautical miles. High flying Unmanned Aerial Vehicles can do slightly better, and satellites much better, but both suffer increasingly from the preceding three effects, and become increasingly expensive as achievable link speed is increased[9].

**The Bandwidth Growth Problem:** The problem of bandwidth growth, or more properly *channel capacity* growth, is inherent in all networks, be they civilian or military. *Demand for capacity always exceeds installed capacity.* In civilian networks, especially the Internet, this demand has been the driving force in the large scale deployment of optical fibre and copper cable networks, and has resulted in an effect called the 'bandwidth law', which states that 'available bandwidth doubles every two years'. Military networks do not obey the 'bandwidth law'. This is because they are primarily wireless radio networks, where communications link capacity is severely limited by the power aperture problem, the footprint problem and radio propagation physics. Therefore the expectation that military networks can achieve the same enormous growth over time as seen in civilian networks is predicated on the validity of the 'bandwidth law' in wireless networks, which is a false assumption[10].

**The Network Congestion Problem:** Computer networks are susceptible to congestion problems, which usually arise when the load on the network exceeds available capacity. The effects of congestion are service dropouts, breakdown in services which are sensitive to time delays in transmission (live video and voice, or real time targeting updates especially) or 'congestion collapse' whereby the network is unable to carry any useful traffic. In a time critical and survival sensitive environment such as military operations, congestion problems can be fatal, yet the conditions in which congestion is most likely to arise are at times of peak activity or rapid situational change, when the demand for new information is greatest. Congestion most frequently occurs in 'bottleneck' stations in any network, which as a result of physical location concentrate traffic from a large number of other stations. It is almost impossible to guarantee that in a wireless radio network no stations will ever become 'bottlenecks' to network traffic throughput. The reality is that achievable performance in any large wireless network will be limited by the performance of the slowest link along a path of interest[11].

**The Sensor Bandwidth Problem:** Modern sensors gather data at rates which are mostly significantly higher than the rates at which data can be transferred, in real time, across wireless radio datalinks of contemporary technology. A reconnaissance camera or imaging radar will capture multiple images of 50 Megabytes or greater size per second, yet the best contemporary network links provide a fraction of the bandwidth required to effect a real time transfer. The growth in sensor data capture capability is set to continue to exceed available network capacity, as imaging chip and radar technology evolves. For the forseeable future, the capacity of sensors to capture data will exceed by a large margin the capacity of networks to transfer that data quickly.

**The Human Bottleneck Problem:** Contrary to the belief held by many, information is not the same thing as raw data. Raw data must be understood and interpreted to produce information, whether this understanding and interpretation is by man or machine is immaterial. The reality for the forseeable future is that human interpretation will mostly be required to extract information from raw data, or validate machine interpretations. In a network centric system this reality puts hard limits on the speed at which information can be collected and distributed via the network, as humans must interpret and validate. Humans are slow and can be prone to error. Until Artificial Intelligence technology can replicate the cognitive reasoning of human beings, this 'wetware bottleneck' will constrain what can be achieved by automation in a network centric system, or 'system of systems'. Some Artificial Intelligence theorists for decades argued that such a breakthrough in technology was imminent, but it has yet to occur. There is no evidence to prove that such a breakthrough will occur over the next two decades[12].

**The Information Integrity Problem:** Computers and computer networks are the most efficient means devised to date for storing and distributing en-mass large volumes of data. The integrity or validity of this data is another matter, since a networked system can and will distribute erroneous data just as efficiently as valid data. Whether errors arise from limitations or faults in sensors, incorrect human interpretation, or simple typographical errors, defective data can be quickly distributed across a warfighting system. This effect is no different from the propagation via the Internet of sensational yet untrue reports or claims, or similar effects in the mass media. The result is that a single individual could produce large scale damage effects quickly, if erroneous data is widely and quickly distributed[13].

**The Rules of Engagement Problem:** The decision to fire a weapon against a target is mostly one which remains in the hands of human beings. No military force globally has yet adopted a policy which permits fully autonomous detection, acquisition, tracking and weapon delivery against a target by a machine. The reason is the risk of a machine inadvertently killing innocent bystanders. A similar problem can arise in a highly networked system, where an operator might elect to launch a weapon on the basis of data gathered by multiple sensors, with the operator and sensors being relatively remote to the target. Unless a high confidence level can be achieved in identifying a target as conclusively hostile, there is a genuine risk that limitations in sensors, and human interpretation of sensors, will result in friendly fire or civilian casualties. Limitations and faults in identification equipment can contribute to such situations, as well as human errors on the part of the operators driving a potential target. As a result, Rules of Engagement imposed upon a military force in times of crisis or war may severely restrict the extent to which the advantages offered by a network can be exploited in combat[14].

**The Fleet Cost Problem:** Networking equipment is not expensive compared to radar equipment, optical imaging equipment or aircraft jet engines. A capable state of the art JTIDS/MIDS network terminal, including the cost of software and amortised integration on a combat aircraft costs of the order of 15 to 25 percent of the cost of a radar or targeting pod. However, when equipping a fleet of platforms, this can add up to a significant cost burden. The Navy operates around two dozen platforms requiring networking, the Air Force well over one hundred platforms, the Army hundreds. To this cost must be added the cost of through life hardware and software upgrades, and replacement equipment with every generation of networking equipment, which might need to be replaced two or three times over the life of a new platform.

**The Compatibility Problem:** Networking hardware and software is inherently complex, and often evolves relatively quickly. A problem observed in both civilian and military networks is that of incomplete compatibility, where ostensibly compatible equipment cannot fully interoperate as some features or options in the network definition are not supported by both equipments. This problem becomes more pronounced if the fleet of platforms is equipped with networking equipment from different vendors, or of different generations. The result of such compatibility limitations is that the network can only reliably provide a subset of its total functionality, to the detriment of its users.

**The Enemy Jamming Problem:** Wireless radio networks are susceptible to jamming by an opponent, to a greater or lesser extent, no matter how good the jam resistance measures designed into the network. The idea of an 'unjammable' communications link has been popular since the 1940s, but will never be implementable due to physics of communications links. A well designed network will cope with jamming by reducing link capacity, effectively slowing itself down, to resist jamming. A not so well designed network will collapse or drop out. The effectiveness of any jamming technique will depend on how closely it is designed to exploit weaknesses in a network, and upon how much jamming power is used. In general, it is unsafe to assume a technologically oriented opponent will be unable to jam a network[15]

**The Enemy Attack on Network Nodes Problem:** Any opponent with reasonable competencies in electronic warfare will be able to identify stations in a network by their radio frequency transmissions. Platforms participating in a network and carrying traffic on behalf of other platforms will by necessity transmit more frequently than other stations, and stations which are bottlenecks in a network which is heavily loaded or nearing congestion, will also transmit more frequently. Targeting attacks on such platforms, for instance by using long range missiles, can cripple a network, or force a shutdown[16]

**The Enemy Attack on Sensor Nodes Problem:** Platforms equipped with sensors are the eyes and ears of a networking warfighting system. Remove them from operation, and the network become blind and deaf, as what remains is the ability to move data around, but no data of value is provided. Most networked systems in use today rely to a large extent on large long range sensor platforms, such as the Wedgetail. Destroying such a platform with a long range missile, or forcing its withdrawal, cripples the networked system[17].

**The Symmetrical Opponent Problem:** The notion that the ADF will only ever confront opponents not equipped with networking technology is both foolish and shortsighted. It effectively assumes that the ADF will only ever be used to deal with opponents of the technological sophistication of the Taliban. The reality of the digital age is that industrialised nations have been rapidly acquiring this technology. It is important that the gap in military effect between an opponent using advanced networking and an opponent using less advanced networking is relatively small, compared to the gap between any two opponents, one of whom has networking and one of whom does not. The availability of Russian networking equipment is public knowledge and has been so for some years.

These sixteen problem areas are well documented and have been the subject of many publications in the global debate on military networking. Each will affect to a greater or lesser extent all military networks, no matter how basic or advanced. These problems define the limitations of military networks, and are unavoidable consequences of the physics, mathematics and technology involved. No amount of wishful thinking can make them disappear.

There should be no doubt whatsoever of the need for the ADF to robustly invest in networking ADF platforms and other assets. Networking will be one of the essential prerequisites in modern warfare, and an important determinant of interoperability with US forces, on the regional or global stage.

No less importantly, the evangelical vision of a networked future embraced by the Defence leadership is an unrealistic and intellectually unsupportable fantasy which attributes to networking gains in military capability which can never be met by any real, implementable military network.

This inflated vision of networking held by the Defence leadership is dangerous, as it provides a false justification for a reduction in the the ADF's capability to deliver firepower, manifested in the Defence leadership's intention to remove the F-111 without credible replacement, and in the preference for the inferior Joint Strike Fighter over the superior F-22A Raptor. If reality matched this inflated vision, the US would not be investing in the F-22A or retaining older assets, which are being progressively equipped with networking equipment.

If the Government opts to accept the Defence leadership's inflated vision of what networking can deliver for the ADF it will be opening up a Pandora's box of unwanted and unnecessary risks arising from the resulting downsizing in ADF capabilities. For all intents and purposes Australia would be emulating the same kind of blunder produced in Britain as a result of Duncan Sandys' misguided vision, decades ago.

**Senator FERGUSON:** *You talk about analytical techniques that favour the Defence solution - that is what you say in your submission [Page 37 Para 7].*

**Dr Kopp:** *When we perform these analyses, we basically use the best case figures that Defence presents for these platforms. In other words, we do not apply a number of standard measures that you would use to, for instance, scale down availability or make assumptions of excess combat fuel consumption. We also made very optimistic assumptions about the drag or performance impact of the types of weapons involved. I would certainly be happy to take that on notice and give you a detailed summary, item by item, of specifically where we accounted for what performance parameters and precisely how we favoured the Defence case.*

**Response by Dr Carlo Kopp:**

Please refer to Annex B Page 130 (lower) of the 17th February Air Power Australia submission.

Cite:

'**Note on Analysis Method:**

The analysis technique and scoring method used is based upon ordinal comparison which is a technique where parameters are ranked by relative magnitude. The scoring is thus based on comparing a large number of parameters against a target, and ranking each score as superior / equal / inferior. This method was chosen over cardinal comparison, in which the relative magnitudes of parameters are each expressed as a number, such as a percentage. For many of the metrics in this annex, this ordinal method in fact favours the Joint Strike Fighter and the F/A-18A HUG, by concealing the scale of advantage enjoyed by the F-22A and F-111 in comparison. This analysis is therefore unusually conservative.'

*In simpler terms, the comparison involves ranking capability or performance, rather than scaling it. This is no different to athletes being awarded gold, silver, bronze, rather than being compared on the basis of performance numbers or scores measured during an event. A silver medal is still a silver medal even if its recipient finished a marathon 60 minutes after the winner did.*

In performing specific modelling of achievable combat effect, we have employed manufacturer's figures or KPP (Key Performance Parameter) figures for weights, fuel burns, engine thrust and weapons payloads.

As many of these these parameters have yet to be proven for the Joint Strike Fighter, and may not be fully met by a production configuration of the aircraft, these estimates will be inherently optimistic.

**Mr CAMERON THOMPSON:** *I refer to paragraph 4(c) of your submission, which is on page 105 in our area. You have listed an estimated price for 2,458 Joint Strike Fighters at $214 billion, which is just mind-boggling. Can you tell me the equivalent figure for the anticipated total of, as I understand it, 381 F-22s? Is there an equivalent overall price? We are talking about unit prices, in the end.*

**Response by Mr Peter Goon:**

The F-22 (ATF) Program achieved Milestone B Approval to enter the Engineering Manufacturing Development (EMD) Phase (now known as SDD) in 1990 with contract award in late 1990. The total program budget (FY90 dollars) was $US57,593.3 million, made up of an RDT&E budget of $US13,883.3 million and a Procurement Budget of $US43,710.0 million (FY90 dollars). This was for 648 aircraft.

The current program budget for the F-22 is $US62,600.0 million (FY05 dollars). The overall cost of development (RDT&E Budget) was about $29,500.0 million (now a sunk cost) with the remainder of the program budget being for procuring 185 aircraft.

In relation to the Joint Strike Fighter Program, Milestone B Approval was obtained in 2001 with contract award in 2002. According to US DoD Budgetary Reporting in 2002, the Joint Strike Fighter total program budget was $US221,400.0 million and made up of an RDT&E Budget of $US24,800.0 million and a Procurement Budget of $US196,600 million (FY02 dollars) for acquiring 2,866 aircraft.

The current (Dec 2005) program budget for the Joint Strike Fighter is reported as $US276,458.9 million, including an RDT&E Budget of some $US42,500 million, for procurement of 2,458 aircraft[18]

Air Power Australia analysis predicts a further nett increase to the Joint Strike Fighter Program reported budget of around $US12bn will be publicly announced around June this year.

Current trends in cost reporting, in particular the sub cost components related to materiel costs, sub contracting, workshare and contributions by partner countries, suggest there is a medium to medium high probability that the JSF Program Budget will overtake the $US300bn mark by the end of this calendar year (2006), if not sooner.

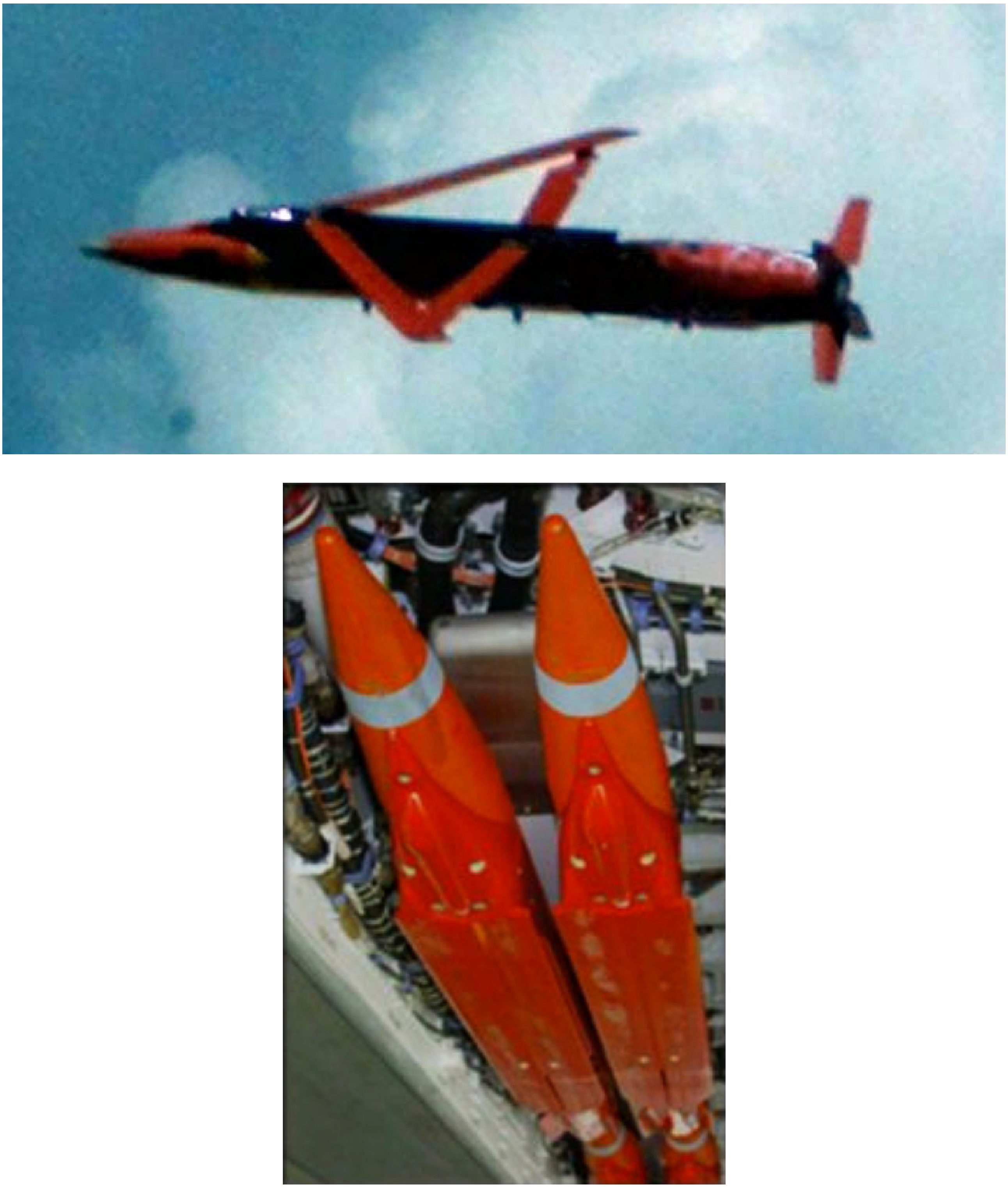

Figure 3: *The new GBU-39/B and GBU-40/B Small Diameter Bomb (upper) was designed around the weapon bay of the F-22A Raptor (lower), which can carry eight of these satellite/inertially guided precision bombs internally (US Air Force).*

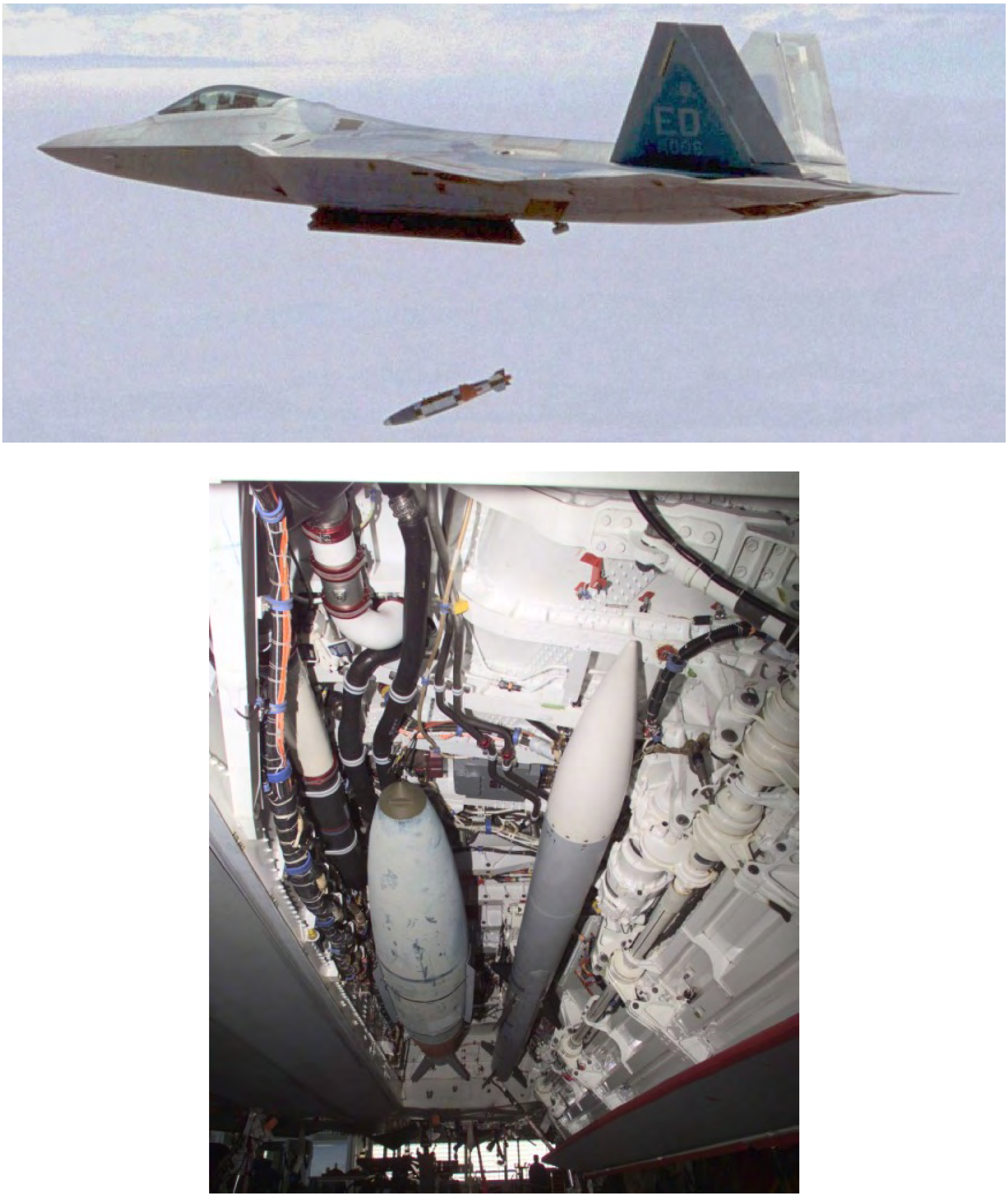


Figure 4: *The F-22A Raptor (upper), can carry a pair of GBU-32 JDAM satellite/inertially guided precision bombs internally. The weapon is wholly autonomous once released and can attack targets through cloud, unlike laser guided bombs which are limited to clear weather conditions. Recently developed enhancements include a radio datalink which permits the JDAM to be used against moving targets such as ground vehicles or shipping. The JDAM proved itself convincingly in Serbia, Afghanistan and Iraq (US Air Force).*

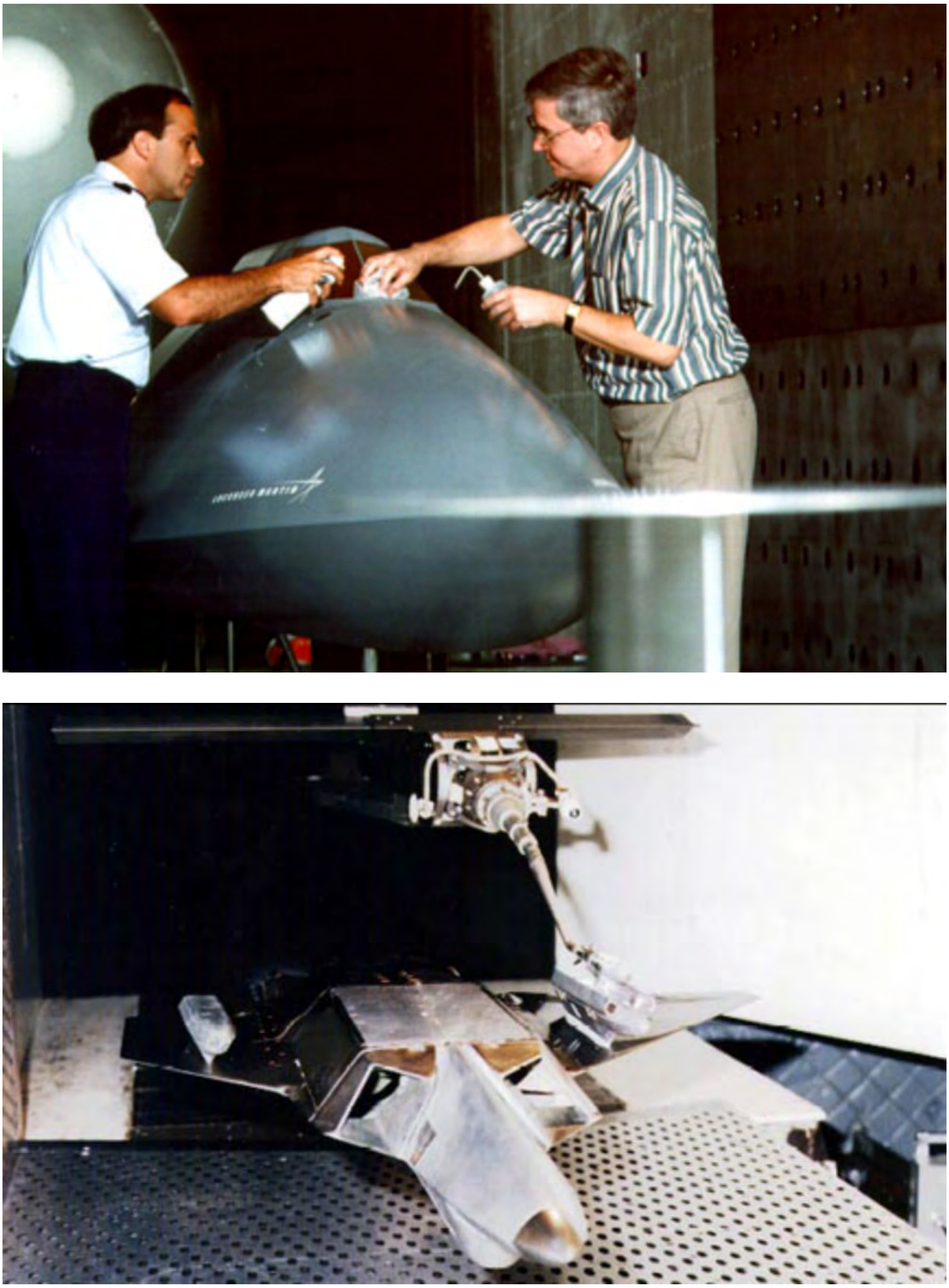

Figure 5: *The US Air Force has invested heavily in the development of a wide range of upgrades for the F-22A Raptor. The upper image depicts testing of an infrared electro-optical sensor fairing to be situated under the chin of the aircraft. The lower image shows wind tunnel testing of a Low Observable weapons pod to be carried on the aircraft's wing pylons (US Air Force).*

**AUSTRALIAN FLIGHT TEST SERVICES**
F-22A MODERNISATION ROAD MAP

## F-22A RAPTOR: USAF APPROVED MODERNISATION ROAD MAP

| PROGRAM DATE | 1.CAPABILITY |
|---|---|
| 2005 -<br>Initial Operational Capability (IOC) | Full Air-to-Air Capability<br>Basic Air-to-Ground (Strike / Attack) |
| IOC + 2 Years<br>(2007) | Improved Air-to-Air<br>Advanced Countermeasures<br>Improved Strike Attack<br>Highly Accurate Air-to-Ground on Ship Targeting (All Weather)<br>Increased Target Coverage with Small Diameter Bomb (SDB)<br>Improved Mission Interoperability<br>Expanded Data Link |
| IOC + 4 Years<br>(2009) | Air-to-Air Enhancements<br>Strike /Attack Enhancements<br>Systems<br>Weapons<br>Advanced Network Centric Capability<br>Global Grid Player<br>Reach Back / Reach Forward<br>Expanded ISR Capabilities |
| IOC + 6 Years<br>(2011) | Improved Advanced Air-to-Air<br>Improved Advanced Strike / Attack<br>Improved Advanced ISR |

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Figure 6: *The US Air Force modernisation roadmap for the F-22A Raptor, as defined in 2004. This series of progressive, incremental upgrades will see the F-22A Raptor fitted with additional strike, networking and ISR capabilities, most of which will be identical or derived from planned strike, networking and ISR capabilities in the Joint Strike Fighter.*

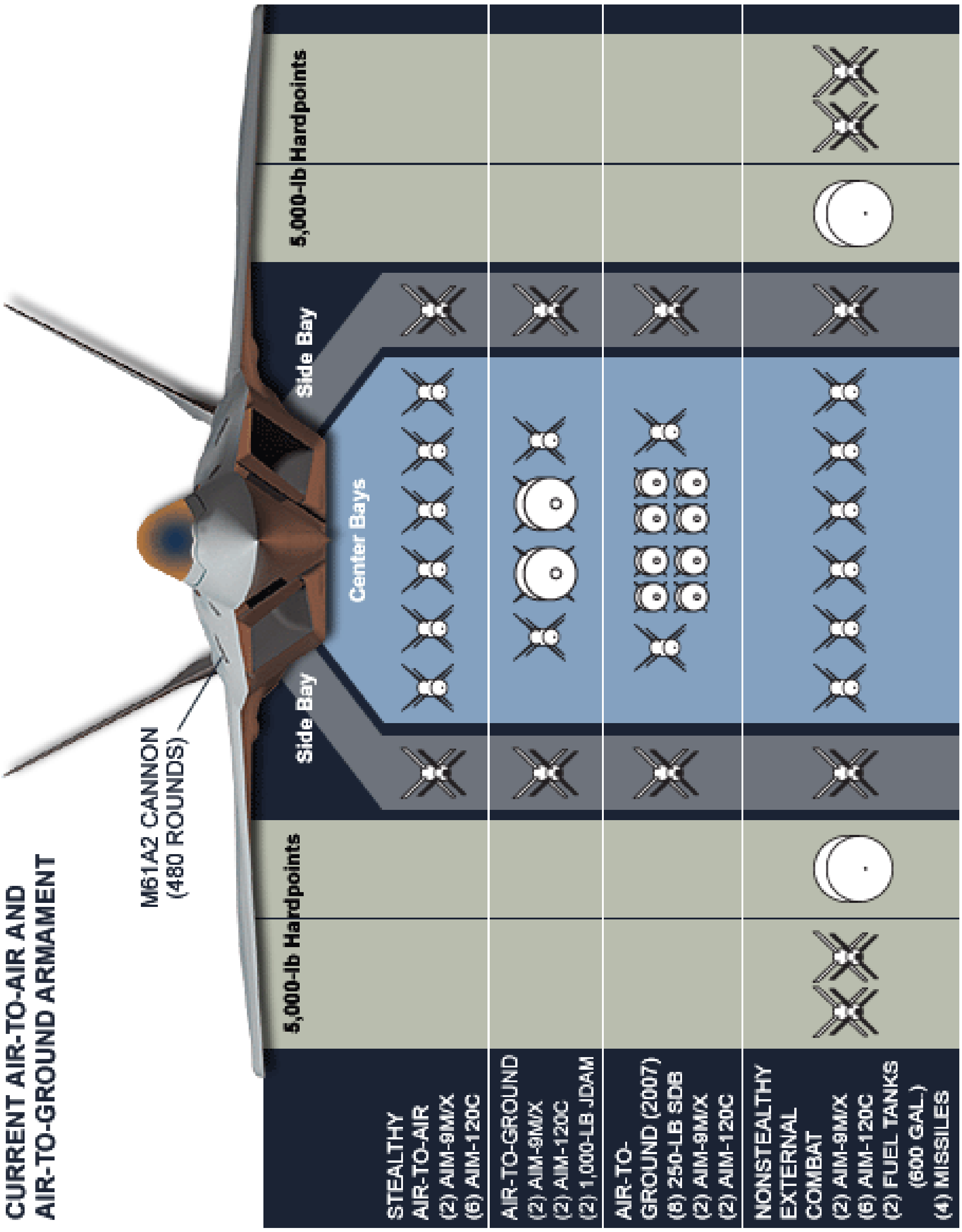


Figure 7: *F-22A Raptor weapons capabilities (Lockheed-Martin Image).*

# 3 Testing Defence Evidence to the Inquiry

The hearing on the 31st March, 2006, saw evidence presented by four parties: Air Power Australia, Dr Alan Stephens, formerly RAAF Historian and Deputy Director of the RAAF Air Power Studies Centre (now Aerospace Development Centre), the Kokoda Foundation, and Defence. This was later supplemented by Submission No 27 by the Department of Defence to this Inquiry.

This submission will test key items of evidence provided by Dr Alan Stephens, the Kokoda Foundation, and Defence against the hard metrics of available data and basic technology.

*Dr Stephens is without doubt Australia's outstanding authority on the past history of the RAAF. However, in the context of this Inquiry, Dr Stephens was one of the earliest public advocates of the idea that Australia should acquire the Joint Strike Fighter, a position articulated initially in his 2002 paper 'Armies, Stealth Fighters, and Homeland Defence', which predated Australia joining the Joint Strike Fighter SDD program by several months, and which some regard to be one of the key intellectual justifications used to support the decision to join*[19].

**Page 21, Dr Stephens: "Yes, I do. There is no question that the F-22A will be the outstanding air superiority fighter. Everyone accepts that. I say as someone who loves aeroplanes but who nevertheless is a taxpayer that I would be highly put out if we were to pay $200 million for a platform. We just do not need to do that. We can find another answer. It is unacceptable to me as a taxpayer to pay that kind of money."**

Given that the procurement cost of the Joint Strike Fighter in the timeframe of interest to Australia now matches or will exceed the procurement cost of the F-22A, Air Power Australia shares Dr Stephens' concern about platform costs. However, given the much greater capability of the F-22A over the Joint Strike Fighter, Air Power Australia assesses the F-22A to be excellent value for taxpayer's money, unlike the Joint Strike Fighter.

**Page 24, Mr CAMERON THOMPSON: "I am indebted to a gentleman from the media there. I was chasing prices before, and he gave me an estimate - I do not know how accurate this is that the cost of the F-22 program was so far $US68 billion for 183 aircraft. If you were to put a transmit receive ISR on top of that, what sort of a jump in price would that be? Do you have any idea?"**

**Dr Stephens: "Very small."**

**Mr CAMERON THOMPSON: "Very small?"**

**Dr Stephens: "I cannot give you a precise number. In that setting, it is small change, but I think it is indicative of the pressure the US Air Force have been under to keep the F-22 program from even greater congressional cuts that they have needed to look for savings wherever they could find them."**

Air Power Australia concurs with Dr Stephens' assessment that the cost of introducing a transmit receive ISR capability on the F-22A is trivial. If we assume this device will be a JTIDS/MIDS terminal, the installation would require primarily replacement terminal hardware, and some enhancements to the software. Current airborne terminal equipment can be acquired for costs of the order of $US250,000 to $500,000 apiece. Indeed, the cost of this capability, and other strike oriented enhancements, was embedded without growth in the original procurement budget for 270 F-22As.

Air Power Australia does not concur with Dr Stephens' observation that 'it is indicative of the pressure the US Air Force have been under to keep the F-22 program from even greater congressional cuts that they have needed to look for savings wherever they could find them'. The most recent and largest cut in numbers to the F-22A program was not produced by Congress, it was an arbitary budget balancing measure adopted, without supporting analysis, by the Office of the Secretary for Defence (OSD) in December 2004, under Program Budget Decision 753. This decision involved an arbitrary cut of around $US10.5 billion to the production budget, reducing production funding from 275 to 178 aircraft. Earlier reduction in numbers were mostly as a result of a Congressional budgetary cap, which permitted the US Air Force to buy as many F-22As as could be extracted from the capped budget. The capping measure saw numbers fluctuating between 322 and 275 aircraft.

*The Kokoda Foundation presented as an independent entity at the hearing. However, in the context of this Inquiry, it is important to note that the Kokoda Foundation is funded by the Department of Defence and a defence contractor, Jacobs Sverdrup Australia Pty Ltd, refer http://www.kokodafoundation.org/sponsor/sponsor.htm. Kokoda's stated research philosophy is that of close collaboration with Defence, cite "A notable feature of almost all Kokoda Foundation research is that it is undertaken in close cooperation with relevant senior officials and others who are directly engaged in relevant functions or who carry relevant responsibilities. Typically such projects involve two or more closed workshops that engage relevant senior officials and others with strong expertise of relevance to the future issues that are being considered. Because these projects rarely revolve around immediate policy imperatives, frank, open and free-ranging debate is the norm. Innovative new insights and approaches are frequently generated. Sponsoring organisations are always offered opportunities to participate in such closed workshops and other research activities.", refer http://www.kokodafoundation.org/projects/research.htm..*

**Page 28 - Mr Connery, Kokoda: "But when we came to our final analysis we kept JSF very much in the picture."**

The Kokoda Foundation report, entitled 'Australia's Future Joint Strike Fighter Fleet: How much is too little?', is focussed almost exclusively on analysing alternative scenarios, assuming the Air Force would be operating a fleet of Joint Strike Fighter aircraft. The report contains no technical or comparative analysis of alternative fighter aircraft. None of these scenarios accounted for developing capabilities across the region in a substantive fashion. No effort was made to estimate required numbers of tanker aircraft to credibly support the numbers of Joint Strike Fighter proposed for the various scenarios.

**Page 30, Prof Babbage, Kokoda: "If you look at the alternatives, you will have either substantially lesser capability in terms of half-generation prior aircraft or something like the F-22. The F-22 is a very expensive aeroplane, but let me make a few comments about it. In my view, it is almost a half-generation, a sort of third-generation, prior to the**

**JSF. I also agree with Alan when he said that many of the lessons from the F-22 program have been taken forward and integrated into the F-35, so it is a much more advanced aeroplane. I think there are enormous advantages. It is also a much more multirole aeroplane and it better suits our needs in terms of data gathering and its capacity to operate within a total network, and that is the way we will be operating. We can figure in all sorts of other things to make sure that the theatre environment - in fact, even the global environment - is much more networked than it has ever been, and that is the environment in which we will be doing almost everything, so I think it fits very well for us. I do believe it is more multirole."**

This statement contains multiple errors of fact.

The statement that '[F-22] is almost a half-generation, a sort of third-generation, prior to the JSF' is simply nonsense. It neglects the fact that the JSF is an attempt to engineer a fighter with third generation class aerodynamic performance, specifically in the category of the F-16 and F/A-18, using elements of technology developed for the F-22A, but excluding key technologies such as supersonic cruise and all aspect stealth. The US Air Force have repeatedly described the F-22A as a 'fifth generation fighter' in public statements over the last 12 months.

The statement that 'many of the lessons from the F-22 program have been taken forward and integrated into the F-35, so it is a much more advanced aeroplane' is a half truth, as many of the evolutions of F-22A technology intended for the Joint Strike Fighter have since been incorporated into planned F-22A upgrades. A specific example is the packaging technology for radar transmit receive modules, or the radar processor subsystem, both to be introduced in the Block 20 F-22A configuration. One of the key aims of the Joint Strike Fighter program was to drive down the cost of such components to drive down the cost of manufacturing the F-22A. In effect the Joint Strike Fighter development budget is a means of funding component production engineering technology for both programs. Claiming the Joint Strike Fighter to be 'a much more advanced aeroplane' is non-sequitur, in that both aircraft are made using the same key technologies.

The statement that 'It [JSF] is also a much more multirole aeroplane and it better suits our needs in terms of data gathering and its capacity to operate within a total network' is also nonsense. The F-22A is significantly more capable than the Joint Strike Fighter in air superiority, air defence, cruise missile defence, deep strike, electronic and radar reconnaissance roles. Even in the close air support and battlefield interdiction role the Joint Strike Fighter is being developed for, the F-22A can carry more external payload and is much more survivable against advanced mobile battlefield air defences such as the Russian S-300 system. The networking capabilities planned for the F-22A will provide the same class of capabilities as provided by the Joint Strike Fighter system.

The statement that 'I do believe it [JSF] is more multirole' cannot be supported by any available hard technical evidence[20].

**Page 30, Prof Babbage, Kokoda: "The F-22, as it is configured at the moment, is a fine air superiority fighter, but that is really about it. You can strap some things on it but it is not really configured to use them very effectively. The F-35 is, and, because it is very stealthy on top, unless you hang external things on it - and, of course, you can carry a**

**lot of things internally - it in fact changes the whole game. It has enough capacity to be very aggressive in taking on air defence systems, for instance going into harm's way and winning. I believe it will be very effective in those sorts of roles.**

This statement contains multiple errors of fact.

The statement that 'The F-22, as it is configured at the moment, is a fine air superiority fighter, but that is really about it. You can strap some things on it but it is not really configured to use them very effectively' misrepresents the capabilities of the F-22A. The baseline Initial Operational Capability configuration now in service includes internally carried GBU-31 JDAM satellite/inertially guided smart bombs, also cleared for supersonic release.

The JDAM provides the F-22A with an all weather autonomous strike weapon identical to that used in 2001 by US Air Force B-52H and B-1B aircraft to annihilate the Taliban - a very effective use of aerial precision strike capability. The US Air Force will replace its fleet of F-117A Nighthawk stealth fighters, flown by the 49th Fighter Wing at Holloman AFB, with F-22As over the next four years. If the claim that the F-22A 'is not really configured to use them very effectively' were truthful, why would the US Air Force be replacing its primary deep strike fighter with the F-22A?

The statement that the Joint Strike Fighter is 'very stealthy' is demonstrably false. The Joint Strike Fighter's stealth capability is so borderline, that it was reclassified as Low Observable rather than Very Low Observable, last year[21]. The Joint Strike Fighter lacks key Very Low Observable design features, both in the forward fuselage and rear fuselage areas. Its engine exhaust at best qualifies as reduced observable. The stealth capability of the Joint Strike Fighter is demonstrably far inferior to that on the B-2A and the F-22A, and is in many respects inferior to the soon to be retired F-117A Nighthawk stealth fighter.

The statement that 'It [JSF] has enough capacity to be very aggressive in taking on air defence systems, for instance going into harm's way and winning' is an error of fact, and directly contradicts planned US Air Force application of the Joint Strike Fighter and F-22A. In the US Air Force view, the F-22A is used to penetrate and defeat opposing air defence systems, to permit less survivable aircraft like the Joint Strike Fighter to operate without being shot down. The Kokoda Foundation are asserting the exact opposite to the US Air Force view of this problem.

**Page 30, Prof Babbage, Kokoda: "There is another thing that I have not heard mentioned so far. I personally believe the F-22 will be extremely difficult to sustain and maintain after about 15 years. Look at the numbers of aircraft that are being bought. If we bought it - that is, on the assumption that the Americans would sell it to us, and I think that is a very big assumption; I am very doubtful about that - it would be only the USAF and us. What would be the assumptions we could build in about sustaining that aircraft? Would it be all we bought? If it were going to be a two-type fleet, the logistic costs of running two aircraft types are horrific. I would suggest to you that that is something that we would best avoid if we could. I believe we have the option of avoiding it, so why bother going down that track when, frankly, in just about every measure, it seems to me that the F35 is a better choice."**

This statement contains multiple errors of fact.

The F-22A has an intended structural design life of around 8,000 flight hours, which is greater than the 4,000 to 6,000 hours typical of 1980s generation fighter designs, which will be flown for around 30 years. It is reasonable to expect that the US Air Force will operate its F-22A fleet for around 40 years. As the F-22A is the top tier of the US Air Force fighter fleet, it will be the first to receive technology and capability upgrades, as has been the case previously with the F-15C-E fighter. As the critical 'enabler capability' for all other US capabilities, support for the F-22A will be prioritised over other fighter aircraft. The notion that 'the F-22 will be extremely difficult to sustain and maintain after about 15 years' directly conflicts with intended US usage of the F-22A, and conflicts directly with the history of how the US support such assets. There is no rational foundation for this claim by the Kokoda Foundation.

There is also no rational basis for the claimed doubts that the US would supply the F-22A to Australia. The Molloy paper makes this abundantly clear.

The claim that the 'logistic costs of running two aircraft types are horrific' is emotive and not supported by numbers. The argument asserted by the Kokoda Foundation is predicated on the assumption that the Joint Strike Fighter can cover the role spectrum adequately and that it does not require supporting assets. Neither of these assumptions are true. If there is an incremental difference in logistical costs between operating a single type fleet or a two type fleet, that difference must be compared against the overall cost in supporting assets for either fleet. The Joint Strike Fighter presents genuine difficulties in this respect, since its small size and payload force larger numbers to be used to achieve equivalent military effect, and this in turn forces more intensive use of larger numbers of aerial refuelling tankers, with concomitant costs in fighter escorts.

**Page 32, Prof. Babbage, Kokoda: "Let me just make a few comments, and I think there are others in the room who might be able to go further. Because the sensors are so good, we are now seeing, for instance, in Iraq, some fighter-bomber and other aircraft being used to monitor movements on and around critical routes. I think we are going to see a lot more of that. This aircraft is going to have far greater surveillance capability. There are all sorts of other things. For example, if you think of what we often call a littoral warfare environment - that is, a coastal environment where there might be a lot of islands - and the sort of complexity that can a rise there, you may want to look for, say, fighter or other aircraft in the area and monitor what they are doing, and you can do that, but you might at the same time want to scan certain areas of the surface for, maybe, a convoy moving down the road or you might want to actually monitor something completely irrelevant. My understanding, from talking to some of the technical people, is that it may even be possible to reprogram the radar to look at, for instance, submarine snorkels or something really bizarre that you would not normally ask a fighter aircraft to do - it is not normally configured to do it - but, because the sensors are software-reprogrammable, it is technically feasible to do it. You might actually get quite good performance and, if that is all you have in the theatre, it could do a really good job for you."**

This statement contains misunderstandings in several areas.

The reference to the use of fighter-bombers in Iraq pertains to the use of what the US Air Force term 'unconventional ISR missions'. This is a very specific niche role, in which a combat aircraft is used to support a small formation of ground troops performing counter-insurgency operations, as a substitute for an unmanned surveillance aircraft. This role involves the aircraft providing a 'God's Eye' view of the area surrounding the ground force, providing assistance to ground troops in tracking insurgents, and providing bombing support if required. This role is a direct evolution of the persistent air support techniques developed in Australia during the 1980s by AVM P.J. Criss (ret), then OC 82WG, using the F-111, migrated to the US Air Force 48th Tactical Fighter Wing, used in Iraq in 1991, and further developed by the US Air Force since[22].

While any combat aircraft with a thermal imaging targeting system can be used in this fashion, the technique specifically favours aircraft which carry a large payload of fuel and weapons, as they can 'persist' over the area of interest much longer. The notion that the Joint Strike Fighter is specifically well suited to the 'unconventional ISR mission' is not correct, as it has lesser endurance and weapon payload than many alternatives. A legacy F-15E using the Sniper XR targeting pod provides the same ISR capability, as the Joint Strike Fighter's EOTS sensor is a derivative of the Sniper XR system, yet the F-15E carries more weapons and fuel and can thus orbit longer.

The critical metric of aircraft suitability for this role is its endurance on internal fuel and weapon payload, since sensors for the 'unconventional ISR mission' or persistent battlefield air support can be readily and economically retorfitted on any combat aircraft. The US Air Force are currently retrofitting targeting pods on the 1962 built B-52H, the 1985 built B-1B and the 1970s built A-10 aircraft for exactly this reason. The Joint Strike Fighter's sensor capabilities for this role are not unique, but its size limits its utility.

The cited hearsay claims that the Joint Strike Fighter's APG-81 fire control radar could be reprogrammed to detect 'submarine snorkels or something really bizarre that you would not normally ask a fighter aircraft to do - it is not normally configured to do it - but, because the sensors are software-reprogrammable, it is technically feasible to do it. You might actually get quite good performance...' indicate a deep misunderstanding of the design optimisations of this class of fire control radar.

The APG-81 is optimised for the battlefield interdiction role, and has specific design features intended to provide very high resolution ground mapping (SAR mode) and detection of moving ground vehicles (GMTI). The radar will do a superb job performing these two specific tasks. A submarine snorkel is however a very different category of target, with a much lower X-band radar signature in comparison with a truck, tank, 4WD or other ground vehicle. Typically, radars optimised for detecting submarine snorkels produce much higher peak power emissions than fighter fire control radars, since snorkels are such small targets. The notion that software changes can provide capabilities that hardware limitations in a radar prevent is simply nonsense, and the notion that 'You might actually get quite good performance' is nonsequitur, and completely unsupportable.

The party who provided this hearsay evidence to the Kokoda Foundation is evidently not literate in radar design technique.

It is worth stating for the record that the F-22A has significant ISR capabilities and the US Air Force intends to use it as much in ISR roles as in strike and counter-air roles.

The F-22A's APG-77 radar is the most powerful multimode fighter radar the US has designed to date and is intended to provide in addition to air-to-air modes, also high resolution Synthetic Aperture (SAR) ground mapping modes, and surface Moving Target Indicator (MTI) modes. These are capabilities similar to those in the APG-81 on the Joint Strike Fighter, but in a more powerful radar which thus permits a footprint around twice that of the APG-81 on the Joint Strike Fighter. In addition planned enhancements to the APG-77 include auxiliary side looking antenna arrays which provide for 270° coverage. The APG-77 will use the same low cost antenna module packaging developed and paid for in Joint Strike Fighter SDD funding, and shares the new radar processor computer developed and paid for in Joint Strike Fighter SDD.

The F-22A's ALR-94 passive surveillance system is the most capable to ever be developed for a fighter, and is specifically intended to detect faint targets. It will be used to not only attack opposing radar and air defence missile systems, but also to collect electronic intelligence. The Joint Strike Fighter's equivalent system is much less capable due to the less demanding needs of battlefield strike operations.

Air Power Australia's assessment is that additional electro-optical ISR capabilities will appear as enhancements on the F-22A over the next decade, as the US no longer has a survivable electro-optical ISR system for performing reconnaissance in heavily defended airspace. Such capabilities are likely to be implemented as weapon bay payloads, used no differently than podded electro-optical ISR systems now used on legacy fighters[23].

**Page 35, Prof. Babbage, Kokoda: "Let me also make the broader point that, when you look at the performance of our defence capabilities into the future and you project where we are likely to be in, say, 20 to 25 years time, a really important question is: will the JSF as we expect it to be configured be well and truly adequate to perform its roles with high security? I think there is absolutely no question about that; it definitely will be able to. It is far more stealthy than anything we or, for that matter, the region have ever seen."**

This statement amounts to an unsupported and unsupportable assertion of opinion. The Joint Strike Fighter has numerous design limitations which make it poorly suited to performing in air superiority roles, and is not well suited to long range strike roles or persistent strike roles. The stealth capability of the Joint Strike Fighter is optimised for the battlefield environment, making it poorly adapted to air superiority and deep strike roles.

**Page 39, Air Marshal Shepherd: "Analysis and commonsense show that 30 to 40 airframes, no matter how capable they are, will not be enough to defend Australia."**

Air Power Australia have asserted from the outset that Australia's fighter fleet should have at least 70 high capability category combat aircraft. Repeated public claims by the Defence leadership that Australia could only afford to acquire 30 to 40 F-22A Raptor aircraft are at odds with publicly available evidence on the cost of the F-22A Raptor and Joint Strike Fighter aircraft. Given that the Joint Strike Fighter is now likely to cost more than the F-22A Raptor, the funding planned for the Joint Strike Fighter would easily fund adequate numbers of the F-22A Raptor.

**Page 41, Mr Pezzullo: "The government's outstanding guidance for Defence is contained in the Defence White Paper 2000. That lays out the foundational basis upon which we do all of our planning, be that for air combat, or other capabilities, and it certainly guides the work that I do and the work that General Hurley does down the line from me in terms of developing capability strategies for government consideration.**

**There have been two updates, as this committee would be well aware, to that document, but the fundamental policy, as the Prime Minister reaffirmed last December, remains the Defence 2000 White Paper. That is what we have to go on. We are not military or aviation enthusiasts, who just go off in the blue sky, if I can dare say that, and design our own capabilities independent of government direction. Government direction, of course, is informed by professional advice that we provide to them. The government has laid down quite clearly what it requires from us in terms of air combat capability. The White Paper determines that Defence will maintain and further develop and integrate and balance a joint force comprised of principally maritime capabilities which is to say mostly air and naval forces that can defend Australia by denying the air and sea approaches to Australia by any credible hostile force.**

**That is on the public record; it is unclassified information. It also requires certain other things from intelligence capability, strike capability and land forces that are not directly germane here, although they have a bearing when you look at the totality of how we achieve military effects."**

This statement is non-sequitur as the Deputy Secretary attributes current interpretation of strategy to 'Government direction'. Concurrently, he also argues that this direction is 'informed by professional advice that we provide to them'. Clearly that 'professional advice' did not include advice that a number of key underpinning assumptions in the 2000 Defence White Paper are no longer valid.

Determining whether the failure to provide such advice to Government was a strategic analysis failure on the part of the Deputy Secretary, or an artifact of other difficulties within Defence, is beyond the scope of this discussion.

What is clear is that current thinking on strategy within the upper echelons of Defence is not taking into account the growth in regional power projection capabilities, with the consequent option of use of coercive power against Australia, while it is also not taking into account developing and extant pressures on the United States, articulated very clearly in the Quadrennial Defense Review report.

Further statements by the Deputy Secretary, in reference to the Air Power Australia submission to the Committee, make this quite clear:

**Page 42, Mr Pezzullo: "The scenario, and it is scenario based, that ultimately is embedded in the alternative submission, is predicated upon a massive erosion of US military and strategic capability. It is predicated upon Australia having to operate independently beyond our immediate regions, as I have defined them in my earlier remarks. It is predicated upon a radically different set of strategic circumstances which, I must say, I do not necessarily see even in the most speculative parts of my crystal ball.**

**The scenario sketched out in the comprehensive submission that you have before you from another party would require, and therefore by definition there would be, a strong element of lead time and warning time be available to us. It would require government of whichever persuasion to radically rethink the scale of its defence budget and the level of investment, particularly in capital.**

**It would require Australia to become self-reliant in a much larger force. It would also require and I think this is the most problematic set of assumptions that our access to the alliance capability and interoperability that we seek to have with our US alliance partners, in a whole range of scenarios and contingencies, be extinguished almost to zero. The only basis upon which I could see that arising would be through a massive political rupture in the relationship. It would also require a massive erosion of the US military capability edge which, again, I do not foresee even in the most speculative parts of my crystal ball."**

The analysis in the Air Power Australia submission was capability based rather than scenario based, and focussed on strategic options available to regional players. The claim that it is scenario based is an incorrect assertion.

As noted previously in this submission, 'a strong element of lead time and warning time be available to us' is not a valid assumption. Once capabilities are in place within the region, a decision to use them against Australia is function of intent of the owner of these capabilities, and any perceived sanctions the owner may assess as risks following the use or threat of use of these capabilities[24].

The claim that the Air Power Australia submission assumes the loss of 'alliance capability and interoperability that we seek to have with our US alliance partners' is false. However, what is more relevant is that having access to 'alliance capability and interoperability' has no bearing on a decision by a regional player to use or coercively threaten the use of a power projection capability against Australia. How 'interoperability' with the United States has any bearing on this matter is wholly unclear, but this statement does illustrate yet again a problem arising in statements by Defence officials, where language is used imprecisely.

The Deputy Secretary asserts that 'The only basis upon which I could see that arising would be through a massive political rupture in the relationship.' This is also non sequitur in the sense that Australia could have a firm commitment to intervention on the part of the United States yet it could still be subjected to threats of attack or an actual attack, both well within timescales that the United States would have difficulty in responding to.

The claim that 'It would also require a massive erosion of the US military capability edge which, again, I do not foresee even in the most speculative parts of my crystal ball' clearly illustrates that the Deputy Secretary has not understood the Quadrennial Defense Review report or its immediate and longer term implications. Erosion of US capabilities is now under way and the point at which it 'bottoms out' remains to be determined.

Subsequent evidence by the Deputy Secretary reinforces these conclusions:

**Page 42, Mr Pezzullo: "But also in terms of the most speculative parts of the crystal ball**

**that I can see, it is one that we do not plan for that is to say a fully networked air force attacking Australia where Australia had no access to the kind of network capabilities that we have been touching on, where Australia's alliance had completely disintegrated for political capability or whatever reasons is something that exists in a parallel universe. I do not mean to say that dismissively."**

For a regional nation to successfully launch a cruise missile attack on Australia or a target of strategic importance to Australia does not require that nation to have a 'fully networked air force'. Indeed, Germany's large scale use of V-1 cruise missiles against the UK in 1944 predated the existence of digital communications technology. This assumption is simply false.

In terms of Australia losing the use of its planned networking capabilities, it does not require that 'Australia's alliance had completely disintegrated for political, capability or whatever reasons'. The use of long range missiles such as the Russian designed R-172 or R-37 against Airborne Early Warning and Control aircraft, or against any aerial refuelling tanker aircraft used as network relays, would substantially deny the availability of the network. No differently, the use of suitable jammer equipment could also degrade the network, or preclude its use while being jammed. There is no requirement for an attacking air force to be networked to use either 'anti-AWACS' long range missiles or high power jamming equipment. Marketing materials produced by Sukhoi now available on the Internet clearly illustrate that disruption of networks and destruction of Airborne Early Warning and Control aircraft by long range missile attack are a major selling point in the marketing of Sukhoi fighter aircraft globally. The implicit assumption in the evidence provided by the Deputy Secretary that such capabilities will not be available to regional operators or indeed used is simply not supportable by the evidence. Indeed, development of these technologies was initiated during the last months of the Cold War by the Soviets to 'equalise' the odds in combat against NATO, which would have had an overwhelming advantage otherwise.

Equally so the notion that such capabilities cannot be operated by regional nations is nonsense - India is now tooling up to manufacture the R-172 missile, and used the TKS-2 intra-flight network to defeat US Air Force F-15Cs in the Cope India exercise.

*It is clear beyond any doubt that senior Defence officials do not understand the import of strategic changes to the region and strategic changes in United States' capabilities, and the impact of these strategic changes upon Australia. It is also clear, beyond any doubt, that senior Defence officials have not provided sound advice to Government on these matters. It is unclear why senior Defence officials impute that responsibility for this situation lies with the Government, as there is no evidence to support that proposition.*

The reality that developing regional capabilities and erosion of US power invalidate some of the assumptions underpinning the 2000 Defence White Paper does not invalidate the basic denial model espoused by that document.

*The denial strategy model remains the best choice for Australia and will remain so unless Australia changes demographically to the extent that it can support an ADF twice or more the size of the current ADF. From a strategy perspective, a simple Strategic Update document which redefines how Australia sees the region would be adequate, were this redefinition to include 'all regional nations* *which have or are developing the capability to deliver strikes against the Australian mainland or Australia's interests in the region'.*

Such a redefinition was first proposed by one of the authors of this submission in a June 2000 ministerial submission, and has been the basis of subsequent related submissions[25].

In force structure terms, extending the credible footprint of the ADF to permit effective denial operations beyond South East Asia requires primarily additional aerial refuelling aircraft, in credible numbers, and retention of the type of long range strike capability characteristic of the F-111. Some growth in satellite and HF communications would also be required.

*In strategy terms, the additional reach of the ADF afforded by a much larger fleet of aerial refuelling tankers and strike aircraft with greater range than the Joint Strike Fighter also translates into the ability to project a significantly larger number of RAAF combat aircraft across South East Asia, than current planning permits. This is strategically important since it acts as a deterrent to any major regional player gaining basing access within South East Asia, with the aim of intimidating Australia.*

Considerations of capability need arising from a redefined regional footprint for the ADF are not confined to the projection of striking power with deterrent aims alone.

The reality is that the ADF will need a significantly stronger capability to deter and discourage, or defeat any long range strikes launched from outside South East Asian geography. This is now a strategic inevitability.

This capability depends as much on having sufficiently robust aerial refuelling capability to deploy and maintain uninterrupted air defence coverage across the North and North West of the continent, as it is dependent on having F-22A Raptor aircraft to engage opposing fighters, supersonic strategic bombers and launched cruise missiles, and sufficient numbers of supporting Airborne Early Warning and Control aircraft.

*It takes very little analysis to observe that current planning, centred on the Joint Strike Fighter, will not provide the type of capability required to be credible. The F-22A is far better suited for this role by virtue of its supersonic cruise capability and much better radar footprint and missile payload. The Joint Strike Fighter may well be a good choice for battlefield interdiction and close air support of ground troops, but it is out of its league as an air superiority and air defence fighter.*

A detailed discussion of the capability needs to be filled to achieve a credible capability for the ADF in dealing with the developing region is provided in the preceding Air Power Australia Submission 20 entitled 'Attaining Air Superiority in the Region'[26].

**Page 44, Air Marshal Shepherd: "As the sole operator of the F-111 in the world, we have an excellent understanding of what it takes to operate and maintain it. We know there are significant issues to be addressed to extend its life. Importantly, we need to look at the total risk involved with extending the operational life of the F-111. " "There are increasing and unknown structural and systems risks with the wings, the airframes, the electrics and the hydraulics as the platform nears the end of its fourth decade of life."**

If these risks are 'unknown', as the Air Marshal claims, then how does he know they are increasing, let alone that they exist at all?

If there are major problems 'with wings, airframe, electrics and hydraulic systems', then how can the aircraft still be considered safe to fly or to retain its airworthiness certification ?

Moreover, if he really does 'have an excellent understanding of what it takes to operate and maintain' then how is it that he is basing this statement on risks that are 'unknown'?

These pronouncements by CAF are not supported by fact.

For instance, in the 1980's there certainly were some problems with the aircraft's hydraulics - the horizontal tail servo actuator (HTSA), the spoiler actuators and the servo damper assemblies, to name but a few of the problem components. These were maintenance-related problems which the RAAF in conjunction with an SME in the Australian Defence Industry, Rosebank Engineering, set about addressing and solving. The solutions were such complete successes that Rosebank Engineering, in fact, did itself 'out of a job', so to speak, since the number of maintenance arisings on the F-111 hydraulic system dropped so markedly such that the pipeline of items requiring repair and maintenance largely much dried up for Rosebank.

Addressing the other areas of the Air Marshal's expressed concerns, one need only read the original draft reports from the Sole Operator Program (SOP) undertaken by the DSTO and talk, on a professional basis, with those engineers and scientists who did the work to realise these cannot be the cause for the Air Marshal's concerns.

Finally, these reports along with what is known as the F-111 Support Study formed the basis for the Government directing and funding the Defence 2000 White Paper position of retiring the F/A-18s around 2012 and operating the F-111 fleet through to 2020.

**Page 40, Air Marshal Shepherd: "There is an avionics and capability risk with respect to obsolescence and the ability of the aircraft to be competitive in the complex future air defence environment." "We would need to do a massive avionics, weapons and electronic warfare upgrade to make the aircraft even adequately operationally capable and survivable. Importantly, even then, it would not match the strike capability of the JSF."**

The reality of this digital era is that all avionics used in combat aircraft are being continuously incrementally upgraded to maintain competitiveness in capability and to ensure supportability. The expectation that any combat aircraft can retain a specific avionics configuration for a long period of time is wishful thinking, and nostalgia for a world which vanished over a decade ago. It matters not whether the aircraft is a Joint Strike Fighter, F-22A or F-111, the reality of this era and the future is that avionics must evolve to maintain capability and supportability. The F-111 is in this respect no different from any other combat aircraft now in service.

The notion that an 'avionics and capability risk with respect to obsolescence and the ability of the aircraft to be competitive in the complex future air defence environment' is nonsequitur, insofar as what remaining legacy avionics hardware exists in the F-111 is there due to decisions made by the Defence leadership to cancel long planned for avionic upgrades on the F-111. The Defence leadership created a situation where planned upgrades were stopped, and is now asserting that the absence of capabilities resulting from these stopped upgrades is a risk requiring retirement of the aircraft.

The claim that 'We would need to do a massive avionics, weapons and electronic warfare upgrade to make the aircraft even adequately operationally capable and survivable' is not supported by fact.

The F-111 has a state of the art core avionic suite introduced during the 1990s Avionic Upgrade Program (AUP), and since then incrementally enhanced with additional hardware and software, with the current Block C-4 configuration including the Mil-Std-1760 weapons interface capability required to support all of the latest generation weapons planned for the Joint Strike Fighter. Much of this hardware is current production technology.

The aircraft was recently equipped with the state of the art Elta 8222 electronic warfare pod, and the AGM-142 Stand Off Weapon.

The remaining items of legacy avionic equipment requiring replacement are the radar suite, comprising the attack radar and terrain following radar, some components in the Pave Tack targeting pod, the legacy Radar Warning Receiver, and legacy cockpit displays. Replacing these does not and cannot constitute a 'massive avionics, weapons and electronic warfare upgrade' by any stretch of the imagination.

There is an abundance of affordable production radar equipment, electro-optical hardware, electronic warfare equipment and cockpit displays available in the current market, specifically designed for incremental upgrades of in service aircraft. The cost of integrating this equipment has declined strongly since the 1980s, as digital technology has dominated the market. If it were otherwise, we would not see the large scale upgrade effort underway in the US across the whole US fleet of military aircraft, including many types which predate the F-111 in service[27].

The claim 'importantly, even then, it would not match the strike capability of the JSF' is extraordinary, in that it almost completely attributes strike capability to the capabilities of the aircrafts' respective avionic suites. The assessment of strike capability in any aircraft must encompass the capabilities of the avionics, the available weapons suite, and the aerodynamic performance capabilities of the aircraft.

Importantly, contemporary avionics and weapons can be typically integrated into any aircraft design, and often at very low cost, compared to new aircraft.

If we compare the strike capabilities of the Joint Strike Fighter against an F-111 with even a minimal package of avionic upgrades to replace remaining legacy hardware, and to introduce a networking terminal, the Joint Strike Fighter is not credible. The F-111 will be capable of delivering all of the strike weapons planned for the Joint Strike Fighter, it will carry twice as many weapons to a much greater distance, it has much greater persistance over the battlefield, and it would have most of the sensor capabilities planned for the Joint Strike Fighter. Defence have since 2003 avoided discussion of which metrics they apply to assessing strike capability. This is understandable, since all established metrics for hard comparisons do not favour the Joint Strike Fighter even in comparison with an F-111 provided with the most basic of technology upgrades.

At the most fundamental level, the philosophy espoused by Defence in comparing the F-111 and Joint Strike Fighter departs from decades of established and proven thinking on how to assess the worth of strike aircraft, and two decades worth of global experience in integrating modern avionics.

Like many other aspects of the contemporary Defence view of the world, it diverges from global best practice almost completely.

**Page 44, Air Marshal Shepherd: "Add to this the ongoing costs of maintaining a dual fleet, half of which would be an orphaned system, and the associated training and logistics systems supporting both types."**

This statement displays a focus in which operational costs and capability are deemed to be of no significance in comparison with overheads in fleet maintenance. This departs from established global best practice, and specifically from the model used by the US Air Force.

As Air Power Australia observed in earlier evidence, the aggregate cost of delivering a capability must be assessed across the whole combat fleet to form meaningful judgements of what is more expensive. The logistical cost of operating two types may well be higher than that of operating one type, but if that single type incurs much higher operational costs by forcing heavier use of larger numbers of tanker aircraft or other supporting assets, the single type is more expensive. This is rational economic thinking, as compared to the philosophy espoused by Defence in which such 'big picture' costs are not employed as a measure of economics in fleet operation.

Most of the ADF's aircraft fleet qualifies as 'orphaned', insofar as unique configurations are used. The Boeing 707 configuration is unique, the F/A-18A HUG configuration is unique, the AP-3C Orion configuration is unique, the Wedgetail AEW&C configuration is unique, much of the helicopter fleet is unique. In fact one is hard pressed to find any ADF aircraft type which is identical in configuration to the same type of aircraft in service overseas. The notion that the F-111 is somehow different in this respect is non-sequitur.

Australia's capability needs will often differ in detail from those of foreign operators, and the result is that ADF will often require unique avionics, weapons or other hardware on platforms which are not common to foreign operators. Indeed, if Australia wishes to maintain any semblance of competition in the procurement of upgrades, Australia must allow for a signficant proportion of ADF platform configurations which are not identical to major foreign operators.

Another consideration is Australia's industrial base. Unique or 'orphaned systems' force the maintenance of the engineering and software skills sets required to modify, upgrade and maintain them. This capability is essential if Australia is to maintain the expertise in country to even understand, let alone evolve modern high technology military equipment.

If the implication by AM Shepherd is accepted, that 'orphaned systems' are somehow undesirable, and the ADF should use only equipment identical to foreign operators, then this has far reaching implications. It is an acceptance of the idea that there should be no competition in upgrade procurement, no uniquely Australian weapon configurations, and no maintenance of engineering integration and support expertise in the industrial base. This is not a 'strawman argument' on the part of Air Power Australia, since this issue was raised in evidence to the committee in 2004.

The incremental economic benefits of a single type fleet are less significant than the operational economic costs incurred by a single type fleet, and impose the further burdens of loss of national expertise in the industrial base and reduced competition in procurement of upgrades. These 'big picture' considerations are of greater importance than any incremental economic benefits of a single type fleet.

**Page 40, Air Marshal Shepherd: "When we did the avionics upgrade program on the F-111 in the 1980s and 1990s, we piggybacked on the similar US Pacer Strike program. This time we would have to go it alone, and that introduces industry risk. "**

1. The AUP contract was awarded to Rockwell Systems Group in 1989. The bulk of the in country work was performed in the 1990s by the people who now form the Boeing Australia workforce, responsible for, inter alia, the deeper level maintenance of the F-111 fleet - the R4 and R5 servicings plus the Block Upgrade Program.
2. The US F-111 Pacer Strike upgrade was the basis of the Australian F-111 Avionics Update Program (AUP) but this activity incorporated a lot of Australian innovation and know how. The AUP system is largely unique in its internal architecture, software, and much of the hardware[28].
3. To 'go it alone', does not introduce 'industry risk' if the requisite competencies, knowledge and skill sets are applied to the task. For example -
   (a) Project Kestrel. Hawker Pacific (now part of Australian Aerospace) developed and undertook the zeroing of the fatigue lives of the six RNZAF Orion P-3K aircraft at a cost of some $NZ96 million. The project involved incorporating new wings, new centre fuselage wing carry through section, fully refurbished empennage and re-manufactured engine nacelles. This project was a huge success.
   (b) Anzac Ships. A success by any measure, despite some teething troubles.
   (c) AIR 5276 - P-3 Avionics Update Program. This program produced the AP-3C, regarded by many in the Maritime Patrol Community as one of the finest avionics suites in the world P-3 fleet.
   (d) F-111 Hydraulic System Component Repair and Overhaul. Australian Industry went it alone, in conjunction with RAAF Engineers, and solved all the problems as well as established a unique in-country capability.
   (e) F-111 Wing Recovery Program. After a difficult start following the catastrophic failure of the DSTO test article, a resounding success.

4. This statement not only misrepresents the history of the AUP program, but it displays a poor understanding of other industry programs, and typifies the 'cultural cringe' that grips some within the ranks of senior Defence officials.

**Page 40, Air Marshal Shepherd: "We know completely the ability of Australian Industry to support this aircraft now, and we are not sanguine at all that a major upgrade would be achievable and supportable within Australia."**

Preceding and following evidence provided by Defence indicates that Defence have a poor understanding of Australian Industry capabilities, and do not appreciate the access to global industry capabilities available to Australian Industry. Providing that judicious choices are made in which contractors are chosen to perform which tasks in any series of upgrades, all of the required skills for future F-111 upgrades and support are available.

The 'due diligence' effort performed in preparing the 2001 Evolved F-111 proposal included a survey of industry capabilities, and numerous discussions with potential suppliers and team members. The proposal was specifically structured around available industry capabilities.

This statement by AM Shepherd displaying a lack of confidence is predicated on the expectation that the F-111 would require a 'major upgrade', which is provably not the case. All of the upgrades required for the F-111 are incremental and could be performed separately, staggering them over a period of several years, to minimise the budgetary impact and risk. The idea that all should be performed concurrently misrepresents what opportunities exist for risk control.

**Page 40, Air Marshal Shepherd: "Any upgrade would also be expensive-in the order of five to eight billion dollars possibly-and would require additional funding on top of that for the F-22."**

*The claim that 'any [F-111] upgrade would also be expensive - in the order of five to eight billion dollars' can only be described as completely absurd and at odds with a vast amount of empirical evidence.*

An upgrade for around 30 combat aircraft costing 5 to 8 billion dollars puts the unit program cost per aircraft at around $167 million to $267 million, which is of the order of the cost of new F-22A or Joint Strike Fighter aircraft.

At the unit costs of the order claimed by Defence, it would be feasible to build new tooling and manufacture new F-111 aircraft.

For comparison, the cost of the F-111 AUP program was of the order of $0.5 to $1 billion, the proposed but never implemented conversion of the F-111G avionic suite to F-111C AUP configuration was of the order of $100 million.

Another good comparison is the US Navy F/A-18E/F Super Hornet program. The cost of developing a largely new and unique airframe, new engines, a substantially new avionic suite and performing integration and testing was of the order of $US5 billion, during the 1990s. The currently cited cost for the development of the EA-18G Growler electronic attack variant of this fighter, with substantially new high power jamming avionics system, is of the order of $US1 billion, with the procurement cost of 90 of these aircraft at $US8.49 billion[29].

Defence are claiming that a major avionic upgrade - not that a major upgrade is required on the F-111 - would incur a similar aggregate cost to the complete development of a new derivative combat aircraft, as was the case with the F/A-18E/F Super Hornet, and also that such an upgrade would be several times the cost of the complete development of the new avionic package for the EA-18G Growler electronic attack aircraft.

Even if the assumptions underpinning this remarkable claim are predicated on the idea that Australia's defence acquisition system is so broken that it cannot deliver credible and affordable upgrades, the cost estimates claimed by Defence are simply not credible by any rational measure.

The issue of actual upgrade costs for the F-111 was addressed in detailed evidence to this Committee in 2004, in Submission 5, entitled Review of Defence Annual Report 2002-03: Analysis of Department of Defence Responses, date June 18, 2004. This analysis, pages 32 to 36, explored cost inflation in upgrade costs then claimed by Defence for the F-111. At that time Defence claimed upgrade costs of the order of $750 million. By double counting some costs and using unrealistic estimates of others, Defence then inflated the cost of these upgrades almost twofold. Air Power Australia responded to that evidence thus:

*"The cited cost of investment for F-111 capability and weapons upgrades for a withdrawal in the 2015-2020 timescale is unrealistically inflated, creating a misleading impression of the scale of investment required. Moreover, no effort has been made by Defence to find cost saving or capability enhancing synergies between these proposed upgrades. A more realistic estimate is AU$300 to $550 million, which provides an avionic upgrade package viable into the 2025 timescale, and more reliable and capable than the model cited by Air Force. In terms of annual outlays over a 7 year period, this falls into the range of AU$43 to $79 million per annum."*

There is no recent evidence to indicate that the technology has changed since 2004 to the extent that the cost of upgrades now should be more than tenfold greater than the inflated upgrade cost figures Defence presented in 2004 evidence.

How Defence managed to inflate their own cited cost of upgrades tenfold over a period of less than two years is unclear to Air Power Australia. Misapplication of any known costing methodology, nor double counting of any costs cannot account for a tenfold inflation.

If we consider other costs required to extend the life of the F-111 longer term, none of these can account for the scale of cost inflation claimed by Defence.

The reskinning of the F-111 lower wing and other wing component replacements to remove fatigue damage are not expensive. The complete wing replacement of a large airlifter aircraft is of the order of $US5-10 million per airframe, so even if we assume an intentionally inflated cost of retrofit of completely new wings for 30 F-111s, the upper ceiling in costs is of the order of $200 million for the whole fleet. Cost estimates for such work provided to Air Power Australia by manufacturers were several times lower and accord well with US costs for such work[30].

The retrofit of replacement engines for the TF30-P108/9 in the F-111C and F-111G could also not account for a tenfold inflation of upgrade costs. The cost of new build GE F110 series engines is of the order of $US5 million apiece, so even counting spares the total procurement cost of new engines for around 30 F-111s is of the order of $US400 million. As the F110 was used as the replacement engine for the TF30 in the US Navy F-14B and F-14D, existing hardware is available to adapt the engine for the F-111 engine bay, at very low integration cost. Moreover, the availability of refurbished mothballed F110 engines from the F-14 fleet would permit the cost of an engine upgrade to be much lower than the coarse ceiling estimate of around $500 million for the fleet.

Even should we inflate the cost of a complete fleet engine upgrade twofold to the order of $1 billion, it cannot account for the $5 to 8 billion upgrade estimate claimed by Defence[31].

**Page 42, Air Marshal Shepherd: "It [two type fleet] would bring with it the strategic risk of a distorted and non-balanced Australian Defence Force."**

This statement is a non sequitur. Balance in a force structure is achieved by having a diversity of capabilities and the flexibility to address a wide range of roles. Replacing two types with diverse capabilities with a single type with narrower capabilities is what creates imbalance.

**Page 42, Air Marshal Shepherd: "In very simplistic terms, what is being proposed by some can be likened to taking an EH Holden - a good car in its day-reworking it from the ground up, calling it a V8 Commodore and expecting it to win first time out at Bathurst."**

The global popularity of deep life extension upgrades on older in service aircraft directly contradicts this assertion. If this were true, why is the US Air Force investing billions in life extension upgrades on the KC-135, C-5, A-10, B-52H, B-1B, E-3, E-8, RC-135, and likely to further invest in upgrades on the F-15C, F-15E and F-16C?

It is worth observing that the F-111 with existing engines will win any race over any distance against the Joint Strike Fighter. With modern engines it would win by an even greater margin.

The EH Holden predates the introduction of the F-111C in Australia by a decade. A more appropriate comparison would have been the HQ Monaro which can still outperform most contemporary coupes.

**Page 42, Air Marshal Shepherd: "When you add up the structural risk, the system risk, the support risk, the financial risk and the overall risk to capability, you have a clear and undeniable question about the viability of the F-111 beyond the period when we plan to withdraw it." "And all these risks increase as the aircraft ages."**

The modern philosophy in the support of older aircraft is to identify sources of age related risk in a design and eliminate them by fleetwide component replacement or repair. This is a direct application of reliability engineering theory developed during the 1950s. The ill conceived plan to replace fuselage centre barrels in the F/A-18 fleet is an example of an attempt to apply this method.

Deep refurbishment or replacement of the F-111 wing is very economical and would remove all risks related to wing structure for another three or more decades. Selective replacement of a range of other structural and system components would remove the risk of these causing problems for another three or more decades.

In 2004 Defence presented evidence to this Committee which indicated that Defence did not accept, in general, the established engineering approach of pre-empting risks and removing them, and instead favoured a reactive approach in which nothing was done until a risk materialised and caused problems, upon which it was addressed. This statement indicates that Defence still do not accept that proper engineering planning should be employed instead of reactive actions to remedy manifested risks. As with the previously cited instance of capability related upgrades, Defence refuse to follow proper engineering practice, then complain about the consequences of their failure to follow proper practice, and then argue that the asset should be retired instead[32].

It is worth observing that the US Air Force B-52H is the oldest bomber in the US fleet, yet is the cheapest to operate and most reliable. This is due to the cumulative effect of two decades of proper engineering practice in the identification and remedy of technological risks. The US effort on the B-52H presents an excellent case study in engineering method centred on preemptively identifying risks and removing them before they manifest themselves. An April, 2004, report detailing Boeing's effort on the B-52H described the definition of a 'Aircraft Sustainment Roadmap to look at and predict where we're going to have failures and problems', 'This is a very detailed look at every element of the aircraft' resulting in the redesign and replacement of a range of problem components[33].

As long as Defence persist in rejecting proper engineering planning practices in the support of aircraft, risks will develop and then manifest, costing far more to correct that pre-emptive measures would have cost. This will be true for any type of aircraft. The F-111 is the least problematic in this respect due to the significant infrastructure investment, skilled contractor and DTSO personnel available, and industry experience with the aircraft.

**Page 44, Air Marshal Shepherd: "Importantly, we do not know what we do not know. We know, from operating a number of ageing platforms - the 707, the F-111 and others - that ageing platforms can give us technological surprises that we cannot foresee. To date, we have been very good in managing those risks and in coming up with technical solutions to those risks. I might ask Dr Lough to explain a bit more about that in due course. We need to be able to get off that increasing risk curve at a time of our own choosing."**

Air Power Australia applauds the sincerity of Air Marshal Shepherd in admitting "we do not know what we do not know".

The management of ageing platforms is a well established and systematic engineering discipline, in which the longevity of components is assessed, by testing and cumulative maintenance statistics analysis. Surprises only arise where prior testing or analysis effort was inadequate, or unsupportable assumptions were made about the ageing mechanisms affecting specific components. Given the maturity of the ageing aircraft program performed on the F-111, and the depth of cumulative industry experience, the notion that Australia lacks the expertise to exploit earlier research effectively is not supportable.

On the contrary, Australian expertise in the support of ageing platforms is highly regarded internationally, to the extent that it is used as an example. A recent statement by US Air Force Chief of Air Staff Gen Buzz Moseley is representative[34]:

*"As to the rest of our fleet, we have an ageing fleet. We are also on the fourth step of a twelve step program, recognizing that we are going to have an ageing fleet for the rest of our careers, if you will, and know that we have to replace about 180 airplanes a year, I think, in order to maintain and decrease the age. We are actually replacing on the order of 80. So there is no doubt that what we have to do is learn to live with an ageing fleet. We are on the road to do that. Part of the process of trying to understand how do you do maintenance better and less expensively is, if you will, accommodating an ageing fleet. We can learn a little bit from our Australian friends for sure about how to do that, and I've also asked the Wright-Patterson folks to come to me with an instrumentation program so that we can have the critical parameters of the airplane monitored over time as we live with this ageing fleet."*

Defence may well be in the position of not knowing what they do not know, but this does not represent the capabilities or understanding resident in Australian Industry, or overseas regard for these capabilities.

**Page 44, Dr Lough: "I suppose the issue with the department's position with the F-111 life of type is really based on three undeniable facts that are all interrelated. The first one is: it is an old aircraft - 40 years plus or minus a few years, which is old by aircraft standards and positively ancient by combat aircraft standards.**

This statement is at odds with publicly available evidence and technical reality. Calendar age is irrelevant in aircraft, as the determinant of viability is structural life and systems age.

1. The US Air Force is currently operating KC-135 tanker aircraft with are 40 years old, but have wings rebuilt during the 1970s and 1980s, and engines and other systems retrofitted during the 1980s and 1990s.

2. It is likely that many of these aircraft will remain in use well past 2030. The US Air Force B-52H fleet was built during the early 1960s and may remain in use until 2040.

3. The US Air Force B-1B fleet was built during the 1980s and is expected to have a calendar age of 55 years when retired in 2040.

4. Current upgrades on 25 year old US Air Force A-10 Thunderbolt aircraft may see these eventually retired with a calendar age of 55 or more years.

5. The US Air Force fleet of C-5 Galaxy transports was built during the early 1970s, yet the fleet is considered to have 80% of its useful service life remaining.

6. Planning for the replacement of the US Air Force fleet of E-3 AWACS and E-8 JSTARS, based on Boeing 707 airframes built during the 1960s and 1970s, has been deferred indefinitely,

opening the prospect of replacement in the 2030 timeframe, with calendar ages of up to 65 years.

Importantly, many of these aircraft types are operated in small numbers, with the smallest fleet sizes of the order of 30 aircraft.

The notion that the F-111 is fundamentally different to support than similar numbers of other aircraft types of similar calendar age, construction technique and basic technology is non sequitur.

The United States have no difficulty in supporting military aircraft for decades. The same is also true of many European nations. Australia's industrial base may lack the scale and technological depth to develop new combat aircraft, but it has for decades maintained a world class capability to support and extend the life of such aircraft.

**Page 45, Dr Lough: "The other point to note is that at the time it was designed and built, it was at the bleeding edge of technology. It is a very good example of engineering practice at that time. For those of us who have seen the lid off an F-111, it is marvellous engineering. The issue with that bleeding edge technology at that time is that it is very complex, it has lots of moving parts, it has lots of replaceable parts."**

Air Power Australia concurs with Dr Lough's assessment that the F-111 is 'marvellous engineering' using the 'bleeding edge of technology' for its era. In many respects the engineering in the F-111 is of a higher calibre than that seen in many more recent aircraft types. The design has significant margin in many respects, making it more durable than newer aircraft. Australia can exploit this to an advantage by operating the aircraft longer.

**Page 45, Dr Lough: "The third undeniable fact is that we are the sole owner and operator of the aircraft. We cannot turn to anybody else to help us manage the aircraft. In the past several years, as a result of the Sole Operator Program and even before that, we have learnt an awful lot about how that aeroplane operates. There is virtually a whole division down at Fishermans Bend in my organisation that is devoted to doing this." "So we have a handle on strategies for managing those issues that we know about, specifically in the structural and technical areas. We have strategies in place to be able to manage that, but remember that the risk, as the air marshal said, still increases with every passing year in how those strategies can get implemented and the risks associated with those strategies. We can see ourselves reasonably clear to making a reasonable, confident assumption that we can manage those issues out to 2012 and, in some cases, a little bit beyond."**

The significant expertise at the DSTO Fisherman's Bend facility, and within the contractor base, will have marginal or little impact as long as Defence refuse to adopt modern pre-emptive risk reduction techniques in planning for the aircraft, or for other types in service.

Knowing the cause of a risk but not addressing that risk neither increases nor decreases the probability that the risk will be manifested. As noted previously, adoption of proper engineering planning practices would see risks reduce over time, as has been observed with the US B-52H fleet[35].

*The mathematics of reliability theory are quite unambiguous in this respect, and proven by decades of practice. As aged components are replaced across a fleet of aircraft, the total population of original components is reduced, and risk is thus reduced. The larger the number of different components which are replaced, the smaller the risk becomes, as the total population of components which can present relevant risks shrinks*[36]*.*

**Page 45, Dr Lough: "The second issue of the strategy is those issues that we do not know about but we can anticipate. The aircraft has a test called a cold-proof loading test, and we are reasonably confident that, in the near future, one or more aircraft will fail that test. Essentially, that is really bringing up a new set of issues that we will have to manage, and that includes downtime and substantial cost that is associated with it. The chances of it failing that test increase with every passing year."**

The Cold Proof Load Test is a valuable technique for detecting structural damage or faults before these faults can threaten flight safety. If an aircraft passes a Cold Proof Load Test it is considered structurally safe for another 2,000 hours of flight.

Cold Proof Load Tests performed in the US detected unseen damage in two F-111 aircraft, one arising from a maintenance problems on one of these aircraft, the other from a manufacturing defect problem. Both aircraft were subsequently repaired and returned to service. A good proportion of early Cold Proof Load Test failures were the result of manufacturing defects.

If problems arise in flightline maintenance, due to deskilling and consequent improper maintenance of D6AC steel structural components, the Cold Proof Load Test will detect these problems if they are severe enough to impair flight safety.

The statement that 'we are reasonably confident that, in the near future, one or more aircraft will fail that test' is non sequitur, unless Defence have specific knowledge of specific problems on specific aircraft about to be tested. If the latter is true, then the aircraft in question should be immediately subjected to a Cold Proof Load Test.

**Page 45, Dr Lough: "The third area that the air marshal mentioned concerns those things that we do not know that we do not know. Essentially, with the sort of stored memory bias there, with every passing year that an unanticipated problem does not occur the chance that it is going to occur next year increases. Therefore we have a sort of accelerating risk building on risk issue that we really just have to manage. Those are really the risk arguments and our judgment is that we can responsibly say that we can manage the risks up till around 2012."**

The DSTO Sole Operator Program and Boeing Ageing Aircraft Program were both established to identify and remove risks resulting from component age. If problems identified by these programs are actioned with corrective measures, there should not be an increase in risk, conversely risk will diminish.

The notion that risk will increase while ageing components are replaced once found to be a problem is non-sequitur. It can only be true if the analysis performed to identify risks is in error, or if the number of aged components in the aircraft is increasing, which is not the case.

**Page 45, Dr Lough: "There are other aspects in terms of managing it past that in terms of the life of type of replacement parts, and Air Commodore McPhail can give you a list of issues regarding how parts will or will not be replaced or can or cannot be replaced. I can give you one example from my technical expertise. It is the rocket motor for the ejection system. The F-111 does not have an ejection seat. The whole crew module gets ejected and there is the rocket motor underneath that does that. Rocket motors are very well produced to very exacting quality assurance standard and, in this case of course, it is a safety critical system so it is a very high safety and reliability standard. The rocket motors have a safe life of 20 years. The last one that we have was manufactured in 1997 but most of the ones that we have were manufactured in 1994 or 1995. That means that they run out of life in 2015. If we want to take it beyond that-and that is the real extreme-we would have to go and start up a defunct production line, and who knows what the cost would be even if they could do it. "**

The existing stockpile and currently established shelf life of rocket motors is adequate to permit operation until 2017.

The re-manufacture/manufacture of replacement rocket motors is feasible and practical. The feasibility of extending the storage shelf life of existing stocks should be explored, considering such activities as recertification and/or different storage techniques.

To test the Chief Defence Scientist's testimony to the Committee, Air Power Australia undertook a trade study, a summary of which is outlined below under the section on Cartridge Activated Devices/Propellant Activated Devices (CAD/PAD). The outcome of this study was passed to the Industry contractor responsible for maintaining the CAD/PAD system for the F-111 fleet.

The study determined that a re-manufacture program for rocket motors to take the F-111 fleet through to 2020 would be achievable within the budgetary envelope of $US7.5 million, including project management costs. Such a program could be established to be ongoing, beyond 2020, with the cost dependent on the number of rocket motors required, when and in what quantities.

*In perspective, the evidence presented by Defence to the Committee on the issue of upgrading and supporting the F-111 is replete with errors of fact, non sequitur conclusions, and permeated with an unquestioning acceptance of extant improper engineering practice, despite this issue being raised repeatedly in evidence during 2004 hearings.*

Further observations can be summarised thus:

**Wings**

There are no 'increasing and unknown' risks with the wings on the F-111 aircraft.

There are increasing and known risks in the testing being performed on the full scale wing fatigue test article at the DSTO. These have been highlighted by Industry on an ongoing basis. Air Power

Australia highlighted these concerns to the former Minister for Defence, to Mr David Fawcett MP and the responsible areas in Defence in communications dating back to December 2004. Air Power Australia risk analysis estimates a medium to medium high probability of a catastrophic failure of the wing in test, as was the case with the previous test article back in 2003. Any such failure in a test program of this type points to the inadequacies in the test instrumentation and inspection periodicities being used to monitor and manage the test. An inspection periodicity of 2,000 equivalent flying hours on the test article is simply too large and the test instrumentation too sparse for enabling the early detection and treatment of any defects that develop, leading to denial of the opportunity to develop more cost effective inspection and repair techniques.

For the record, the crack that resulted in the catastrophic failure of the previous wing test article was initiated on the first day of testing and was not discovered until it had grown to the point of catastrophic failure some 18,000 test hours (over 18 months) later. Such a catastrophic failure on a fatigue life extension test article points to a seriously flawed test procedure being in place.

The structural analysis and testing done by the DSTO and DGTA on the wings identified those areas that needed to be explored from an engineering perspective, both in terms of the Ageing Aircraft Program as well as normal aircraft maintenance. These areas are detailed in the ASIMP Volume II document. These areas are being scanned and repaired as required, as the wings go through normal wing bay servicing.

The other areas of concern were the vent holes, stiffener run outs and the fuel transfer grooves. All these areas have known fixes that are being implemented. More cost effective fixes have been recommended by Industry and are awaiting acceptance by Defence.

In service wings are not developing the same amount of cracking nor cracking to the same extent as observed on the test articles at the DSTO. This raises serious questions about the design of the test being used by DSTO.

Fully refurbished/re-manufactured wings for the F-111 aircraft could be produced in Australia by Australian Industry for less than $A1.4 million per wing set with a Non Recurring Engineering (NRE) cost of $8 million. A large portion of the NRE work has already been done as part of the Sole Operator Program and follow on work in Industry. Additional wings and wing components are available from the AMARC in the US at very low prices.

**Airframe**

There are no 'unknown and increasing' risks in relation to the airframe of the F-111.

The airframe exhibits some minor cracking, as is to be expected, at DADTA points, however none is an issue of any major concern and these are dealt with in the normal service cycle. This is standard for all aircraft and, on the F-111, is very much under control.

There could be some logistics improvement in this area of the aircraft's maintenance, from a cost effectiveness perspective. That is to say some of the recurring points such as the Intake Spike Tab could be fixed for once and for all with a different approach rather than just removing the crack every 2,000hrs.

However, Defence has yet to accept the recommendations from Industry on such cost effective approaches, as observed previously. The stress corrosion cracking that has been observed, mainly in the forward fuselage section, is also dealt with during normal maintenance servicings. Detailed inspections on a range of aircraft within the fleet have not revealed any structural related problems of significance.

Though there is some interesting science in the F-111 airframe, no observed problems are 'life threatening' and these are dealt with using standard logistics and engineering methodologies during normal servicing.

### Hydraulics

There are no 'increasing and unknown' risks in the hydraulic system of the F-111.

The aircraft's hydraulic system has been 'quite stable and reliable' since RAAF Engineers and Rosebank Engineering fixed the problems back in the late 1980s/early 1990s. In fact, the solutions have been so effective that Rosebank Engineering has effectively reduced it own workload as the 'repairable items pipeline' has dried up. Statistics on the hydraulic system can be obtained from Rosebank Engineering.

There is currently a logistics issue in relation to hydraulics which effects nearly all Defence aircraft and hydraulically powered ground support equipment. This issue relates to the type of hydraulic oil that is being supplied and arose because the Joint Fluid Logistics Agency changed the type of hydraulic oil that it was supplying without prior notice or consultation with the maintainers of the equipments so affected. Further information on this situation can be provided, if required. Suffice to say, the effect on the aircraft is not a safety or airworthiness issue and is being accommodated through standard aircraft maintenance measures.

### Electrical Wiring

There are no 'increasing and unknown' risks with the aircraft's electrical wiring.

Two thirds of the electrical wires were replaced during the AUP and are only 10-15 years old. As each Block Upgrade has been done, other wiring has been replaced. For instance, all wiring in the wings has been replaced and is now only about a year old. These activities have been done as part of the standard maintenance on the aircraft, they are not expensive and have been done very cost effectively.

There is an ongoing wiring program in place that assesses any risks, in a quantitative sense and looks at all wires to determine if replacement is required. This program is unique to the F-111. No other aircraft in the RAAF or ADF fleet has such a program.

### Oxygen System

There are no 'increasing and unknown' risks with the aircraft's oxygen system.

There is an ongoing oxygen system program that looks for issues with that system. This is robust engineering program.

There are 'known and increasing' risks in relation to the training, competencies and skill sets needed to perform the operational level (R1, R2, and R3 Servicings) maintenance on the aircraft currently being done by the RAAF.

**Cartridge Activated Devices/Propellant Activated Devices - CAD/PAD (Crew Module and Other Explosive Ordnance Activated Systems)**

There are no 'increasing and unknown' risks with the crew module escape system. All risks were clearly identified back in the 1990s in the F-111 Life Support Study and follow up Sole Operator Program activities. The risks that were identified included the need to source an additional manufacturer for the crew module rocket motor, either in Australia or overseas.

As a result, funding was approved by Cabinet to enable the F-111 fleet to operate out to 2020, as per the guidance in the Defence 2000 White Paper. Some of this funding was to ensure the crew module escape system could be kept operational till 2020.

The current stocks of components will go out to 2017 and the rocket motor is the determining item as no new rocket motors have been purchased and Defence has not addressed the issue of manufacture at this stage. The rocket motor is a 1960s design which is well within the competencies and skills of a nation that, inter alia, has successfully produced the Nulka Hovering Rocket Decoy system.

In the 1970s and 1980s, the Australian Mirage fighters were equipped with the Matra R530 radar guided missile. Life of Type extension programs on the rocket propellant were established by the RAAF, DSTO and Industry here in Australia. Those batch lots of rocket motors deemed out of life being remanufactured, again in Australia, by refilling the rocket casings with new propellant to extend the life of the motors and thus the missiles.

As a result of Dr Lough's testimony to the Committee in relation to the rocket motors, Air Power Australia undertook a trade study aimed at identifying the capabilities to enable rocket motors to be sourced to support the F-111 fleet out to 2020 and beyond. Air Power Australia identified an Australian company with the requisite skills, experience and accreditations for undertaking life extension and re-certification of the existing rocket motors. Air Power Australia also identified the original equipment manufacturer for the rocket motors, established they were still in the business of producing CAD/PAD systems and determined they have the capability to undertake a rocket motor re-manufacture program.

Air Power Australia has determined that a re-manufacture program for over 100 rocket motors, out of the 150+ units currently in storage, to take the F-111 fleet through to 2020 and beyond would be achievable within the budgetary envelope of $US7,500 thousand, including project management costs. Past 2020, such a program could be ongoing at a cost of $US26k per rocket motor as well as establish the means for producing newly manufactured rocket motors at an estimated (ROM) cost of $US35k per rocket motor.

To perform this trade study, Air Power Australia expended some 5 man hours, two international telephone calls, 5 E-mail communications and 20 minutes of STD telephone charges.

**Electronic Warfare (EW) Suite**

The Electronic Warfare suite has recently been upgraded and has fully functioning chaff/flares, ELta 8222 jammer and ALR-62 Radar Warning Receiver. These equipments have been shown to be very effective against a range of threats during Red Flag exercises conducted in the US.

It is important to observe that with the in country maintenance of the Electronic Warfare suite, Australia can develop and program its own techniques for countermeasures, vital in adapting rapidly to new or unique threats. This capability may not persist if the Joint Strike Fighter is acquired.

**Page 47, Air Marshal Shepherd: "We have done an analysis, but it is important to remember that the F-22 will not meet all the roles that we require in the air environment."**

Defence never followed the conventional approach of first defining formal capability requirements, in detail, for the AIR 6000 program, and then shortlisting candidate aircraft on the basis of detailed analysis of how closely they comply with this requirement. Given the absence of a rigorous and formal evaluation of the F-22A Raptor vs the Joint Strike Fighter, the claim that 'We have done an analysis' is difficult to reconcile with the history of the AIR 6000 program.

The claim that 'the F-22 will not meet all the roles that we require in the air environment' is not supportable by factual evidence, unless these roles were defined to exclude the capabilities of the Joint Strike Fighter as well.

That the F-22A Raptor is a multirole fighter capable of fulfilling a wide range of diverse roles is an established fact, which the Defence leadership have strenously denied despite overwhelming public evidence for several years.

A recent interview with LtGen D.A. Deptula, Vice Commander US Air Force PACAF at Hickam AFB, published in Australia, demonstrates this clearly[37]:

Defence Today: "The capabilities of the F-22A are not well understood outside the USAF, and the aircraft is widely being portrayed by critics as a 'pure air superiority fighter' with little capability for other roles. Given the considerable strike, and intelligence - surveillance - reconnaissance capabilities inherent in the F-22A, how does ACC envisage this aircraft used in combat? Should we expect F-22A units permanently stationed in the Pacrim?"

*Lt Gen Deptula:*

*"The F-22A is truly a multi-mission transformational combat aircraft. With its advanced integrated avionics providing unparalleled situational awareness, supercruise capability (the ability to fly faster than the speed of sound without afterburner), and stealth technology it is the only operational fifth-*

*generation fighter in the world. It combines these capabilities with precision weapons to provide a joint force commander an unprecedented level of capability.*

*The F-22A is not just an F-22A. One of the challenges we have as a result of historical traditions are labels. In addition to traditional fighter and bomber missions, the F-22A can conduct the kind of activities that an Airborne Warning and Control System (AWACS) does, or the RC-135 surveillance aircraft does, or what an electronic attack aircraft does. What the F-22A brings to the equation is not just another aircraft to replace F-15s, but a multitude of capabilities for a joint force commander–it's not just an F-22A–it's an F/A/B/EA/RC/E-22. These capabilities will secure 21st century battlespace awareness with an exponentially increased ability to find, fix, track, target, engage and assess targets while at the same time providing critical information to other aircraft and ground forces, and it provides unique cruise missile defense options for theater commanders and for homeland defense."*

Defence Today: "The Joint Strike Fighter is to occupy an important niche in the USAF force structure, replacing the A-10A 'Warthog' and F-16C in interdiction and strike roles. Given the highly specialized strike oriented design of the Joint Strike Fighter, is there any basis for claims by F-22A critics that the Joint Strike Fighter is a suitable substitute for the F-22A in air combat and deep strike roles?"

*Lt Gen Deptula:*

*"The Joint Strike Fighter (JSF) is not a substitute for the F-22A. In fact, the JSF will rely on the F-22A for air dominance. The F-22A offers the aerodynamic performance and maneuverability required to counter advanced double-digit SAMs, and next generation air threats that are growing throughout the Pacific theater of operations. As you stated, the F-35 JSF is a low cost, multi-mission aircraft primarily designed for air-to-ground operations to replace Air Force F-16s and A-10s. Today the F-15 and F-16 are a highly successful synergistic team; the F-22A and F-35 will be the winning team of the future."*

*"We cannot afford not to invest in the F-22A. The F-22A is an insurance policy for our nation's defense as the linchpin for establishing air dominance and precision attack capabilities in the future. Too many people look at the F-22A as a single role aircraft. As I mentioned above it can perform the roles of not only air-to-air, but surface attack, suppression/destruction of enemy air defense's, airborne warning, electronic attack, cruise missile defense, and others. It can perform roles and in situations that the F-15E, and joint strike fighter cannot. Given the multiple capabilities-and magnitude of capabilities-of the F-22A, it is worth every penny of the American taxpayer's investment."*

LtGen Deptula's observations align closely with comments on the F-22A program made by US Air Force Chief of Air Staff General Buzz Moseley, interviewed by US media in December, 2005[38]:

Media:

*"What happened to the Block 20, 30 and 40 capabilities? Are those off the table now that you're pulling [F-22A Spiral Development] funding?"*

General Moseley:

*"No. If you look at small diameter bombs, it's there; if you look at JDAM supersonic, subsonic, it's there; if you look at the wide variety of missiles it's all there; look at the datalink, it's all there. To field the air dominance fighter, all those are in there. I've got to be able to strike surface targets as well as air targets. "*

Other US assessments align with the US Air Force view of the F-22A capabilities. David L. Rockwell of the Teal group, writing in the February, 2006, edition of the American Institute of Aeronautics and Astronautics journal 'Aerospace America', states:

*"However, the Air Force has changed the primary mission of the Raptor from air superiority to strike. This might seem odd, considering how the Air Force's argument for not cutting the F-22 rested on its very different mission compared to the Joint Strike Fighter. Even more unexpected is the plan to add many air-to-ground capabilities to the APG-77. Unfortunately, these new capabilities have recently become classified, and very little information is available."*

It is abundantly clear that the Defence leadership in Australia have perceptions of F-22A capabilities and roles which directly contradict the factual evidence, and the understanding of F-22A capabilities and roles held by its users, the US Air Force, and US industry. Consequently, all comparisons of the F-22A vs the Joint Strike Fighter made by the Defence leadership are fundamentally in error.

The claim that 'the F-22 will not meet all the roles that we require in the air environment' can be easily tested against the basic roles the Air Force can be expected to perform over coming decades:

**Air Combat - Offensive:** In offensive fighter sweeps against opposing fighter aircraft, the F-22A decisively outperforms the Joint Strike Fighter in close and beyond visual range combat, by virtue of better stealth, better agility, supersonic cruise capability and better radar and passive detection capabilities.

**Air Combat - Defensive:** In defensive fighter patrols against opposing fighter aircraft, the F-22A decisively outperforms the Joint Strike Fighter in close and beyond visual range combat, by virtue of better stealth, better agility, supersonic cruise capability and better radar and passive detection capabilities.

**Air Combat - Interception of Bombers:** The supersonic cruise capability of the F-22A allows it to intercept bombers which are kinematically well outside the performance capabilities of the Joint Strike Fighter.

**Air Combat - Interception of Cruise Missiles:** The F-22A has significantly better radar performance and the capability to carry a larger payload of air-to-air missiles, making it many times more effective than the Joint Strike Fighter in intercepting cruise missiles.

**Air Strike - Strategic:** The supercruise and superior stealth capability of the F-22A allow it to attack targets in environments where the Joint Strike Fighter could not survive. The F-22A carries an identical number of JDAM or Small Diameter Bomb smart bombs in its internal weapon bay to the Joint Strike Fighter.

**Air Strike - Maritime:** The supercruise and superior stealth capability of the F-22A allow it to attack surface warships in environments where the Joint Strike Fighter could not survive. The F-22A carries an identical number of JDAM or Small Diameter Bomb smart bombs in its internal weapon bay to the Joint Strike Fighter. Datalink aided variants of the Small Diameter Bomb are planned, and datalink aided variants of the JDAM were used to attack moving ship targets during the 2005 Resultant Fury exercise in the Pacific.

**Air Strike - Defence Suppression:** Suppression or destruction of enemy air defences, comprising radar and missile systems, is one of the primary roles of the F-22A, but not the Joint Strike Fighter.

**Air Strike - Counter-Airfield:** The supercruise and superior stealth capability of the F-22A allow it to attack airfields and aircraft on the ground in environments where the Joint Strike Fighter could not survive. The F-22A carries an identical number of JDAM or Small Diameter Bomb smart bombs in its internal weapon bay to the Joint Strike Fighter.

**Air Strike - Battlefield Interdiction:** The supercruise and superior stealth capability of the F-22A allow it to attack enemy ground forces in environments where the Joint Strike Fighter could not survive. The F-22A carries an identical number of JDAM or Small Diameter Bomb smart bombs in its internal weapon bay to the Joint Strike Fighter. Datalink aided variants of the Small Diameter Bomb and JDAM would be used. The APG-77 radar on the F-22A is more powerful than the APG-81 on the Joint Strike Fighter resulting in better detection performance against moving vehicles with smaller radar signatures.

**Air Strike - Close/Precision Air Support:** The supercruise and superior stealth capability of the F-22A allow it to attack enemy ground forces in environments where the Joint Strike Fighter could not survive, and with covert capability absent in the Joint Strike Fighter. The F-22A carries an identical number of JDAM or Small Diameter Bomb smart bombs in its internal weapon bay to the Joint Strike Fighter. Datalink aided variants of the Small Diameter Bomb and JDAM would be used[39].

**ISR - Surface Passive Electronic:** The supercruise and superior stealth capability of the F-22A allow it to surveil targets in environments where the Joint Strike Fighter could not survive. The ALR-94 passive detection system on the F-22A is more capable than the system planned for the Joint Strike Fighter resulting in better detection performance against hostile targets[40].

**ISR - Surface Radar Imaging:** The supercruise and superior stealth capability of the F-22A allow it to surveil targets in environments where the Joint Strike Fighter could not survive. The APG-77 radar on the F-22A is more powerful than the APG-81 on the Joint Strike Fighter permitting greater standoff range.

**ISR - Surface MTI:** The supercruise and superior stealth capability of the F-22A allow it to surveil targets in environments where the Joint Strike Fighter could not survive. The APG-77 radar on the F-22A is more powerful than the APG-81 on the Joint Strike Fighter resulting in better detection performance against moving vehicles with smaller radar signatures.

The supercruise capability of the F-22A has important implications in strike and ISR roles. It allows the F-22A to enter and egress hostile airspace faster, minimising exposure to enemy defences. In

ISR roles, it is permits the F-22A to cover twice the area a Joint Strike Fighter could in the same time.

The argument that the Joint Strike Fighter will have a wider range of strike weapons integrated and cleared for release compared to the F-22A is dubious. The current SDD threshold weapons list is a small fraction of what it was three years ago, as a result of which production Joint Strike Fighters will require additional investment to integrate the full suite of possible strike weapons. Were the Air Force to acquire F-22As rather than Joint Strike Fighters, it would be looking at similar investment to add additional strike weapons.

Testing the capabilities of the F-22A against the Joint Strike Fighter in all of these key roles indicates that it either significantly outperforms or matches the capabilities of the Joint Strike Fighter. This is entirely consistent with public assessments of the F-22A by the US Air Force.

The claim that 'the F-22 will not meet all the roles that we require in the air environment' has no basis in fact, and is strongly misleading.

**Page 48, Air Cdre Harvey: "I will address the first issue of cost. The current officially released price - and I have to be careful of the terminology - the average unit recurring fly-away cost for the conventional take-off and landing variant is $US45 million in 2002 reference dollars. That is the benchmark figure. I believe that the potential cost discussed was actually a procurement cost that included a whole range of support equipment as well. So we have to be careful about the costing basis there as well. I also notice that submission No. 20 to this inquiry talked about JSF prices and they managed to get confused between now year dollars and then year dollars. In fact, their price was inflated by over 40 per cent of the real cost. The current cost is $US45 million in 2002 prices and any escalation above that is possible, but the numbers being referred to cover such things as all the broad support costs et cetera for the program."**

This statement is at odds with publicly available data contained in budgetary reports to the US Congress and performance audits by the US Government Accountability Office (GAO). It also defies belief that senior Defence officials continue to try to encourage the Parliament and, therefore, the people of Australia to infer from the selective wording they use that the price Australia will pay for the Joint Strike Fighter capability is $US45 million per aircraft. The 'selective wording' used by senior Defence officials when responding to questions on the Joint Strike Fighter pricing was disassembled in Part 1.1 of Submission No 20 and shown to be, at best, confused and confusing. The term 'average unit recurring fly-away cost for the conventional take-off and landing variant' pertains to the recurring element of the flyaway cost for an aircraft somewhere around production number 800 in the currently planned full rate production phase of the Joint Strike Fighter Program. The quoted figure of $US45 million bears little resemblance to the recurring fly-away cost let alone the total fly away cost let alone the unit procurement cost for aircraft built in Stage 4 of the Low Rate Initial Production (LRIP-4) phase of the program from which senior Defence officials intend to procure the first tranche of aircraft.

Use of such 'selective wording' in the commercial world would likely invoke criticism under the Federal Trade Practices and State Fair Trading Acts.

The simple way to resolve the question as to what price Australia is likely to pay for the Joint Strike Fighter capability would be for Defence to table the Joint Strike Fighter Program Cost Model, identifying the full cost of the capability they seek and when in the associated LRIP and Full Rate Production phases of the Joint Strike Fighter Program they are recommending the Government procure this capability.

As to the claim by Air Commodore Harvey that ‘they managed to get confused between now year dollars and then year dollars’, the Air Power Australia Submission No 20 does not use the term ‘now year dollars’.

The term ‘then year dollars’ is employed four times - once on Page 31 in the analysis of total operating expenses for the F-111 out to 2020 as presented in the RAAF Air Combat Capability paper dated 04 June 2004 and three times on Page 134, being the ZOCT (R) Table of Parametric Comparisons. The former usage favoured the position portrayed by the RAAF because it resulted in a higher value for comparison purposes in 2004 discounted present value (PV) dollars. Overall, the use of the term ‘then year dollars’ was in accordance with standard accounting practices and in keeping with the description contained in the US DoD Glossary of Acquisition Acronyms and Terms, 12th Edition - July 2005. The term ‘now year dollars’ does not appear in this glossary.

Therefore, Air Power Australia is having some difficulty understanding what Air Commodore Harvey means by “they managed to get confused between now year dollars and then year dollars” when one of these terms does not appear in our submission and the other is used in accordance with world’s best practices.

**Page 49, Air Cdre Harvey: “The DSTO has done detailed analysis of the avionics architecture and the software approach for that. Their assessment of the approach is that it is very sound. They have learnt from other programs, such as the F-22, in trying to extract the software layer from the hardware layer to allow them to do such things as upgrade processes as they go through.”**

The avionic architecture model used in the Joint Strike Fighter is based on the F-22A model, which evolved from the Pave Pillar studies, but employs significantly more software thus adding significant development risks. Planned for through life upgrades in the F-22A and the Joint Strike Fighter will see significant commonality in computer hardware and related avionic components.

The greater issues Australia must confront with the Joint Strike Fighter are a result of its hobbled aerodynamic performance and limited stealth performance. Putting the same computer technology into two aircraft with vastly different performance and stealth characteristics will not make the less capable one any more capable.

**Page 49, 50 Dr Gumley: “There is range of prices that the F-22 might be sold to us for. No negotiations or discussions have ever been had on price, but we get some indication from US congressional data on how much they are paying for their aeroplanes. The range is anything of the order of $US105 million to $US115 million per copy. But additional to that, if we were to acquire planes like that, we would be paying substantial update costs. The aeroplanes coming out now are already in need of update in some areas because**

**they have been out for many years."**

Dr Gumley's candour in observing that Australia has never formally requested negotiations or discussions on price is commendable, and the authors concur with the order of magnitude unit flyaway pricing cited for the latter part of the currently funded US Air Force build. Indeed, this is the first accurate public statement on this matter by any party in Defence. The cost of any F-22A aircraft supplied to Australia would be lower as these aircraft would be subsequent to the US build. It is also worth observing that the development of these cited technology updates was mostly completed under funding for the Block 20 upgrade, which was in flight test last year.

**Page 49, 50 Dr Gumley: "There are FMS [Foreign Military Sales] costs, which is the charge the US government charges Australia to process the orders. Sometimes they waive those fees; sometimes they do not. We have not had the discussion yet but there is always the question of: do we have to pay our share of the past research and development and bringing it into manufacture? What is our share of the amortisation?" "The Americans will have about 183 or 184 F-22s by the time they finish their program. If we were to get 40 or 50 then we would be paying probably 20 per cent of the R&D costs of that aircraft. Maybe that will be waived it; maybe it will not be - we do not know - but that would add up to an extra $100 million per aeroplane."**

Dr Gumley's concerns about the issue of research and development funding amortisation are reasonable, and given his recent experience with the Joint Strike Fighter, justifiable. However, the F-22A would be supplied as an FMS article, and protection of US intellectual property in many key capabilities would be a powerful disincentive to any attempts to retrospectively amortise development funds.

Established US practice, and legislation governing Foreign Military Sales of equipment, generally exclude development funding. US legislation is quite specific on this, refer FMS Pricing as per 22 USC 2762:

*(d) Competitive pricing*[41]

*(1) Procurement contracts made in implementation of sales under this section for defense articles and defense services wholly paid for from funds made available on a nonrepayable basis shall be priced on the same costing basis with regard to profit, overhead, independent research and development, bid and proposal, and other costing elements, as is applicable to procurements of like items purchased by the Department of Defense for its own use.*

*(2) Direct costs associated with meeting additional or unique requirements of the purchaser shall be allowable under contracts described in paragraph (1). Loadings applicable to such direct costs shall be permitted at the same rates applicable to procurement of like items purchased by the Department of Defense for its own use.*

This legislation mandates that US contractors and government sell equipment at the same procurement cost at which it is sold to the US military, plus a small FMS fee. As the US budgetary system is based on separate budgets for development and for production procurement, taking the sunk cost of product development in previous years and using it as an additional R&D cost surcharge is not allowed.

This is also why the Joint Strike Fighter program is unique, since it is intended to share development costs between the US taxpayer and SDD participants. To effect this cost sharing mechanism, the Joint Strike Fighter SDD partnering scheme had to be devised and implemented.

The F-22A development budget, almost completely spent now, cannot be 'sliced up' retrospectively to add a surcharge to the procument cost of export aircraft without an amendment to existing 22 USC 2762 legislation.

The only situation in which Australia could be expected to pay development costs would be in a situation where Australia contracted to have unique features, weapons or equipment added to the F-22A design, in which case it would be obliged to cover the cost of developing these modifications.

**Page 51, Dr Lough: "In essence, when you do the force on force analysis, it is highly unlikely that a jammer will be able to get the sort of capability to be able to do that very large jamming in most network-centric environments. Fundamentally, network-centric environments, especially the one for the JSF, are designed with an electronic warfare countermeasures process in mind."**

All networks are based on digital communications links between platforms and systems. These links employ specific radio modulation techniques, which in modern equipment will be designed to be jam resistant, but can never be 'jam-proof'. The physics of radio communication preclude this. Given enough jammer power, any signal can be specifically jammed.

Networks such as the JTIDS/MIDS system have known limitations due to the CCSK modulation technique used which make it susceptible to specific types of jamming, accepting that JTIDS/MIDS has good resistance to most trivial analogue era jamming techniques[42].

Dr Lough's assertion that 'it is highly unlikely that a jammer will be able to get the sort of capability to be able to do that very large jamming in most network-centric environments' makes implicit assumptions which cannot be proven.

The claim that jamming equipment will not have the capability to degrade or disrupt a network cannot be supported without specifying the characteristics of the network modulation and jamming technique used. Given that the JTRS network technology to be used in the F-22A and Joint Strike Fighter is still in development, it is not possible to make firm pronouncements on its future level of jam resistance, as it is impossible to make firm pronouncements on the capabilities of jammers built to defeat JTRS.

The JTIDS/MIDS system was expected during the 1980s to be nearly immune to jamming, yet since then numerous weaknesses have become apparent.

Electronic warfare is an evolutionary process and countermeasures have always emerged over time to defeat specific systems, as they are deployed. The difficulty becoming apparent now with jam resistant networking techniques is that jam resistance is improved mostly by increasing the radio channel bandwidth being used, yet that bandwidth is becoming increasingly congested over time.

There is no factual basis from which Dr Lough can attribute a specific likelihood to the issue of future jam resistance of networking equipment.

**Page 52, Air Marshal Shepherd: "We need to continue to do the analysis on how many centre barrels we need to upgrade."**

The analysis to determine the number of aircraft that will need to undergo the Centre Barrel Replacement Program has taken literally years. The time and resources applied to this task are indicative of the way Defence approaches risks and the deskilling within Defence, particularly at the senior levels, that has led to this approach, as outlined previously.

**Page 54, Air Marshal Shepherd: "I stress again: our analysis and our assessment is that the JSF has the capability that we need."**

As per previous analysis, this statement has no basis in fact.

To test this statement and the observation that it has no basis in fact, it is recommended the Committee call for Defence to table the reports of their analysis and their assessment[43].

**Page 2 Submission No 27:**

**"Mr HATTON: What is the expected total Unit Procurement Cost per unit in current year-dollars for the F-35 JSF?" "How does that figure compare to the total Unit Procurement Cost per unit in current year-dollars for the F-22A Raptor?"**

**Defence Response:**

**"The F-35 AUPC is made up as follows:**

- **The total procurement budget for the F-35 is US$154.3B (2002 prices).**
- **This is for 2458 aircraft.**
- **The AUPC for the US program is therefore US$63m per aircraft (2002 prices).**
- **This is approximately US$67.3m per aircraft in 2005 prices.**

**Note: This is the average cost for all 3 variants; the Australian preferred CTOL is the least expensive variant."**

**"The total procurement budget for F-22 is based on:**

- **The total procurement budget is US$31.6B (2005 prices).**

- **This is for 181 aircraft.**
- **This results in an Average Unit Procurement Cost (AUPC) of US$175m per aircraft in 2005 prices."**

The answer provided by Defence to this question on comparative pricing is not a proper answer to the question, since it provides **Average Unit Procurement Cost** cost figures rather than actual Unit Procurement Cost figures at the time when Australia would purchase either aircraft.

As Australia would be buying the F-22 at the end of the build of 185 aircraft, the Average Unit Procurement Cost cited by senior Defence officials is significantly higher than the cost Australia would buy at. Conversely, as Australia would be purchasing the Joint Strike Fighter at the beginning of the production build, the Average Unit Procurement Cost cited by senior Defence officials is smaller than the cost Australia would have to pay. Therefore, this answer is inherently misleading. It also demonstrates senior Defence officials are not listening to expert advice nor doing the necessary due diligence on this project, including understanding let alone analysing the information that is available in budgetary and performance audit reports to the US Congress on the Joint Strike Fighter and F-22A programs.

The use of the term '2002 prices' is incorrect. The 'price' is what is paid for an item. On the plans for low rate initial production (LRIP) of the Joint Strike Fighter tabled by Lockheed Martin earlier this year, aircraft will not begin to be 'sold' till sometime after 2010. Even based on an optimistic 'due diligence' risk analysis, this date slips to sometime after 2014. The use of this term is thus misleading and demonstrates senior Defence officials either do not understand or choose not to understand, let alone objectively analyse, the overwhelming amount of independent expert and Congressional budgeting information available on the Joint Strike Fighter Program.

The figure of 'US$154.4B' cited by Defence is actually from what is called the Baseline Estimate established at contract award in 2002, consisting of an RDT&E Budget of some $US21,300 million (the Baseline Budget for the SDD Phase) and $US154,300 million for the Baseline Procurement Budget for a total Baseline Budget of $US175,600.0 million. This figure is in 2002 dollars and does not include any economic and program escalation costs. As the name describes, this the 'baseline' budget for the Joint Strike Fighter Program. The other figure that forms the Baseline Estimates for the project is in 'current year' dollars which does include the estimated costs for economic and program escalation applicable at the time of contract award (FY2002). The Baseline Estimate for the Joint Strike Fighter Program in 'current year' dollars was set initially in 2002 at $US231,000 million, made up of an RDT&E Budget of $US34,400 million and a Procurement Budget of $US196,600 million in 'current year' dollars. Since that time (2002), much has changed in the Joint Strike Fighter Program. The planned number of aircraft to be produced has dropped from the 'baseline estimate' of 2,866 to the 'current estimate' of 2,458 and costs have increased markedly.

At the very least, senior Defence officials should be using the 'current estimate' figures which are provided in the Selected Acquisition Reports to the Congress in both 'base year' dollars (2002) and 'current year' dollars. Put simply, estimates in 'current year' dollars take into consideration economic and program escalation/descalation factors considered applicable up to the point of expenditure of the relevant cash flow projections that, in aggregate, make up the budget estimate. In other words, the best estimate at the time of the expected expenditure or, for the purposes of this exercise, a far closer representation of the 'price' than the figures used by senior Defence officials.

The 'current estimates' for the Joint Strike Fighter Program Budget in December 2005 were -

1. Base Year (2002) dollars: Total Budget = $US201,729.4 million consisting of an RDT&E Budget of some $US36,193.1 million and a Procurement Budget of $US165,536.3 million.
2. Current Year dollars: Total Budget = $US276,458.9 million consisting of an RDT&E Budget of $US45,200.2 million and a Procurement Budget of $US231,258.7 million.

If one wishes to refer to the term 'price', then the more correct figure to use would be in 'current year' dollars. Therefore, the Average Unit Procurement Cost (AUPC), based on the figures provided in the SAR of December 2005, would be around US$94.08 million.

Putting aside all the discussion about 'average unit recurring flyaway costs', '2002 base year dollars', and whether or not the $US45 million cited by senior Defence officials is anywhere near what price Australia would be required to pay for the Joint Strike Fighter aircraft, there is a common sense approach which also demonstrates the absence of any objective 'due diligence' being applied by senior Defence officials.

Comparing the build configuration of the Joint Strike Fighter to that of the F-22A, the Joint Strike Fighter has one engine rather than two, its avionics will be comparable in cost, and this will all be packaged in a slightly smaller airframe. Therefore, overall, the difference in the mature production cost of the Joint Strike Fighter to that of the F-22A Raptor will be made up of the cost of one engine, the incremental differences in the cost of equivalent avionic items, and the difference in cost of producing a smaller airframe.

Therefore, parametrically, the difference in mature unit production cost between the Joint Strike Fighter and the F-22A Raptor is likely to be in the order of $US10 million to $16 million per aircraft.

The present LRIP cost for the Joint Strike Fighter F135 engine with spares is around $US20 million per unit with a mature, learned out cost target of around $US10 million per engine. The unit procurement cost for LRIP Phase 4 Block 1/2 aircraft is currently estimated, from US DoD budgetary figures, to be somewhere between $US114.1 million and $US136.8 million.

The unit procurement cost for the last four Raptors in the currently planned production will be around $US126.65 million per unit. The F119 engine for the F-22A is at a learned out cost of some $US8.2 million dollars per unit.

**Page 3 Submission No 27: Mr HATTON:**

**"What analyses have been done to ascertain the potential benefits to Australian industry if Australia was to enter the F-22A Raptor program as the International Launch Partner?"**

**Defence Response: "The F-22A has not yet been released for export. That said, scope for Australian industry involvement in the F-22A Program is likely to be very low because the initial aircraft development is now complete (i.e., except for future upgrade requirements) and production runs are expected to be too small to support cost effective 'second-sourcing' of components."**

The answer provided by Defence to this question on industry benefit is not a proper answer to the question, since does not state what analyses have been done.

The answer provided is in error, indicating that it is likely no such analyses were ever performed.

Analysis by Air Power Australia has identified a number of high value added opportunities for Australian industry to participate in F-22A development activities:

1. Clearance of a range of weapons not covered in the existing EMD program, on internal and external stations.
2. Development of software to support the integration of a range of weapons not covered in the existing EMD program.
3. Development of software to provide additional modes in the sensor suite, especially to support planned ISR upgrades.
4. Development and supply of ground exploitation equipment for ISR capabilities to be incorporated in planned upgrades.
5. Integration and qualification of additional sensors, such as a thermal imaging sensor.
6. Development of active radar countermeasures for HF and VHF band threat radars.
7. Development of Low Observable components and materials suitable for export to nations to whom the US may not be prepared to export standard F-22 hardware[44].
8. Provision of test range facilities to support qualification of sensors.

Australia currently retains world class capabilities in weapon clearance, system integration, embedded software development and testing. These are all 'knowledge intensive' industry activities which are inherently high value added, and mostly involve retention of high levels of expertise over long periods of time.

The focus of industry activities advocated by senior Defence officials, in contrast, is in the area of component and support equipment manufacturing, as observed in industry participation in the Joint Strike Fighter SDD. This is an area of intensive competition in the global market, with low profit margins, often modest or low personnel skill requirements, high uncertainty in future workload, and demanding often high capital equipment investment with a high risk of little or no payoff. Future workloads and the resulting viability of industry players in the Joint Strike Fighter program will be critically exposed to fluctuations in future build numbers of this aircraft.

Industry opportunities arising from participation in F-22A development and support activities are not tied to production volumes and are thus insensitive to production volumes. Given the very high skill levels involved in such work, the range of credible competitors in the market is much smaller. All software products will require long term development support over the life of the aircraft, thus providing a stable sustainable workload.

**Page 3 Submission No 27:**

**Mr HATTON: "How is this terminology [LO/VLO] currently defined?"**

**Defence Response: "There is no universally agreed categorization scheme for stealth terminology."**

This is not a correct answer. Terminology has evolved and there is established usage in US literature.

During the earliest days of the US stealth program, all stealth aircraft were described as 'low observable'. This included the F-117A and the B-2A stealth bomber, described as having radar signatures the size of ball bearings, marbles, large insects or small birds. Such targets are known to have signatures of the order of -30 dBsm down to -40 dBsm, where dBsm is deciBels referred to a square metre.

By the 1990s, attempts were made to reduce the radar signatures of more conventional aircraft, mostly by the application of absorbent materials. These aircraft had radar signatures typically a factor of 10 to 100 greater than true stealth aircraft. Therefore a change was needed in terminology to distinguish true stealth aircraft from aircraft which were less detectable, but not truly stealthy.

The result was the adoption of the term Very Low Observable (VLO) to describe aircraft with high stealth performance, such as the F-117A, B-2A and F-22A. Aircraft with inferior stealth performance were then labelled Low Observable (LO). This puts VLO aircraft in the range of -30 dBsm to much smaller than -40 dBsm, whereas LO aircraft fall into the range between conventional aircraft at +10 dBsm to 0 dBsm, and VLO aircraft.

The result is frequent confusion for those without prior experience in the area.

Classification of the Joint Strike Fighter is inherently problematic since its nose region has the potential for good VLO category performance, whereas its aft region is demonstrably in the LO category, and strongly dependent on the wavelength of a threat radar. A conservative label for the Joint Strike Fighter is LO as the least effective aspect of the aircraft's radar signature will dominate its ability to survive. An optimistic label for the Joint Strike Fighter is VLO taking the best case performance of the aircraft's nose area as dominant.

# 4 Conclusions

This Submission comprises three main sections. The first of these addresses issues of increasing cost in the Joint Strike Fighter, the second responds to questions on notice by Committee members, and the third tests evidence provided to the Committee by Defence and its supporters.

Fourteen principal observations arise, mostly as a result of evidence provided by Defence.

**Observation §1:** Within Australia's time window of interest for replacing the F/A-18A fleet, the Joint Strike Fighter will be more expensive to acquire than an identical number of much superior F-22A Raptor fighters.

**Observation §2:** The opportunity to procure or otherwise acquire F-22A Raptor fighters earlier than the Joint Strike Fighter allows Australia to avoid the very expensive, high risk and low payoff elements of the F/A-18 HUG Program including the Fuselage Centre Barrel Replacement Program, the integration of additional guided munitions, and the further enhancement of avionics.

**Observation §3:** If Australia opts for the Joint Strike Fighter rather than the production F-22A Raptor, it will have to accept progressively increasing costs over time. For all intents and purposes, this is an 'open chequebook' with no certainty in terms of an upper ceiling in costs. This will represent a high risk to the Australian taxpayer, but also a political risk for every Federal Government in office between now and the delivery of the final Joint Strike Fighter aircraft.

**Observation §4:** The evidence provided by senior Defence officials excludes the import of strategic changes to the region and strategic changes in future United States' capabilities, and the impact of these strategic changes upon Australia. Consequently, there is no evidence to support the proposition that senior Defence officials provided sound advice to Government on these matters.

**Observation §5:** Testimony provided by senior Defence officials, and the Kokoda Foundation, concerning the performance and capabilities of the F-22A Raptor multirole air dominance fighter, and the manner in which the US Air Force will use this aircraft, does not reflect what is publicly known about the F-22A. Multiple claims made by senior Defence officials directly contradict public statements by the US Air Force on these matters.

**Observation §6:** Evidence provided by senior Defence officials on the cost structures which apply to the acquisition of military aircraft from the US is not accurate, and repeatedly understates the resulting acquisition costs in the Joint Strike Fighter, and mostly overstates the resulting acquisition costs in the F-22A Raptor.

**Observation §7:** The evidence provided by senior Defence officials concerning risks in the support of older aircraft is predicated on the use of improper technique. Techniques which should be used in the reduction of technical risk are not understood, and the adoption of modern engineering planning techniques which can be used to reduce risks is rejected. The adverse consequences of this lack of understanding and rejection of appropriate planning technique are then erroneously attributed by Defence to the calendar age of the military aircraft in question.

**Observation §8:** Testimony provided by senior Defence officials on the risks inherent in the retention of the F-111 departs from fact. The testimony inflated the cost of F-111 life extension upgrades **tenfold**, to a magnitude similar to the cost of developing an entirely new fighter design. No justification was provided to explain this inflation. For comparison, evidence provided in 2004 by Defence inflated F-111 upgrade cost figures only twofold.

**Observation §9:** Evidence provided by senior Defence officials on Australian Industry capabilities, in the design and development of upgrades, or support of military aircraft systems, is in error, including cost structures and reasoning on how to approach risks inherent in such activities. Australian Industry experience and lessons learned overseas in such programs, for estimation of risks and costs, and establishment of viable, sustainable outcomes, are absent in this evidence.

**Observation §10:** Testimony provided by senior Defence officials ignores the limitations of networking equipment in hostile jamming environments and the risks that arise as a result. Consequently greater robustness is attributed, than historical experience and expert advice indicates to be safe.

**Observation §11:** There are no less than sixteen well established technical reasons why the adoption of Network Centric Capabilities will not provide the military effect Defence claim it will. While networking capabilities are essential for the future of the ADF, they are not a substitute for the firepower delivery capabilities of platforms, and cannot be used as a justification for force structure downsizing or the acquisition of inferior platforms.

**Observation §12:** Given the poor quality of evidence provided by senior Defence officials across a wide range of areas, when responding to reasonable questions by the Committee, it is evident that all advice tendered to Government in these areas should be tested independently to ensure that Government and the Australian community are not exposed to the risks which result from defective advice.

**Observation §13:** The absence of cogent argument, supported by hard data and traceable evidence, in the testimony provided by senior Defence officials, is proof of a failure to perform 'due diligence' in capability development and acquisition, including the application of formal Test and Evaluation philosophies and techniques. This is demonstrably so in the decisions to pursue the Joint Strike Fighter, F/A-18 life extension, early retirement of the F-111, and in the rejection of the F-22A Raptor. The systemic nature of this failure can also be seen in the recently tabled ANAO Report on the management failures in the Air 87 Tiger Armed Reconnaissance Helicopter Project, the primary cause being clearly identified in Table 1.1 of the report[45].

**Observation §14:** The evidence presented by senior Defence officials to this Inquiry demonstrates a much higher frequency in errors of fact, non sequitur conclusions and lack of rigour, compared to the evidence presented in 2004 in relation to these matters. There is a remarkable consistency of misunderstanding, non sequitur conclusions and errors of fact, a rejection of alternatives and risks, selective bias in analysis, absence of contingency plans, and poor definition of objectives. This is no different from that observed in recent and well documented overseas decision failures[46].

# Submission Endnotes

[1]Refer ANAO Audit Report No. 36 2005-06.

[2]Refer Kringen J.A., 'How We've Improved Intelligence. Minimizing the Risk of 'Groupthink'', Washington Post, Monday, April 3, 2006; A19, http://www.cia.gov/cia/public_affairs/press_release/2006/How_We_Improved_Intelligence.pdf, also 'Report on the U.S. Intelligence Community's Prewar Intelligence Assessments on Iraq', http://intelligence.senate.gov/conclusions.pdf, and http://en.wikipedia.org/wiki/Groupthink, accessed May 2006.

[3] Bill Sweetman, 'Lockheed Martin Resolute Over JSF Partner Concerns', Interview, Janes Information Group, 14 March 2006.

[4] Derived from C Kopp, *Sixteen Bounds on the Capability of Networked Military Systems*, unpublished draft paper, submitted May, 2006.

[5] Refer C Kopp: The Properties of High Capacity Microwave Airborne Ad Hoc Networks, PhD Thesis, School of Computer Science and Software Engineering, Monash University, Melbourne, 2000, 435pp; C Kopp and C S Wallace: TROPPO - A Tropospheric Propagation Simulator, School of Computer Science and Software Engineering, Monash University, Melbourne, 21pp. Technical report 2004/161; Defense Industry Daily - AESA Comlinks: DID Reader Has Done Prior Research, http://www.defenseindustrydaily.com/2006/01/aesa-comlinks-did-reader-has-done-prior-research/index.php.

[6] Refer Ippolito L.J. 'Propagation Effects Handbook for Satellite Systems Design, A Summary of Propagation Impairments on 10 to 100 GHz Satellite Links with Techniques for System Design'. NASA Reference Publication 1082 (04), 4th Edition, 1989, NASA Scientific and Technical Information Division; Flock W.L. 'Propagation Effects on Satellite Systems at Frequencies Below 10 GHz, A Handbook for Satellite Systems Design', NASA Reference Publication 1108 (02), 2nd Edition, 1987, NASA Scientific and Technical Information Division; Blake L.V. 'Radar Range-Performance Analysis', Lexington Books, 1980, Ma.; Blake L.V. 'Prediction of Radar Range'. in Skolnik M.I. (Ed) Radar Handbook, Second Edition, McGraw Hill, 1991.; Meeks M.L. 'Radar Propagation at Low Altitudes'. Artech House. 1982. Ma.

[7] A good example of this problem taking effect is the replacement of the APQ-181 Ku-band radar on the B-2A stealth bomber with an X-band design, as the radio spectrum used by this radar was reallocated for commercial use. Existing US datalink equipment for the AGM-130 and EGBU-15 smart weapons will also have to be replaced due to the loss of L-band spectrum used by this equipment. Many other examples exist.

[8]Air Power Australia recommends the Committee seek the opinion of Dr Vivian Crouch, former DSTO Engineer and President of the Southern Cross Chapter of the International Test and Evaluation Association (ITEA). Dr Crouch has dedicated a considerable amount of his life to raising awareness on the radio spectrum problem.

[9] Refer Ippolito L.J. 'Propagation Effects Handbook for Satellite Systems Design, A Summary

of Propagation Impairments on 10 to 100 GHz Satellite Links with Techniques for System Design'. NASA Reference Publication 1082 (04), 4th Edition, 1989, NASA Scientific and Technical Information Division; Flock W.L. 'Propagation Effects on Satellite Systems at Frequencies Below 10 GHz, A Handbook for Satellite Systems Design', NASA Reference Publication 1108 (02), 2nd Edition, 1987, NASA Scientific and Technical Information Division; Blake L.V. 'Radar Range-Performance Analysis', Lexington Books, 1980, Ma.; Blake L.V. 'Prediction of Radar Range'. in Skolnik M.I. (Ed) Radar Handbook, Second Edition, McGraw Hill, 1991.; Meeks M.L. 'Radar Propagation at Low Altitudes'. Artech House. 1982. Ma.

[10] Refer http://www.ntia.doc.gov/top/conferenceworkshops/2001_outreach_workshops/three_laws.html; also Kopp C., Reflections on Information Age Air Warfare, Journal of Information Warfare, Edith Cowan University, Perth, WA, Australia, ISSN: 1445-3312, Vol 3, Issue 3, pp 11-28., also Kopp, C. 5th Australian IW&Sec Conference - Nov 2004 - Boyd, Metcalfe and Amdahl - Modelling Networked Warfighting Systems (Slides)http://www.csse.monash.edu.au/ carlo/archive/PAPERS/IWC5-Kopp-2004-Slides.pdf

[11] Good examples of network capacity demand are Intelligence, Surveillance Reconnaissance platforms which can demand in excess of 50 Megabits/sec of link capacity per platform, if all sensors are active. A single live video link demands around 2 Megabits/sec of link capacity per platform. A targeting datalink used to guide a smart bomb may not require much bandwidth, but link delay must be constant and stable to permit multiple updates per second per weapon. A single reconnaissance image of high quality may be 50 Megabytes or greater in size. Refer N Giroux and S Ganti, 'Quality of Service in ATM Networks', Prentice Hall, 1998; H J Chao and X Guo, 'Quality of Service Control in High-Speed Networks', John Wiley & Sons, 2002; Grenville Armitage, 'Quality of Service in IP Networks', MacMillan Technical Pub, 2000.

[12] Refer Kopp C., NCW 101 - Part 1 - Information and Why it Matters, Defence Today, May 2005, http://www.ausairpower.net/DT-NCW-101-1.pdf.

[13] Refer Kopp C., NCW 101 - Part 1 - Information and Why it Matters, Defence Today, May 2005, http://www.ausairpower.net/DT-NCW-101-1.pdf.

[14] Numerous case studies of this problem exist, including the loss of the KAL 007 to Soviet interceptors, the USS Vincennes incident, the Kosovo tractor bombing incident, the bombing of Canadian troops in Afghanistan. It is important to observe that in every incident multiple human errors and sensor limitations contributed to tragedy.

[15] Refer Leroy Van Brunt 'Applied ECM', Vol 1, 1978, Vol 2, 1982, EW Engineering Inc. P. O. Box 28 Dunn Loring VA; Fitts R.E., 'Strategy of Electromagnetic Conflict', Peninsula Publishing, 1978; R. L. Peterson, R. E. Ziemer and D. E. Borth, 'Introduction to Spread Spectrum Communications', Prentice-Hall, Englewood Cliffs, NJ, 1995.

[16] Refer Leroy Van Brunt 'Applied ECM', Vol 1, 1978, Vol 2, 1982, EW Engineering Inc. P. O. Box 28 Dunn Loring VA; Fitts R.E., 'Strategy of Electromagnetic Conflict', Peninsula Publishing, 1978; R. L. Peterson, R. E. Ziemer and D. E. Borth, 'Introduction to Spread Spectrum Communications', Prentice-Hall, Englewood Cliffs, NJ, 1995; Kopp C., Reflections on Information Age Air Warfare, Journal of Information Warfare, Edith Cowan University, Perth, WA, Aus-

tralia, ISSN: 1445-3312, Vol 3, Issue 3, pp 11-28., also Kopp, C. 5th Australian IW&Sec Conference - Nov 2004 - Boyd, Metcalfe and Amdahl - Modelling Networked Warfighting Systems (Slides)http://www.csse.monash.edu.au/ carlo/archive/PAPERS/IWC5-Kopp-2004-Slides.pdf.

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[18] Data sourced from US Selected Acquisition Reports for December 1990, December 1991, December 2001, December 2002, and December 2005.

[19] Refer Alan Stephens, Armies, Stealth Fighters, and Homeland Defence, PAPER NUMBER 5, AEROSPACE CENTRE, January 2002.

[20] There is a wealth of Joint Strike Fighter marketing material which makes the claim that the aircraft is multirole, but these are never supported by any comparative evidence. In general such materials represent a good example of 'deception by omission' in that the limitations in top end aerodynamic performance are never discussed, but the presence of air combat modes in the APG-81 radar is strongly emphasised. What is however prominent in such materials is the use of concept scenarios showcasing design features of the aircraft. These invariably see a multiplicity of scenarios presented for battlefield strike and close air support, but usually only one scenario for air combat. Were the Joint Strike Fighter truly multirole, air combat scenarios and marketing of associated design attributes would match or outnumber strike scenarios. Historically, air combat performance and capability was been a better selling tool for fighters than bombing capabilities, if it were otherwise we would not see the menagerie of flying displays we do at air shows and marketing events.

[21] And subsequently reclassified back to Very Low Observable after media controversy in Australia.

[22] Work on this technique was started in late 1989 by then CO 1SQN, GPCAPT Criss, who continued developing the technique until late 1992, including the incorporation of a radio datalink to transmit imagery to ground troops. The latest generation of targeting pods now emulate this model, using radio datalinks. Australia was at the forefront of global development in these techniques, which were abandoned shortly after AIRCDRE Criss departed Amberley for another posting.

[23] This is the same model as adopted for Australia's four RF-111C aircraft, but implemented using 25 year newer sensor technology.

[24]The 'warning time' argument is an artifact of 1950s strategic planning, when a protracted buildup and mobilisation of manpower intensive forces and industries was required in preparation for conflict. This model ceased to be valid by late 1960s, when the advent of precision weapons and technology intensive force structures displaced dumb non-precision weapons and manpower intensive forces in most industrialised militaries. The use of this argument in the contemporary context is not rational.

[25] Refer Kopp C, *Regional Denial: An Alternative Deterrent Strategy for the ADF*, A Contribution to the ADF Force Structure Debate, June 2000, unpublished ministerial submission. This document

was written as a supplement to RAAF APSC Working Paper 82, *A Strategic Tanker/Transport Force for the ADF*, published in 2000, and provided a supporting strategic rationale for the expansion of the RAAF's tanker fleet.

[26] Kopp Carlo and Goon Peter (2006), 'Attaining Air Superiority in the Region - Inquiry into Australian Defence Force Regional Air Superiority', Submission to the JOINT STANDING COMMITTEE ON FOREIGN AFFAIRS, DEFENCE AND TRADE DEFENCE SUBCOMMITTEE, February 17, http://www.aph.gov.au/house/committee/jfadt/adfair/subs/sub20.pdf, last accessed April 2006.

[27] Most contemporary hardware developed for upgrades is packaged into chassis with identical or similar dimensions to legacy avionic equipments in wide use, to facilitate rapid and cheap integration. Standard power, cooling and digital data interfaces are used, and often existing analogue interfaces supported. Usually software source code is available off the shelf to be embedded into the existing software in target upgrade aircraft, to minimise the time to develop the upgrade. Good examples include JTIDS/MIDS network terminals, mission computers, data modems, radios, cockpit displays, electronic warfare equipment and radars. The era of 'custom designed' avionics crafted around a specific platform is gone, since cost pressures have forced significant commonality in avionic equipments across disparate aircraft fleets, globally.

[28] The AUP program exploited elements of the Avionics Modernisation Program (AMP) for the F/EF-111A/E/G and the later Pace Strike for the F-111D/F, but used software which is almost completely new. Subsequent evolution via the Block Upgrade Program has seen the system chnage considerably from the less capable Pace Strike system.

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URL: http://www.house.gov/pitts/initiatives/ew/050713-CRS-hornet.pdf, accessed May 2006.

[30] Refer Bolkcom C, 'Airlift: C-17 Aircraft Program', CRS Report for Congress, RL30685, April 27, 2004, URL: http://www.globalsecurity.org/military/library/report/crs/crs_rl30685.pdf, accessed May 2006; the figure is based upon a non-competitive quote by Warner-Robbins Air Logistics Center for the C-141B Starlifter.

[31] The only other possibility is that of a propagated typographical error, where 500 - 800 million was transcribed as 5,000 - 8,000 million. If this was the case, it demonstrates an incapacity to understand order of magnitude costs on the part of many Defence personnel.

[32] Refer JSCFADT Submission 5, entitled Review of Defence Annual Report 2002-03: Analysis of Department of Defence Responses, date June 18, 2004.

[33] Refer Lewis P, 'The Bomber is Back', Boeing Frontiers, Volume 02, Issue 11, April 2004, URL: http://www.boeing.com/news/frontiers/archive/2004/april/cover1.html, Last accessed May 2006.

[34]'Secretary, Chief discuss future Air Force issues', Air Force Link,
http://www.af.mil/news/story.asp?id=123015774, accessed May 2006.

[35] Refer Lewis P, 'The Bomber is Back', Boeing Frontiers, Volume 02, Issue 11, April 2004, URL:

http://www.boeing.com/news/frontiers/archive/2004/april/cover1.html, Last accessed May 2006.

36 Refer Bazovsky I., 'Reliability Theory and Practice', Prentice Hall, NJ, 1961; Kopp C., 'System Reliability and Metrics of Reliability', Lecture Notes, PHA Pty Ltd, 1996, http://www.ausairpower.net/Reliability-PHA.pdf, accessed May 2006 - Dr Kopp taught hardware, systems and software reliability theory at Melbourne University over a three year period.

37 Refer Defence Today, Vol.4 No.5, March/April, 2006, Interview with General David Deptula, p58.

38 'Secretary, Chief discuss future Air Force issues', Air Force Link, http://www.af.mil/news/story.asp?id=123015774, accessed May 2006.

39 The absence of an electro-optical sensor on the current F-22A configuration can be remedied by the integration of an external targeting pod, or adaptation of prior development work performed on the chin mounted electro-optical sensor fairing. Neither are expensive upgrades.

40 Sweetman B, 'Raptor Rising', EDefense Online, September, 2001,
URL: http://www.edefenseonline.com/default.asp?func=article&aref=09_01_2001_IF_02;
cite: "Some of the fighter's blackest capabilities reside in the BAE Systems (Nashua, NH) AN/ALR-94, which has been described as "the most technically complex piece of equipment on the aircraft." The ALR-94 is a passive receiver system with far greater capability than the simple radar-warning systems fitted to most other fighters. It can detect sidelobes, as well as main lobes, and can accurately locate and track any emitting target. It is very likely that it uses the 2,200-module active electronically scanned array (AESA) of the fighter's Northrop Grumman (Baltimore, MD) AN/APG-77 radar as a highly sensitive and accurate adjunct receiver. Information from the ALR-94 and non-emitting sources - such as the fighter's datalink - is used automatically to cue the radar, cutting down on electronic emissions. High-priority emitters, such as fighter aircraft at close range, can be tracked in real time by the ALR-94. In this mode, called narrow-band interleaved search and track (NBILST), the radar is used only to provide precise range and velocity data to set up a missile attack. If a hostile aircraft is injudicious in its use of radar, the ALR-94 may provide nearly all the information necessary to launch an AIM-120 AMRAAM and guide it to impact, making it virtually an anti-radiation AAM. "The enemy dies relaxed," observed a Lockheed Martin manager."

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43 Any claims that this would compromise security are not reasonable, and should any classified items of technical data or figures present issues, these could be selectively censored on a word by word basis. Defence have to date failed to explain the underpinning assumptions for what analysis they may have performed, the methodology employed, what opposing capabilities they have planned for, and what alternative fighters they have tested the Joint Strike Fighter against.

44 This is of particular value to the US since it provides an implicit 'firewall' protecting US stealth technology.

[45]Refer ANAO Audit Report No. 36 2005-06.

[46]Refer Kringen J.A., 'How We've Improved Intelligence. Minimizing the Risk of 'Groupthink", Washington Post, Monday, April 3, 2006; A19, http://www.cia.gov/cia/public_affairs/press_release/2006/How_We_Improved_Intelligence.pdf, also 'Report on the U.S. Intelligence Community's Prewar Intelligence Assessments on Iraq', http://intelligence.senate.gov/conclusions.pdf, and http://en.wikipedia.org/wiki/Groupthink, accessed May 2006.

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Figure 8: *F-22A Raptor (US Air Force).*

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