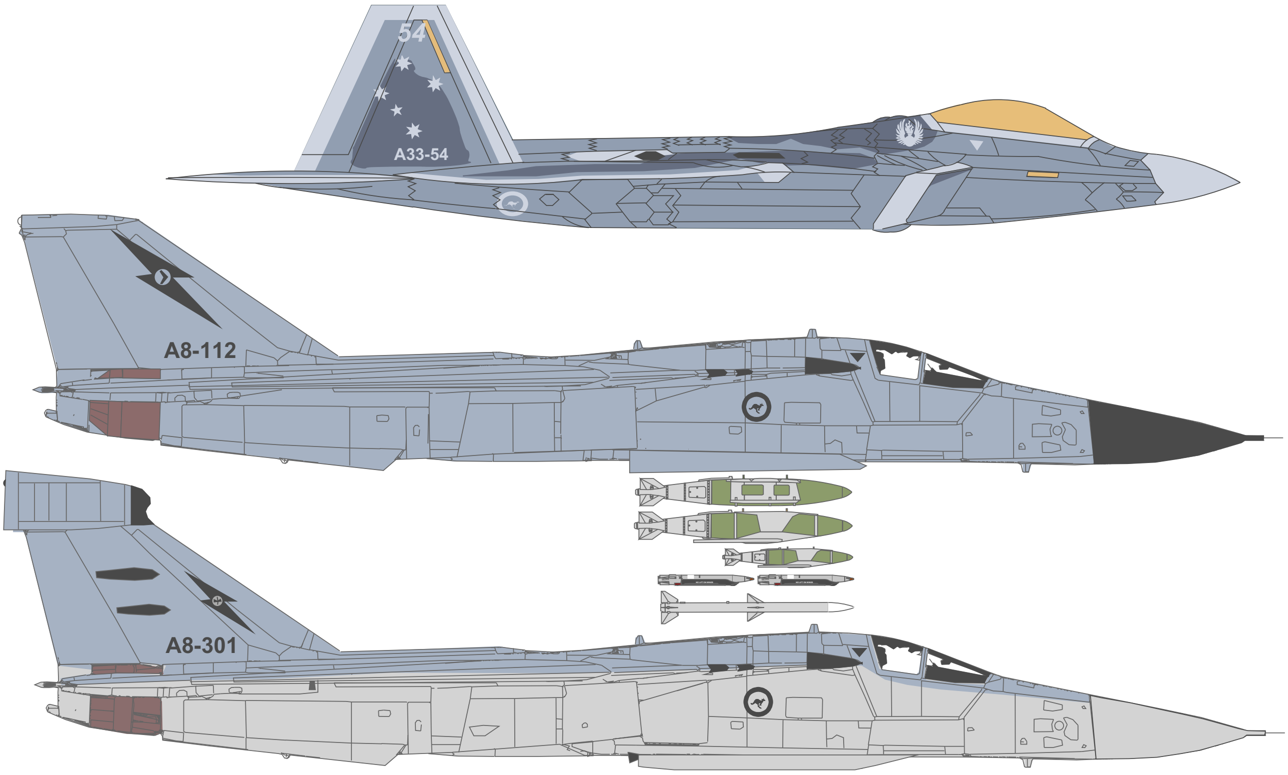

Strategic Needs and Force Structure Analysis: The Thinking Behind the F-22A and Evolved F-111 Force Mix Option

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The F-22 and Evolved F-111 Force Mix Option

Executive Summary

Australia is facing a rapidly changing regional strategic environment. This is a byproduct of industrialisation and growing wealth in Asia, which has seen a spending spree on modern weapons on the scale of the last years of the Cold War. The growth in military capability across Asia is coinciding with a period of strategic overstretch and military equipment block obsolescence in the United States, which will be less able to intervene on Australia's behalf in coming decades.

Many Defence planning assumptions held for decades are no longer true, due to the rapid influx of advanced Russian and other weapons technologies. Future warning times will be short, regional capabilities to operate and support modern weapons will be much better, many regional nations will be able to strike over long distances, and much of the technology acquired from Russia now matches or outperforms most US and EU supplied military equipment.

A wide range of advanced weapons are now in service or being procured across the region. These include advanced variants of the Sukhoi Flanker fighter, which has prodigious range, exceptional performance, and advanced avionics and systems competitive against Western fighters. The new Russian PAK-FA stealth fighter is being actively marketed in the region. Russian aerial refuelling tankers and equipment are becoming more widely used. Most regional nations are procuring advanced Airborne Early Warning and Control (AEW&C) aircraft, not unlike Australia's Wedgetail. Advanced missiles with 400 km range, intended to kill AEW&C and tanker aircraft, are being procured in the region, as well as smart bombs with laser, television and satellite guidance. Many regional nations are deploying 'Tomahawk-like' cruise missiles, while India, Pakistan and China are manufacturing indigenous cruise missiles. Advanced long range air defence missiles such as the Russian S-300PMU series are now appearing in the region.

Australia needs to fundamentally rethink its planning for the future of the RAAF, as few currently planned RAAF capabilities will be competitive in the region in the near future. New capabilities not currently addressed include those needed to defeat advanced Russian fighters, cruise missiles and their delivery systems, and the capability to strike at very long ranges, enhancing what is extant in the F-111 fleet. A much more capable air combat fighter than the planned F/A-18F and Joint Strike Fighter will be required.

The only fighter aircraft that can reliably defeat the advanced Russian fighters and air defence systems is the F-22A Raptor, currently being introduced into the US Air Force fleet. The F-22 has high stealth performance, high agility and supersonic cruise, which are absent in all other alternatives. It can deliver precision weapons against surface targets through any known and anticipated air defences. It is the primary US system planned for cruise missile defence. Its advanced sensors allow it to perform intelligence, surveillance and reconnaissance roles.

Deployment of the F-22A with its superior capabilities permits Australia to safely retain the unique capabilities of the F-111 longer term. The F-111, by virtue of its size and performance, has greater range and persistence than any contemporary fighter. It can carry large bunker busting weapons which smaller fighters cannot. Its large internal fuel capacity reduces its demand on aerial tanker support, making it operationally, and environmentally, much cheaper to operate than smaller aircraft.

The *F-22A and Evolved F-111 Force Mix* option envisages that Australia acquire at least fifty F-22A

Raptor aircraft to replace immediately the legacy F/A-18A HUG, and to incorporate a series of low risk and low cost upgrades to the F-111 fleet to reduce support costs and enhance capabilities. These upgrades would not only enhance strike capabilities, but also allow the F-111 to supplement the F-22A in the cruise missile defence role.

In addition, further innovative, cost effective and low risk capability gains are feasible by recovering mothballed EF-111A Raven electronic attack aircraft, and upgrading them accordingly. This vital capability fills a large gap in the Australia's force structure.

An established trend in Defence since 2000 has been an effort to 'de-risk' projects and programs by transferring responsibility for support overseas. This is a consequence of the down sizing of Defence throughout the 1990s', which has led to serious de-skilling within the organisation and industrial base. The 'de-risking' philosophy is not in the national interest. Risks, when properly managed, equal opportunities. The well accepted concept of TEAM Australia is thus being replaced by the current approach of handing the control of sovereign assets into the hands of overseas corporations. By design, the F-22A and Evolved F-111 Force Mix reverses this trend while enabling real returns on investment to be made on what now exists under TEAM Australia[1].

The F-22A and Evolved F-111 Force Mix option involves much lower risk, and cost, while providing much greater total capability than any other alternative. Conservative cost estimates against the legacy F-35 Joint Strike Fighter and F/A-18F Super Hornet plan shows that the F-22A and Evolved F-111 Force Mix option saves the taxpayer at least A$16 billion in direct costs, while it sustains and grows the nation's critical industrial base, and avoids the funding spike and balance of payments problems inherent in current Defence planning.

In conclusion, the *F-22A Raptor and Evolved F-111 Force Mix option* offers flexibility in decision making and related budgeting without incurring an interim loss in combat capability. Concurrently, the F-22A Raptor and Evolved F-111 Force Mix addresses these challenges and associated risks in an innovative and cost effective manner, consistent with the Australian heritage of self reliance and being able to 'punch above its weight' on the international stage.

Contents

Part I

Analysing Australia's Strategic Needs

Part I discusses strategic needs in the context of the evolving regional environment, with a strong focus on capabilities, strategic risks and the impact of United States 'strategic overstretch'. Key force structure requirements for the future of the RAAF are identified, with a coherent, balanced solution presented in Part II.

1 Strategic Considerations

The ability to achieve and maintain air superiority in any escalated regional conflict is vital to Australia's future. Any regional crisis of substance, whether involving Australia alone or in coalition with Australia's allies, in particular, the US, would occur in a strategic environment which has seen the greatest geographically localised and sustained long term investment in combat aircraft, guided weapons and supporting capabilities, since the last decade of the Cold War in Europe[2].

To put this in context, the "creeping arms race" in Asia sees the aggregate number of new high capability category combat aircraft acquired or ordered across the Asia-Pacific-Indian region since the end of the Cold War numerically rivalling the Warsaw Pact during its final decade. Importantly, many of these aircraft are much evolved and improved derivatives of the last generation of combat aircraft deployed by the Soviets, and are technologically equivalent and often more advanced than the RAAF's current and planned fleet, and US Navy and Air Force assets in this region[3].

As a result, three considerations become of critical importance to Australia.

The first of these considerations is that the absence of a decisive advantage in Australia's capability over regional nations provides opportunities for Australia to be coerced in any regional dispute. What would the outcome of the East Timor crisis have been if Indonesia had at that time parity or superiority in air power over Australia?

The second consideration is that any regional dispute which devolves to a shooting conflict leaves Australia in the position where a limited capacity to defend high value economic assets and Navy and Army assets denies options. If the RAAF is unable to extend a protective umbrella over amphibious forces, as it is committed to defending the North West Shelf and Timor Sea energy industry, then amphibious operations are not an option. Air Warfare Destroyers cannot credibly provide protection in such a hostile environment. A future government is placed in the position where it may have to concede a regional dispute.

The third consideration is that Australia's standing and influence across the region will decline, as its capability declines relative to the region. Asia has been historically very competitive, and players who fall behind the majority in the region lose the capacity to influence events. This behaviour is a byproduct of the regional cultural environment and cannot be avoided. Australia has for five decades relied upon its superior air power in this region to 'punch above its weight', a capability advantage being abandoned with the intended F/A-18F and Joint Strike Fighter acquisitions.

Figure 1: *Perhaps the most visible change in the region following the end of the Cold War has been the proliferation of large 'high capability' category air superiority fighters, often with multirole capabilities. This chart illustrates which types are being acquired, deployed or operated by regional nations. Australia currently operates the smaller 'low capability' F/A-18A and plans to acquire the 'low capability' Joint Strike Fighter and F/A-18F. This places Australia firmly in the same force structure planning bracket as Thailand, Taiwan, Bangladesh and New Zealand. This division of fighters into 'high capability' and 'low capability' categories is based on the United States Air Force 'High - Low Mix' model, abbreviating the more formal 'high capability and performance category' and 'low capability and performance category'. Examples of the 'high capability' category include the F-14, F-15, Su-27/30/35 and F-22, examples of the 'low capability' category include the F-16, F/A-18 and planned Joint Strike Fighter. (C. Kopp).*

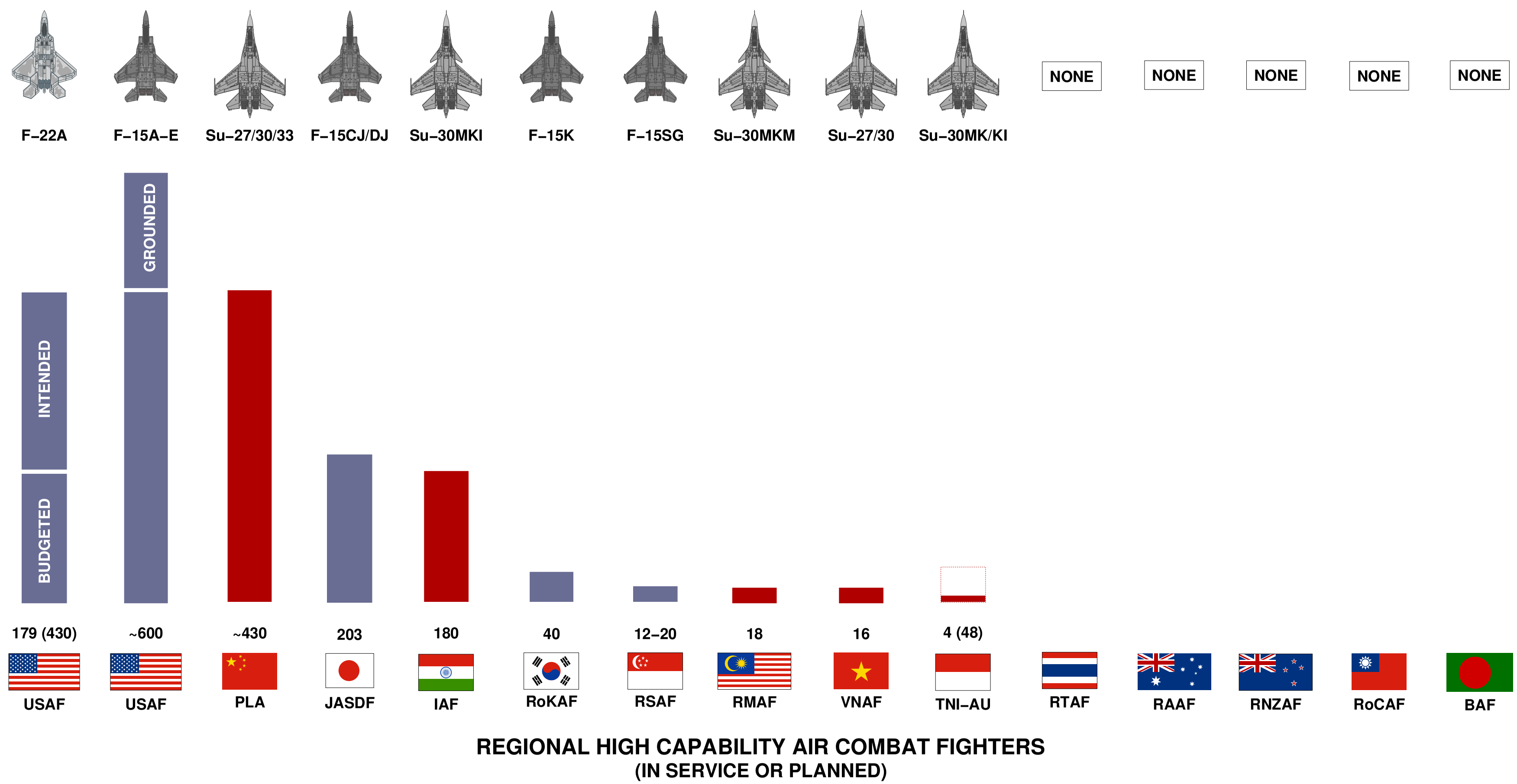

Figure 2: *This chart displays currently planned numbers of high capability category air combat fighters to be deployed by regional operators. Final numbers of the Su-27SK, Su-27SMK, Su-30MKK, Su-30MK2 Flanker B/G and derivatives remain to be determined, and Russian sources claim that in excess of 500 aircraft could be acquired by China alone. Taiwan has actively sought mothballed US F-15 fighters, but the US has not agreed as yet to provide the type. Australia, New Zealand and Bangladesh, uniquely, have no intent to deploy high capability category air combat fighters (C. Kopp).*

> Until recently, Australia has enjoyed an undisputed advantage in modern air power, numerically, technologically and in operational skills, over most nations in the region. This historical advantage is now disappearing as Asian nations buy some of the best products in the market.

The root cause of the changes in military capability we have been observing across the region is the industrialisation and thus increasing wealth of Asian nations.

What we observe is a pattern not unlike that seen in Europe over one hundred years ago, when rapid industrial growth resulted in an unprecedented concentration of wealth and power in Europe. This wealth fuelled the Great War, and the Second World War. During this period, Japan was the sole power in Asia to industrialise and this provided it with the capability to execute its military campaigns in China, South East Asia and the Pacific, all driven by a need for resources and markets.

Since 1950 we have seen Japan reconstitute its shattered economy, and subsequently climb to the position of Number 2 economic power after the US. More recently, South Korea has followed Japan and is now a significant manufacturing economy on the global scale. Both Taiwan and Singapore, despite their lesser size, have robust modern economies with significant high technology sectors. However, the most important development over the last decade has been the rise of China as a major industrialised economy on the global scale. China will surpass Japan and become the world's Number 2 economic power after the US.

China's rise has had numerous important consequences. The first of these is that the Chinese leadership is becoming increasingly preoccupied with reliable access to materiel and energy resources, and markets for its manufactured products[4]. The second important consequence is that China has much more wealth available for military spending. This is reflected in unprecedented qualitative and quantitative changes in China's military capabilities, and an active shift away from the historical doctrines of continental defence, to a doctrine of regional dominance[5][6].

This capability growth is developing while China's strategic relationships with other regional players, including the United States, become increasingly competitive, manifesting in increasingly competitive 'keep up with the neighbours' military spending patterns across the region.

India is following a similar path of industrialisation to China, albeit more slowly, but with notable successes in areas such as information technology and aerospace. Not unlike China, it is growing its military capabilities and thus its ability to project its influence and power across the region. While India enjoys good relations with Western nations at this time, it has a well established history of pursuing its own interests with little regard for global, and especially Western, opinion[7].

For much of the last decade India and China pursued a 'tit-for-tat' strategy in the acquisition of advanced Russian military hardware, with India often acquiring the most sophisticated products Russia could supply. That relationship now includes respective Indian and Chinese co-development and co-production of advanced Russian missile and aerospace technology. It is likely the established competitive dynamic between China and India will continue through this century[8].

Military growth in Asia has coincided with the United States suffering severe "strategic overstretch", arising from heavy and sustained spending commitments resulting from the Global War on Terror.

With the highest operational tempo seen since the peak of the Cold War, often much higher, service life across the diverse US fleets of aircraft, helicopters, ships and land vehicles is being burned out at rates often several times greater than the peacetime operating hours budgeted for since the early 1990s. That these fleets are much smaller than during the Cold War produces the simple and unwanted effect of driving up the average annual operational hours per equipment item.

The undesirable byproduct of this is that a great many key US programs intended for recapitalisation of existing Cold War era military equipment fleets have been deferred, cut back or cancelled, to fund the higher optempo and urgent replacement of equipment such as helicopters and ground vehicles. Increased costs for petroleum based fuels mostly due to increased demand in Asia have further exacerbated the funding problem.

US budgetary figures for 2007 indicated a shortfall of US$20 billion per year out to 2020 for US Air Force programs alone. Examples include arbitrary funding caps limiting production numbers of the F-22A Raptor to 183 aircraft, the CTOL F-35A Joint Strike Fighter to around 800 aircraft, early closure of the C-17A production line, cancellation of critical electronic attack programs (EB-52H), restructuring and deferral of the critical Joint Tactical Radio System (JTRS) high speed network, and cancellation of Electronic Warfare Self Protection upgrades for the B-1B (Defensive System Upgrade Program or DSUP). To these can be added a wide range of Army, Navy and Marine Corps programs.

The latest development in this declining force structure has been the grounding, since last December and now most likely permanent, of no less than 163 of the fleet of 441 F-15A-D air superiority fighters, as a production defect was found in these aircraft, after one of them broke apart in flight. This is 37 percent of the fleet, and the life of the remaining aircraft will be burned out much faster as they will have to absorb the workload of the grounded aircraft[9].

In strategic terms, the funding pressures the US confronts both now and over the coming decade will have important consequences[10].

1. Military personnel numbers reduced in recent years may not be restored over the coming decade.
2. The US will continue to operate Cold War era equipment at least a decade longer than planned for, especially military aircraft, and fleet sizes will be reduced.
3. The proportion of new generation systems in the force structure such as the F-22A and JSF will likely be smaller than planned for, reducing the potency of US forces compared with growing capabilities in Asia.
4. Research and development funding for new technology will remain scarce, reducing the ability of the US to rapidly adapt to competing non-US technology.

From an Australian strategic perspective, the important consideration is that the US will have a diminished capability to intervene in any nation state disputes in the Asia-Pacific-Indian region. The deterrent impact of US capabilities in Asia will also be reduced. While the US will remain the dominant global military superpower over the next two decades, its margin of superiority over other major nations will be significantly reduced.

For Australia this means a US which is less able to intervene on Australia's behalf in a regional crisis, and also less likely to do so unless circumstances literally threaten Australia's survival as a nation state.

The diminished capability of the US to intervene on Australia's behalf in the region, and the significant growth in regional capabilities, open up opportunities for a range of regional nations to apply coercive force against Australia, unless Australia has a credible deterrent capability. Should deterrence fail, Australia must have the required capabilities to defeat the coercive application of military power within the region. Shortfalls in Australian capability relative to regional nations directly translate into opportunities to use coercive force against Australia, with all of the destabilising effects which result.

2 Benchmarking Regional Capabilities vs Force Structure

The 'creeping arms race' in Asia and ongoing proliferation of advanced Russian designed weapon systems in Asia changes much of Australia's strategic calculus.

Historically, Australian Defence planners relied on the idea of 'ten years of warning time' which assumed that a decade would be required for a regional nation to build up capabilities which could threaten Australia or its interests.

> The 'ten years of warning time' assumption is now wholly invalid, as deliveries of Russian equipment have been effected in recent years in timescales of three years or less. Indeed, where deliveries have involved refurbished or new equipment from Russian warstocks, deliveries as short as months have been observed. For all intents and purposes, the warning times for the delivery of many advanced capabilities must now be assumed to be of the order of months.

Another assumption which has been common in Australian Defence planning is that regional nations lack the training and support capabilities to effectively use modern weapons systems, and a related assumption observed frequently is that regional nations cannot find the talent in their national gene pools to effectively operate modern equipment[11].

> The assumption of inferiority in regional operational and support skills is no longer true. Much improved tertiary education systems, overseas university education of personnel, and more disciplined and structured recruitment programs have seen strong improvements in the operational and support skills base across the Asia-Pacific region. Moreover, Russian contract personnel and instructors are now readily available to fly and maintain combat aircraft and other advanced weapons to fill gaps in a client's personnel capabilities. A good case study is in recent African conflicts, where both sides crewed much of their air force capability with former Soviet republic contract personnel.

The third assumption which remains common in Australian Defence planning, yet is no longer true, is that aerial attacks against Australia require basing in the archipelago to Australia's north, as was the case during the Second World War and early Cold War / Confrontation periods[12].

> The proliferation of aerial refuelling technology, strategic bomber technology, and cruise missile technology into Asia now permits regional nations to launch coercive air and missile strikes against Australian territory or regional interests from a wide range of locations other than the Indonesian archipelago.

A fourth invalid assumption remaining commonly in use is that the Russians only export 'dumbed down' technology to clients, as was the practice during the Cold War period.

Russian military technology for export now generally outperforms products supplied to the Russian military. Good examples include the Sukhoi Su-30MKI/MKM Flanker H fighter, the Sukhoi Su-35-1 Flanker E+ fighter, the Novator R-172/K-100 'AWACS killer' missile, the S-300PMU-2 Gargoyle Surface to Air Missile system, and a range of electronic systems developed since the early 1990s.

The historically accepted force structure planning practice of using in situ Indonesian and Malaysian capabilities as a regional benchmark, scaled back by assumptions of personnel skills and capabilities shortfalls, is no longer acceptable and its continued use will result in significant strategic risks being incurred.

A more appropriate approach is the 'capability centric model' whereby key items of advanced military technology available in the region, and being marketed into the region, are used as hard benchmarks for ADF capability definition. This model must be used with due consideration to deployment timelines, as there is no point in defining future ADF capabilities to defeat past regional capabilities, rather than future regional capabilities. The strategic folly of both the F-35 Joint Strike Fighter and F/A-18F Super Hornet decisions is centred in their inability to compete against capabilities which are now arriving in this region, let alone capabilities which it is known will arrive in the region over the next decade.

2.1 Air Combat Capabilities - The Sukhoi Flanker (2010-2020)

The Sukhoi Flanker family of combat aircraft is the numerically and technically most significant capability the ADF will have to deal with in any future regional contingency. This aircraft was first deployed by the Soviets during the 1980s, as a counter to the contemporary US F-15 Eagle family of fighters. The Flanker is larger, more agile, carries a longer ranging radar and bigger weapon load than the F-15 series. Unlike the F-15 which has seen only modest evolution since the 1980s, the Flanker has been subjected to aggressive and ongoing technological development since it was first exported in 1992.

The gap in capabilities between the early production Su-27S/SK Flanker B and the most advanced variants such as the Su-27SKM Flanker B+, the Su-30MKI/MKM Flanker H and Su-35BM/Su-35-1 Flanker E+ is much greater than in any Western built equivalents, such as the F-15 series[13].

A common misconception is that a large difference in fighter capability is required to achieve a large difference in combat effect. Experience from every conflict since 1914 suggests that even a modest advantage in performance and weapons capabilities can produce a decisive effect, all else being equal. The gap in performance and weapons capabilities provided by the latest Flankers over the F-15 series, and earlier Flanker models, is well in excess of the capability gaps observed in most such historical case studies[14].

The Su-35-1 Flanker E+ now represents a critical benchmark in regional air combat capabilities in the 2010 to 2020 timeframe.

Figure 3: *The latest Flanker variant is the Su-35BM/Su-35-1 Flanker E+, which matches or outperforms the key capabilities of all Western fighters other than the F-22A Raptor (Sukhoi/KnAAPO).*

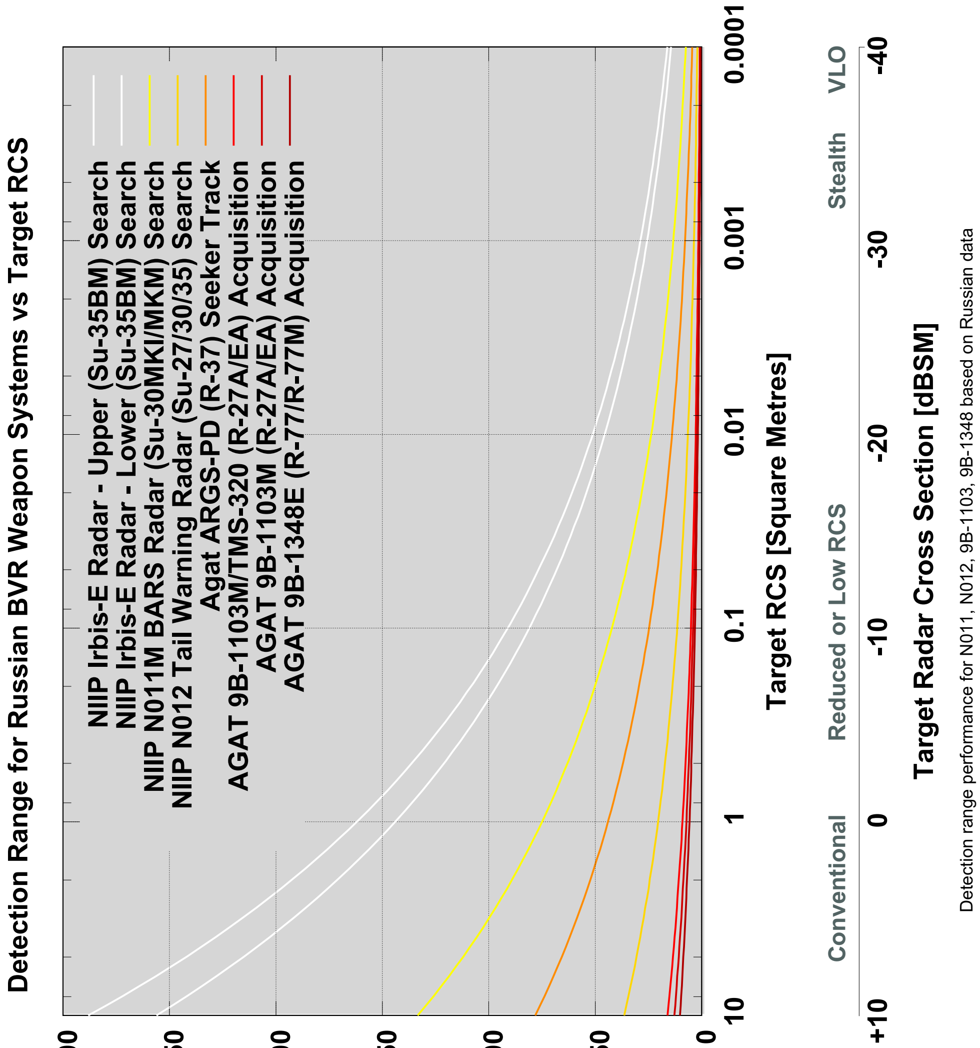

Figure 4: *The Su-35BM/Su-35-1 Flanker E+ is equipped with the 20 kiloWatt peak power Irbis E multimode ESA radar, a development and block upgrade of the N011M BARS with triple the power rating. This chart compares the detection range performance of the Irbis E, BARS, N012 tail warning radar, and a range of Agat designed missile seekers. It is significant that the Irbis E can achieve useful combat effect even against aircraft with radar signatures of 1/10 of a square metre - only a highly stealthy fighter like the F-22A can reliably defeat an Irbis E equipped fighter (Tikhomirov NIIP, Agat data).*

Importantly, the high level of compatibility between the Su-35-1 Flanker E+ and late model Su-27SKM and Su-30MKM is likely to see advanced systems and weapons migrate from the Su-35-1 Flanker E+ to the latter variants over the next decade, in block upgrades[15].

Russian manufacturers have adopted the US model of retrofitting advanced technology designed often for very different programs, to enhance existing operational fleets. A good example is the migration of the Khibiny M system from the specialised Su-34 Fullback bomber to the Flanker E+ series.

In assessing the Su-35-1 Flanker E+ we must consider that this aircraft incorporates most or all of the technological advances seen in recent Western built fighters, including the F-15K/SG Strike Eagle, F/A-18E/F Block II Super Hornet, F-16E Block 60, Eurofighter Typhoon, and Dassault Rafale. The Su-35-1 will have a supersonic cruise capability, challenging the F-22A Raptor.

Key capabilities which will be deployed in a 2010 - 2015 timescale Flanker variant will include:

- supersonic cruise using the AI-41FU or AI-31F-117C engines, comparable to the F-22A.
- thrust vector control using the AI-41FU or AI-31F-117C engines, comparable to the F-22A.
- external fuel tanks for a combat radius of ≈ 1,000 nautical miles, comparable to the F-111.
- Buddy refuelling capability using a centreline UPAZ-1A pod.
- Advanced glass cockpit with large panel displays, emulating the F-35 JSF cockpit.
- The encrypted TKS-2/R-098 (Tipovyi Kompleks Svyazi) Intra Flight Data Link (IFDL) which can network up to 16 fighters.
- A 'JTIDS-like' datalink for networking with other systems, including AEW&C/AWACS systems and surface based radars.
- Advanced variants of the KNIRTI L175M Khibiny M channelised Radio Frequency Surveillance system.
- Advanced variants of the KNIRTI L005S Sorbtsiya-S electronically steerable defensive jammer, including Digital RF Memory (DRFM) capabilities.
- Tikhomirov NIIP Irbis E high power phased array radar, claimed by the designers to match the power and detection range of the F-22A's APG-77.
- An imaging Infrared Search and Track Set comparable to the Eurofighter PIRATE[16].
- Four channel digital flight controls, comparable to the latest Western production fighters.
- Full Authority Digital Engine Controls (FADEC), comparable to the latest Western production fighters.

- Radar signature suppression coatings capable of thirty-fold reduction in the upper band (i.e. X- and Ku-band) signatures of engine inlets.
- Western COTS technology mission computers, comparable to the latest Western production fighters.
- Advanced Helmet Mounted Displays, comparable to the latest Western production fighters.
- Optical fibre internal digital bussing, comparable to the latest Western production fighters.
- The ramjet powered Vympel R-77M Air to Air Missile, with digital active radar, heatseeking and passive anti-radar seekers, with range comparable to the UK Meteor.
- Variants of the very long range Vympel R-37 Arrow and Novator R-172/K-100 'AWACS-Killer' missiles with ranges between 160 and 215 nautical miles.
- Electro-optical, laser and satellite guided smart bombs in the 500 kg and 1,500 kg class.
- Supersonic cruise missiles including the Yakhont and Moskit/Sunburn series.
- Subsonic cruise missiles such as the Novator 3M-14A, comparable to US Tomahawk variants.
- Supersonic ramjet powered anti-radar and anti-shipping missiles in the Kh-31 Krypton series.

> The only Western built combat aircraft which has performance and capabilities decisively superior to such advanced Flanker variants is the F-22A Raptor. All other types fall short in one or more capability areas, and all fall short in performance. Both the F-35 Joint Strike Fighter and F/A-18F Super Hornet qualify as 'multiply inferior'.

2.2 Air Combat Capabilities - The PAK-FA (2015-2035)

The Russian PAK-FA (Future Aviation System for Tactical Aviation) is a stealthy supercruising air superiority fighter intended to enter service over the coming decade. While it is often described as 'Russia's JSF', the twin engine PAK-FA is being developed for air combat rather than battlefield interdiction. Therefore its design objectives are much closer to those of the F-22A Raptor rather than the underpowered F-35 Joint Strike Fighter.

> Given what is known about the advanced technology being installed in the Flanker fighters, and Russian disclosures on the PAK-FA stealth and propulsion design, it is clear that the only Western fighter capable of credibly countering the PAK-FA is the F-22A Raptor. The PAK-FA will provide the same generational advantages in performance and capability over established Western fighters as are provided now by the F-22A.

Figure 5: *The agile, stealthy and supercruising Russian PAK-FA is often described as 'Russia's JSF', but this is misleading since its design objectives are much closer to those of the F-22A Raptor than the F-35 JSF (Saturn).*

2.3 Air Combat Capabilities - Force Multipliers (2005-2035)

The acquisition of advanced fighter aircraft across the region is being paralleled by the acquisition of a wide range of capabilities intended to multiply or enhance the combat effect of these fighters.

Aerial refuelling capability is now becoming a common feature of regional force structures. India and China have procured Russian Ilyushin Il-78 Midas tankers, Japan the Boeing KC-767A, Singapore the Boeing KC-135R, while China has rebuilt a portion of its H-6 Badger fleet into tankers which compare closely to the UK's former V-bomber tanker fleet. The development of China's indigenous turbofan powered H-6K bomber is likely see this extended range design also adapted for aerial refuelling.

Of no less concern is that more recent variants of the Russian Flanker fighter are equipped with a buddy refuelling capability, using the centreline UPAZ-1A pod. Operators of such Flanker subtypes have the option of extending combat radius by committing some portion of their fighters to the tanker role, as the US Navy is now doing with its F/A-18E/F Super Hornets.

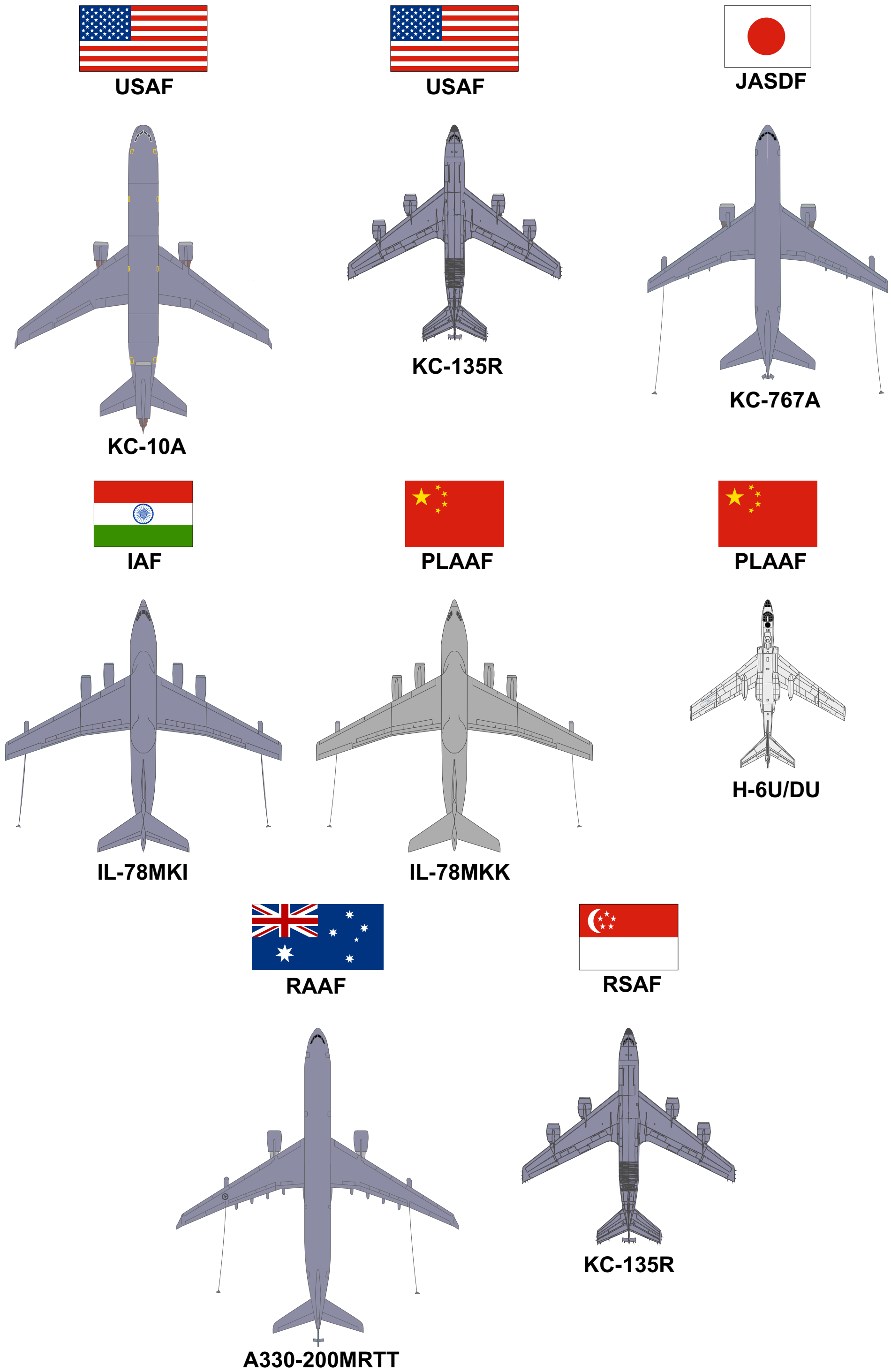

Figure 6: *Many regional nations are acquiring aerial refuelling tanker aircraft (C Kopp).*

Other important capabilities are being acquired in the region. India has been the first to order very long range Novator R-172 ‘AWACS killer’ missiles, developed to destroy surveillance aircraft and aerial refuelling tankers from ranges in excess of 200 nautical miles. Russia is marketing this missile, and the similar Vympel R-37 / AA-13 Arrow to regional nations. A nation without an Airborne Early Warning and Control (AEW&C) / Airborne Warning And Control System (AWACS) or aerial refuelling capability can use these weapons to deny an opponent the use of these capabilities, either by destroying them in combat or threatening them.

Systems for high power jamming of surveillance systems are also appearing in the region. China acquired the Russian Topol-M jammer, while Russia is marketing a range of ground based jamming systems specifically designed to impair AEW&C/AWACS radars.

Figure 7: *An option available on several Flanker variants is a buddy refuelling system, allowing the Flanker to act as an aerial refuelling tanker aircraft. Regional nations which cannot afford dedicated tanker aircraft have the option of emulating the US Navy practice of using fighters as buddy refuellers (KnAAPO).*

Figure 8: *The 400 kilometre range Novator R-172/K-100 ‘AWACS killer’ missile on display at the MAKS 2007 trade show (Strizhni.info).*

Figure 9: *Precision Guided Bombs or 'smart bombs' have proliferated globally since the end of the Cold War, with US, Israeli, French and Russian products now widely available. Within the region, the Russian KAB-500 and KAB-1500 series are now widely deployed. These bombs combine the best aerodynamic features of the US GBU-8, GBU-10 and GBU-15 weapons, with laser, television, thermal imaging or satellite guidance. Warheads include blast, bunker busting, fuel air explosive and most recently, thermobaric designs (Legion.ru).*

Figure 10: *Raduga Kh-55SM Granat / AS-15 Kent cruise missile with conformal fuel tanks (RuMoD).*

2.4 Strike Capabilities - Cruise Missiles (2010-2035)

The introduction of a wide range of Russian developed, and more recently indigenous, smart bombs in the Asia-Pacific region is well documented. Strategically this amounts to regional operators finally closing the gap and acquiring one of the decisive technological advantages held by Western powers since the late 1960s.

What is less well appreciated in Australia is the large scale introduction of a wide range of advanced cruise missile types by regional operators, with anti-shipping, land attack and dual role capabilities. Dual role cruise missiles are typically anti-shipping weapons with additional satellite navigation capability to permit attacks on land based targets. These cruise missiles can typically be launched by aircraft, land mobile systems, surface warships and submarines. Physically small and flying at low altitudes, they present challenging targets for surface based missile batteries and fighter aircraft tasked with interception.

Until recently only the US and Russia deployed significant inventories of cruise missiles, with China manufacturing much improved derivatives of the late 1950s Soviet P-15 Termit/Styx, designated as the Silkworm series.

Types recently introduced across the region include:

- The Novator Club or SS-N-27 Sizzler family of missiles, including the subsonic 3M-54E1 and 3M-14E comparable to anti-shipping and land attack variants of the 1980s US BGM/AGM-109H/L Tomahawk MRASM. These weapons can be launched by surface warships and Kilo class submarines, the latter currently operated by India and China, and ordered by Indonesia. An air launch variant for the Flanker was displayed at the MAKS 2007 trade show in Moscow.

- The supersonic hybrid 3M-54E / SS-N-27 Sizzler missile, provided for Indian and Chinese Kilos.
- The Russian supersonic NPO Mashinostroyenia 3K-55/3M-55/Kh-61 Yakhont or SS-N-26, supplied to China, and its licence built Indian derivative, the PJ-10 Brahmos A/S. These formidable missiles have no Western equivalent, and can be launched from aircraft, land mobile systems, surface warships and submarines.
- The Russian supersonic Raduga 3M-80, 3M-82 and Kh-41 Moskit or SS-N-22 Sunburn, launched by 956E Sovremennyy class destroyers and the Su-33 and Su-35-1 Flankers. There is no Western equivalent.
- Pakistan is deploying the indigenous Barbur cruise missile, comparable to the BGM/AGM-109H/L Tomahawk MRASM.
- China is deploying the indigenous CHETA YJ-62/C-602, comparable to the BGM/AGM-109H/L Tomahawk MRASM.
- China has deployed the indigenous CHETA KD-63, an advanced turbojet derivative of the Silkworm series, on the new build H-6M Badger bomber.
- China has deployed the indigenous DH-10, generally considered to be equivalent to the US BGM-109A/C Tomahawk Block II/III series.
- China illegally acquired in 2001 samples of the Russian Raduga Kh-55SM Kent strategic cruise missile from Ukrainian warstocks, this weapon being equivalent to the Boeing AGM-86 ALCM series. It is not known whether a reverse engineered variant now exists[17].

Russia continues to actively market the Sizzler across the region, while India has begun to market the Brahmos. China is likely to soon market the YJ-62 series, as it has marketed the Silkworm series. The latest Chinese launch platform is the new production turbofan powered H-6K Badger bomber, currently in flight test.

From a strategic perspective the large scale deployment of cruise missiles across the region, using a diverse range of launch platforms, including widely used Flanker fighters and Kilo class submarines, presents a new and unprecedented risk, as these weapons are accurate, difficult to stop, and permit the attacker to stand off and employ ‘hit and run’ attacks. This puts a premium on the capability to intercept or interdict these launch platforms, and to intercept cruise missiles once launched.

The US cruise missile defence strategy is centred on the deployment of the F-22A Raptor, since it is the only fighter which combines the necessary radar performance and supersonic cruise performance for this role. It is to be supported in this role by the E-8C JSTARS surveillance platform using its large X-band radar. There are no such defensive capabilities currently planned in Australia to deal with regional cruise missile capabilities.

Figure 11: *India is now marketing the supersonic Brahmos cruise missile for export (upper right), while Russia continues marketing of the Raduga Kh-41 Moskit/Sunburn (upper centreline station), and Novator 3M-54 Club/Sizzler (centre). China is expected to export the Tomahawk-like CHETA YJ-62 (lower).*

2.5 Air Defence System Capabilities (2005-2035)

The region has seen the ongoing proliferation of a range of highly capable air defence weapons and surveillance capabilities, since the early 1990s.

The Russian designed Almaz S-300PMU2 Favorit (SA-20 Gargoyle) and S-400 Triumf (SA-21 Growler) family of Surface to Air Missile (SAM) systems are often regarded to be 'Russia's Patriot'. In many respects the more recent variants of this family of systems outperform the latest US Patriot variants, and all have significantly better mobility and low altitude coverage than the US Patriot.

First deployed during the late 1970s, as the road transportable S-300PT, this family of weapons has been subjected to aggressive technological evolution and technology insertion, since then.

While these weapons, like the 'equivalent' US MIM-104 Patriot, employ a large phased array engagement radar with excellent jam resistance, the Russian S-300PMU-2 and S-400 systems employ an additional 64N6E series phased array search radar, which compares very closely to the US SPY-1 Aegis naval search radar, a capability absent in the Patriot. All key battery elements can be deployed or stowed for transit in a matter of minutes.

The Russian 48N6E and 96M6E series missiles are direct equivalents to the US Patriot PAC-3 and ERINT missiles in performance and guidance technology. The advanced extended range 48N6DM variant used by the S-400 has a range against aircraft targets in excess of 200 nautical miles.

Using similar digital technology to the PAC-3, the current S-300PMU2 and S-400 missile systems are formidable weapons which can engage targets at all altitudes and speeds. As these weapons were developed from the outset to defeat the US AGM-86 and BGM-109 Tomahawk cruise missiles, they are highly effective against all but the stealthiest aircraft and cruise missile types. The latest S-400 derivative system is also claimed to incorporate the hypersonic two stage 9M82M missile, previously used in the potent mobile Antey S-300VM / SA-X-23A SAM system. Software and interfaces in the S-400 system permit it to control legacy missile batteries such as the 5V28E / SA-5 Gammon, and interface with a wide range of other early warning sensor systems.

To enhance low altitude coverage the Soviets developed the unique mobile 40V6 series elevating masts, which can be used to raise surveillance and engagement radars up to 40 metres above terrain, almost doubling the radar coverage footprint against low flying targets like cruise missiles. Most battery components are mounted on or towed by high mobility 8 x 8 all terrain variants of the MAZ-543 Scud launcher vehicle.

A range of other surveillance radars are available to cue the S-300PMU2 and S-400 systems, including the digitally enhanced lower frequency band 55Zh6-1 Nebo UYe / Tall Rack, 1L13-3 Nebo SV/SVU, and 5N84AE Oborona-14 / Tall King systems. Due to the VHF band radio frequencies employed, these radars have useful detection capabilities against smaller stealth aircraft. This permits the use of such radars as early warning assets and to cue fighters or SAM engagement radars to stealthy targets[18].

Figure 12: *The high mobility NIIIP 64N6E2 Big Bird is an acquisition radar with similar capabilities to the naval SPY-1 Aegis system (upper). The high mobility 30N6E2 engagement radar is the Russian equivalent to the Patriot MPQ-65 (lower), (Almaz-Antey).*

Figure 13: *Novator 9M82M / SA-X-23A hypersonic two stage air defence missile (upper). All S-300PMU and S-400 battery components are highly mobile, connected by a radio network (centre). The S-300PMU family of systems is available with mobile mast systems providing up to 40 metres of elevation, to improve capability against cruise missiles and low flying aircraft (lower), (Almaz-Antey).*

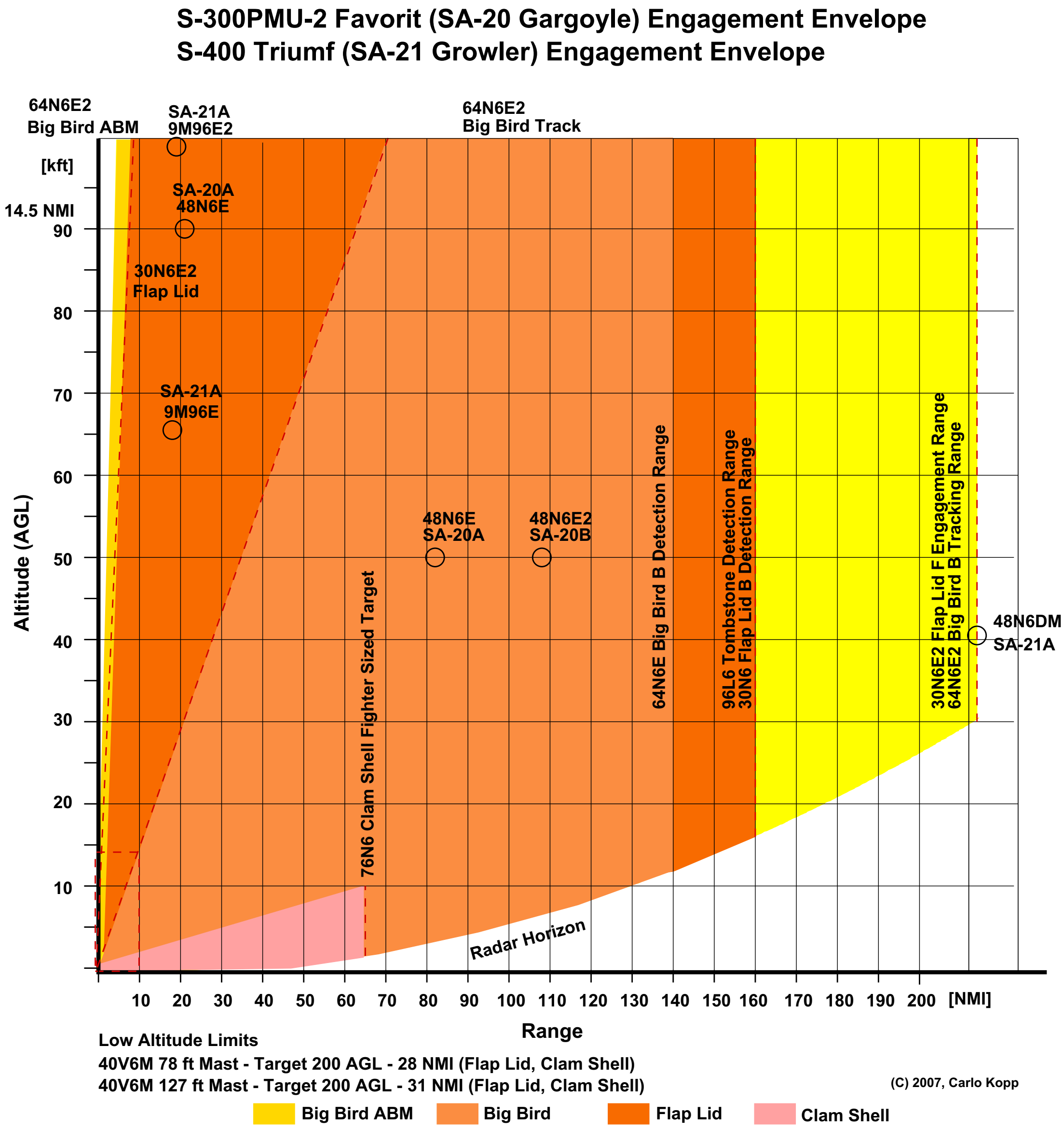

Figure 14: *The potent S-300PMU and S-400 family of SAM systems provide all altitude coverage against targets to significant ranges (C Kopp).*

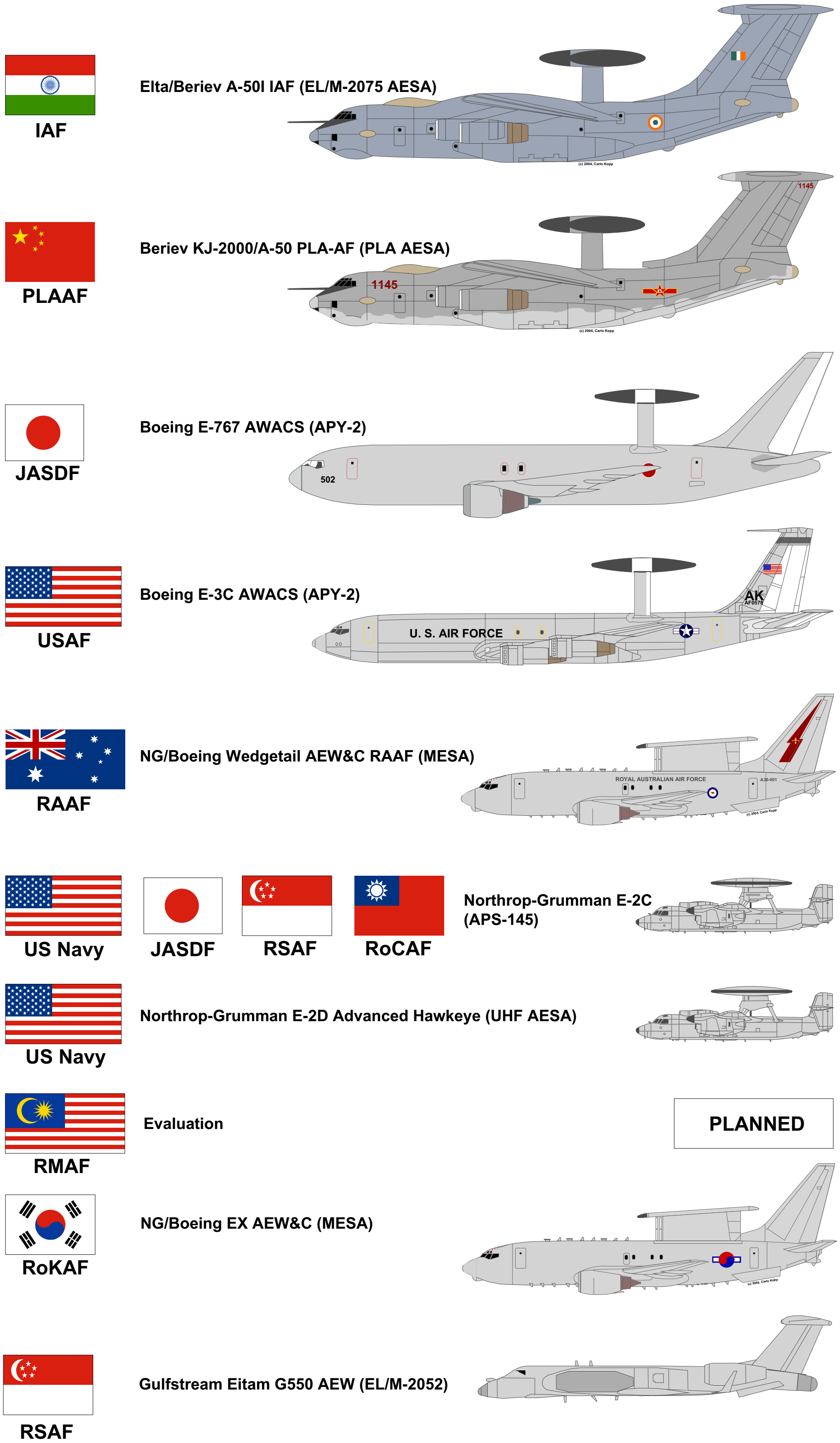

Figure 15: *Most regional nations are acquiring Airborne Early Warning and Control aircraft, and importantly, most new systems employ agile phased array radars (C Kopp).*

The long range area defence capabilities of the S-300PMU2/S-400 systems are typically supplemented by highly mobile and agile point defence missile systems such as the Tor M1 / SA-15 Gauntlet and 2S6 Tunguska / SA-19 Grison. Following the well established Soviet doctrine of 'layered defence', the SA-15 and SA-19 would be used to engage aircraft or stand off weapons which 'leaked' past the S-300PMU2/S-400 systems, and following the more recent 'anti-access' doctrine, to protect the S-300PMU2/S-400 systems from attack using smart bombs or stand off weapons.

China has deployed over a dozen S-300PMU batteries, contributed funding to the development of the S-400, and is manufacturing cloned hardware. Indonesia has publicly expressed interest in acquiring these systems.

The US Air Force consider only the B-2A Spirit and F-22A Raptor to be capable of surviving in airspace defended by these missile systems. Part of the designated role of the F-22A is to hunt down and destroy these systems. There are no capabilities in ADF service or planned which would be survivable in airspace defended by the S-300PMU2 and S-400.

Regional investment in air defence capabilities is not confined to long range missile systems and supporting radars alone.

Airborne Early Warning and Control (AEW&C) / Airborne Warning And Control System (AWACS) aircraft are being widely acquired across the region. Nations without AEW&C capability are now the exception rather than the rule. With the exception of legacy systems operated by the US, Japan, Singapore and Taiwan, all recent procurements of AEW&C systems include agile jam resistant electronically steered array radar systems, the same technology used in Australia's Wedgetail.

China has been setting the trend in the region, and currently has no less than three indigenous AEW&C system development programs in place, including the KJ-2000 phased array system similar to the Israeli A-50I, the KJ-200 phased array system similar to the Ericksson/SAAB Erieye, and a rotodome system carried by a Y-8 transport.

The adoption of AEW&C systems across the region is paralleled by the adoption of digital datalink technology for networking air defence systems, fighter aircraft and surveillance systems. US aligned nations have been acquiring the JTIDS/MIDS/Link-16 network, while the Russians are actively marketing a direct technological equivalent labelled as a 'Link-16 type' data terminal.

All of the available evidence indicates a now well established trend across the region to emulate US force structure models and technology in air defence capabilities. Regional nations will employ networked systems, which tie together combinations of AEW&C systems, surface based radars, passive surveillance equipment, fighter aircraft and surface based air defence missile systems, the latter highly mobile. The sole impediment to the sophistication of such systems will be available funding, with wealthier nations acquiring robust systems, and not so wealthy nations acquiring only components of these systems.

3 RAAF Force Structure Considerations

The proper design of military force structures is a complex, intensive, but relatively straightforward task. The outcome of a successful design is to provide the appropriate mix of capabilities to successfully achieve some given strategic objectives. Unsuccessful designs will typically not be able to meet these objectives, and often also are more expensive to implement and operate, compared to a successful design[19].

A critical consideration is that the capability of the force structure must be considered as a whole, and making choices of specific elements without consideration of the rest of the force nearly always produces a poor outcome.

The scale of strategic changes in the region requires that the future RAAF force structure be suitably adapted, if Australia is to simply retain the strategic position it held in this region until a decade ago. We cannot assume that we will have an asymmetrical advantage in possessing basic capabilities, e.g. 'we have AEW&C and our opponent does not', the best we can plan for is that we will have incrementally or substantially better capabilities than potential opponents.

Extant and developing regional capabilities will require that the RAAF acquire several 'key capabilities' neither currently deployed nor planned for deployment. These include[20]

1. Capability to decisively defeat Sukhoi Su-27SK, Su-27SMK, Su-30MK, Su-35BM/35-1 Flanker, PAK-FA and future growth variant fighters, including models equipped with supersonic cruise engines.
2. Capability to defeat strategic bombers such as the H-6K Badger, Tu-95MS Bear and Tu-22M3 Backfire. Fighter aircraft must have the supersonic performance to effect intercepts against supersonic bombers, and be supported with sufficient refuelling capability.
3. Capability to defeat cruise missiles, including subsonic and supersonic weapons. Fighters must have the aerodynamic performance, radar performance and weapon payload to credibly intercept low flying cruise missiles in flight. Sufficient aerial refuelling must be available.
4. Capability to perform long range 'counter-force' strikes to pre-emptively defeat regional offensive capabilities in a crisis. Sufficient aerial refuelling capability must be available to reach targets at distances of 2,500 nautical miles or greater.

These basic 'key capabilities' must exist, and sufficient numbers of aircraft be available for the capability to be credible. While the RAAF will need to provide a much broader mix of capabilities, these 'key capabilities' are necessary prerequisites for all others.

Additional considerations include:

1. Achieving sustainability in operations.

2. Achieving survivability in operations.
3. Achieving persistence and reach in operations.
4. Achieving situational awareness in operations.
5. Achieving network robustness in operations.
6. Performing electronic attack (i.e. jamming) against opposing networks and intelligence, surveillance and reconnaissance systems in operations.
7. Achieving coalition interoperability.

The legacy force structure model, centred on the F/A-18A/B HUG, F/A-18E/F and later F-35 Joint Strike Fighter is not capable of providing the 'key capabilities', due to the basic design limitations of these three aircraft types. It is further impaired by planning to acquire only six Wedgetail AEW&C aircraft, and five KC-30/A330-MRTT tanker aircraft, and the absence of a range of other important intelligence, surveillance and reconnaissance, networking relay, and electronic attack capabilities.

At the most fundamental level, the legacy RAAF force structure plan is built around completely inappropriate types of fighter aircraft, supported by inadequate numbers of intelligence, surveillance and reconnaissance systems, aerial refuelling aircraft, network relay capabilities, and no dedicated electronic attack capability.

In assessing what changes need to be made to the RAAF force structure, it is clear that some assets in service are well suited to the extant and developing region, including the F/RF-111C/G and the Wedgetail AEW&C. Less suited is the KC-30 tanker, as more than twenty would be required to achieve the necessary fuel offload performance to support any RAAF fighter fleet structure, including the current one.

Considerable analysis and modelling by the authors, an ongoing effort since 1998, has determined that the best balance in capability, cost, risk and other considerations, can be achieved by acquiring the F-22A Raptor as a replacement for the F/A-18A/B HUG, and extending the life of the F-111 by at least a decade, with a series of specific capability and maintainability upgrades.

In the simplest of terms, the enormous capability advantage provided by the F-22A Raptor in defeating opposing fighter aircraft and surface based air defences makes the choice of additional strike capabilities a matter of economics rather than anything else. The recent Red Flag exercises in which F-22As escorted RAAF F-111s prove this convincingly. Moreover, the F-111 has an unassailable economic advantage over all alternatives since it is an in service asset, and requires significantly less aerial refuelling than all of its proposed replacements.

This paper will further detail the specific advantages of the force structure model using the F-22A Raptor and F-111. A detailed discussion of the force structure rationale is provided in Annex A to this paper.

Part II

A Coherent and Balanced Force Structure Solution: The F-22A and Evolved F-111 Force Mix

Part II outlines the coherent and balanced force structure solution derived from the analyses discussed in Part I, specifically, the F-22A and Evolved F-111 Force Mix proposal, and discusses capability, cost, risk and industry issues in the context of Australia sovereignty.

The F-22 and Evolved F-111 Force Mix Option

4 The F-22A Raptor Air Dominance Fighter

The F-22A is a revolutionary aircraft, with key capabilities possessed by no alternative, making it also quite unique.

It is the only Western combat aircraft in existence, and planned, which combines high stealth capability with supersonic cruise capability and high agility[21].

Stealth capability amounts to the ability to defeat opposing sensors, especially radar, thus effecting surprise in combat. Like all defensive capabilities, stealth performance varies widely across fighter types. At this time the F-22 has the best stealth performance of any high performance fighter in existence, or planned.

This kind of stealth capability has to be designed into an aircraft from the outset and cannot be added by upgrades[22].

Supersonic cruise capability is the ability to maintain supersonic speeds without the use of engine afterburners. Afterburners will consume a fighter's fuel many times faster than its engines burn fuel without the afterburner engaged. An engine with supersonic cruise capability allows a fighter to perform in the manner a fighter without this capability would, were it using its afterburner all the time. At this time the F-22 is the only production fighter which has been designed from the outset for supersonic cruise[23].

Supersonic cruise capability of this kind also has to be designed into an aircraft from the outset and cannot be added by upgrades. While Russia has started producing a supersonic cruise engine for the Sukhoi fighters, these fighters were not designed for sustained supersonic flight and will not be competitive against the F-22.

The F-22 is a genuine multirole fighter, in that it is designed to defeat opposing fighters, and to attack the most heavily defended surface targets with smart bombs.

When used as an air superiority fighter, the F-22 has no peer in Beyond Visual Range combat, as its combination of stealth and supersonic cruise provides it with the ability to engage and disengage at will, in a fashion no other fighter can. In mock engagements flown in the US, the F-22 has repeatedly won engagements in which a single F-22 was pitted against multiple F-15 fighters[24].

In close combat the F-22 has greater agility than any fighter other than the most advanced Russian Sukhois.

The F-22 carries the most powerful and longest ranging radar ever fitted to an air combat fighter. This allows it to detect and engage targets from greater ranges than opposing and competing fighter types. The radar is so powerful, that the US Air Force envisage using it as a microwave Directed Energy Weapon to disrupt the electronics in opposing aircraft and cruise missiles, at close ranges[25].

The F-22 is designated as the primary fighter to be employed by the US Air Force in the planned cruise missile defence architecture.

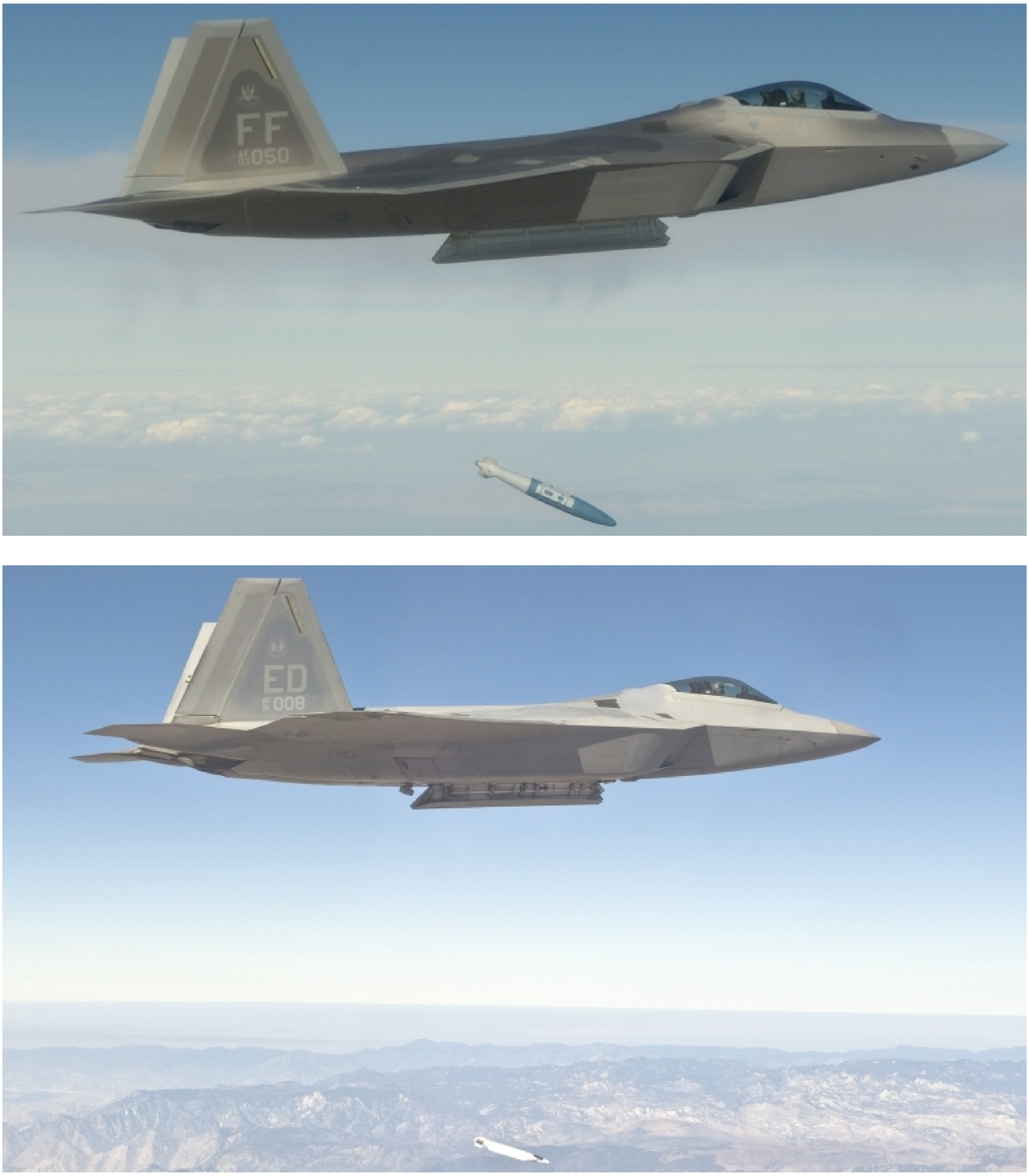

Figure 16: *The stealthy supercruising F-22A Raptor will become the backbone of the US Air Force. The F-22A will escort non-stealthy and stealthy strike aircraft in high threat environments, defeating opposing fighter and surface based missile defences, and strike at high value heavily defended surface targets. The F-22A is regarded to be an "unstoppable" bomber, armed internally with a pair of GBU-32/B JDAM satellite inertial guided bombs (above), or up to eight GBU-39/B SDB glidebombs (US Air Force).*

The F-22 and Evolved F-111 Force Mix Option

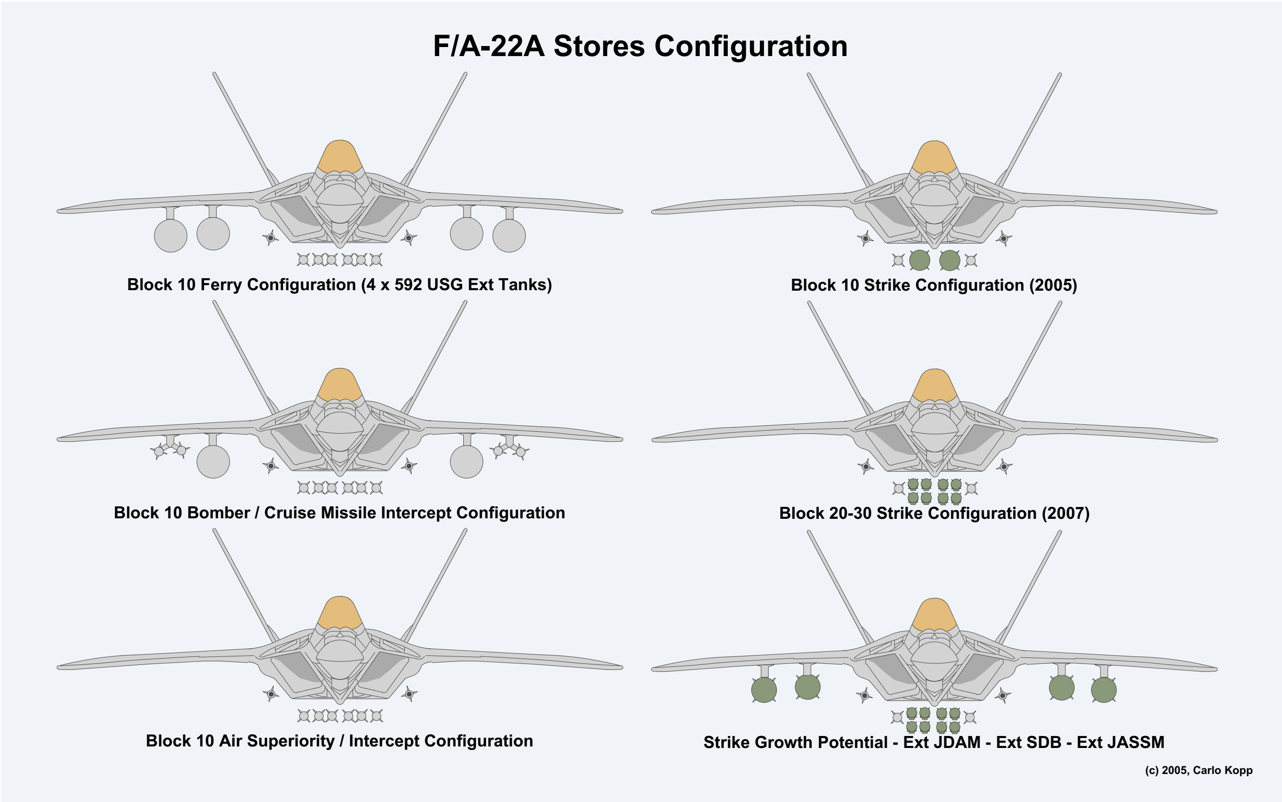

Figure 17: *F-22A weapons capabilities (C Kopp).*

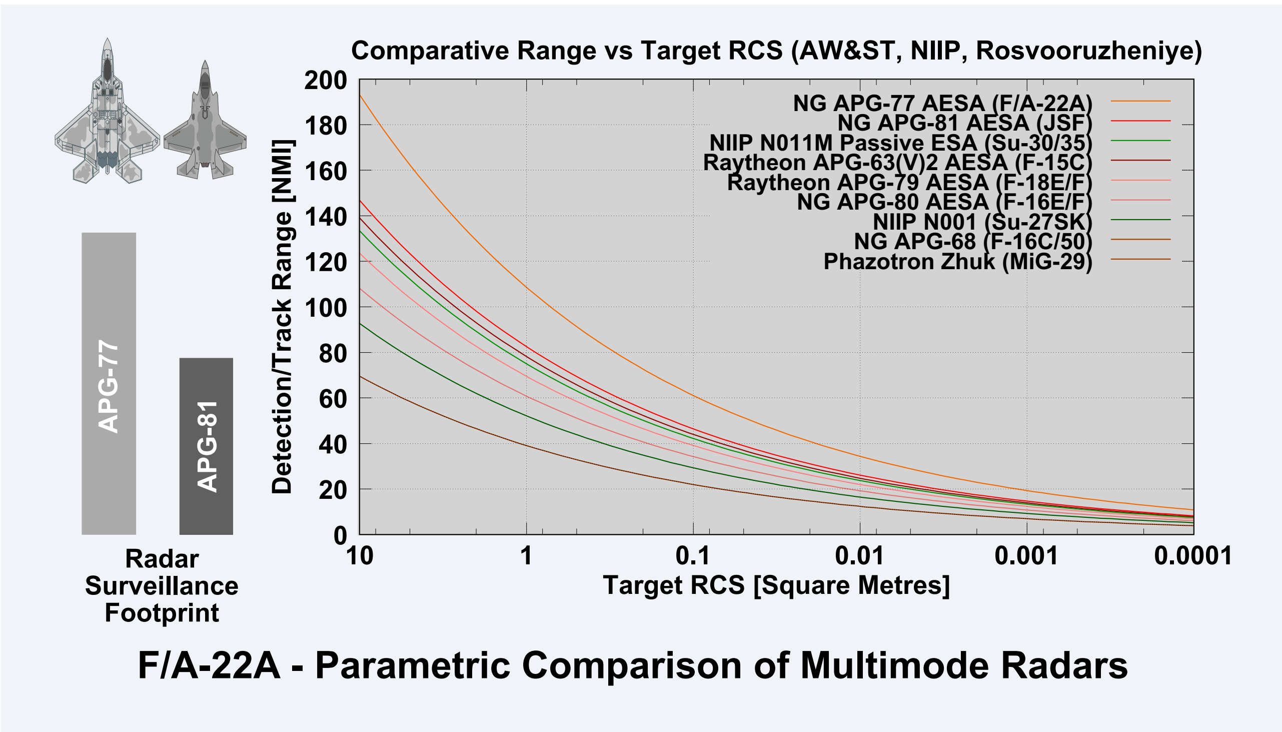

Figure 18: *F-22A radar capabilities (C Kopp).*

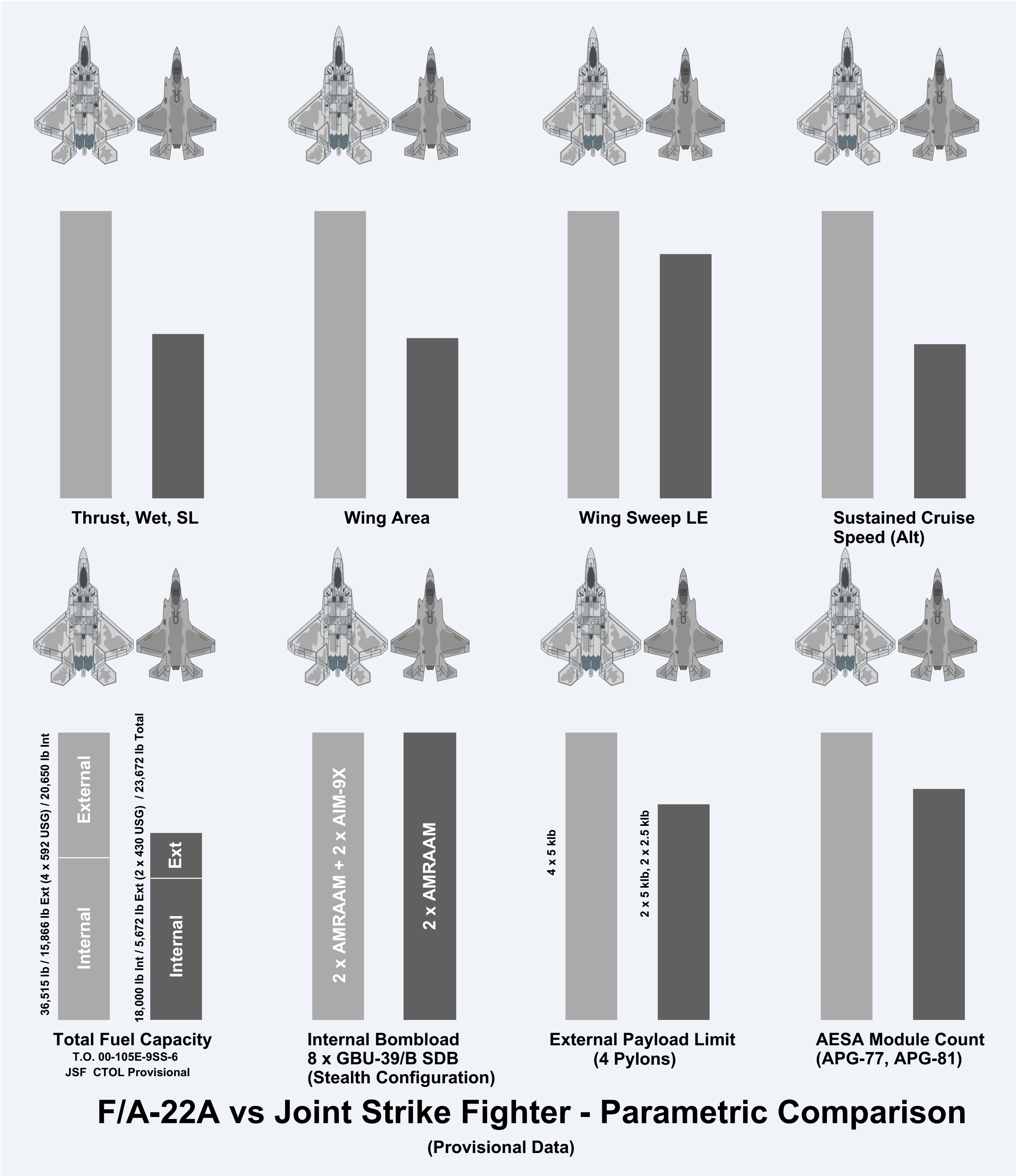

Figure 19: *F-22A vs JSF capabilities (C Kopp).*

The F-22 and Evolved F-111 Force Mix Option

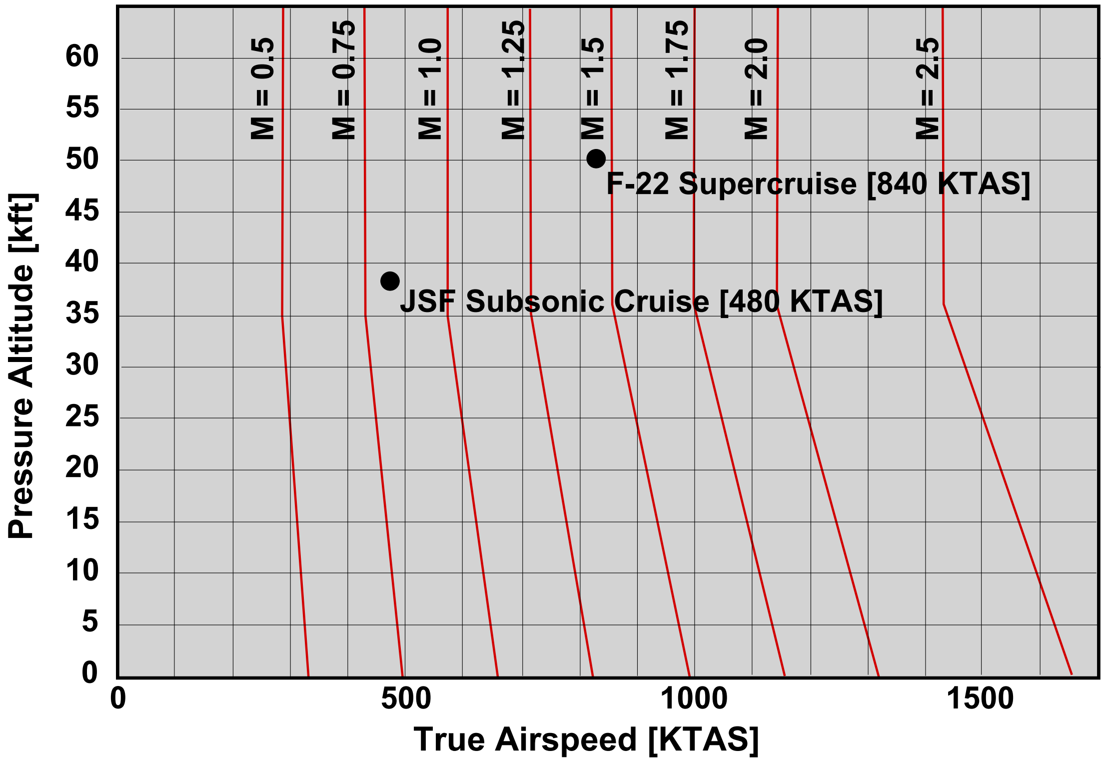

Figure 20: *F-22A supersonic cruise (C Kopp).*

This is by virtue of the F-22's ability to better detect small low flying cruise missiles, compared to all other aircraft. The supersonic cruise capability of the F-22A allows it to cover a much larger footprint than conventional fighters, and provides the additional performance to reliably intercept supersonic cruise missiles and launch aircraft, if required.

When used as a bomber, the F-22 has unchallenged survivability in the face of the most capable air defence missile systems known and envisaged. The combination of supersonic cruise at high altitude and high performance stealth puts the F-22 out of the reach of most Surface to Air Missile types, and makes it effectively invisible to those Surface to Air Missile types with the performance to reach it. It remains the most survivable strike fighter ever built.

Supersonic cruise capability contributes to the F-22's productivity, as it can transit distances at twice the speed of any competing alternatives, even allowing for aerial refuelling, and thus it can produce more sorties per day than any other fighter.

The F-22 can carry two internal 450 kg smart bombs or up to eight internal 175 kg Small Diameter Bombs, and has the inherent capability to carry up to four 1,000 kg external smart bombs or cruise missiles on wing pylons[26].

The APG-77 radar in the F-22 has recently been enhanced to provide high resolution ground attack capabilities comparable to other state of the art strike fighters, providing it with the same autonomy as specialised bomber aircraft[27]. Testing is under way to introduce a high data rate network capability

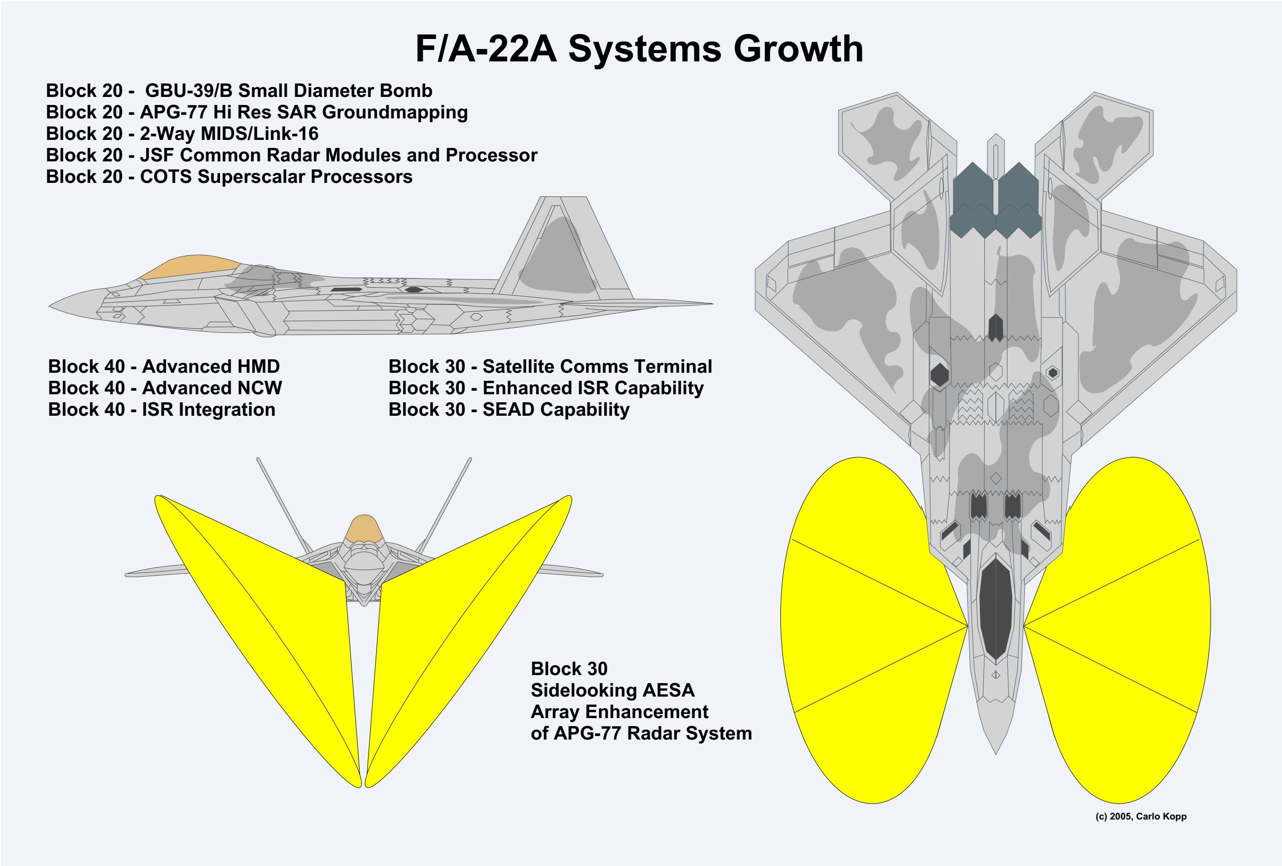

Figure 21: *F-22A growth capabilities. The Block 20 GBU-39/B Small Diameter Bomb is currently in flight test. The Block 20 APG-77(V)1 radar with full high resolution groundmapping capability completed flight test certification in March, 2007, and has been in production since last year. Testing was performed on the radar last year to demonstrate its ability to transmit network messages at broadband data rates and long distances, with rates of 500 to 1,000 Megabits/sec achieved (C Kopp).*

into the radar using its antenna to send and receive data[28].

Another unique capability in the F-22A is the ALR-94 passive Radiofrequency Surveillance System, designed to locate hostile radio frequency emitters such as radars. This system is considered to be comparable to specialised emitter locating equipment used on aircraft dedicated to hunting an opponent's air defence missile systems[29].

The US Air Force also intend to use the F-22 as an Intelligence, Surveillance and Reconnaissance (ISR) asset, exploiting its superlative sensors and exceptional survivability. In this role the F-22's supersonic cruise capability allows it to gather intelligence twice as fast as a conventional aircraft.

Used either as an air combat fighter, a bomber, or an Intelligence, Surveillance and Reconnaissance asset, the F-22 is far more productive by virtue of its supersonic cruise capability, thus allowing a single F-22 to do the work of two or more less capable conventional fighters[30].

Public claims by some parties that Australia cannot gain access to the F-22A are not accurate.

The export of this system, and other advanced technology, requires that the US perform the full LO/CLOEXCOM assessment for export of the F-22A to Australia, as Congressional and Executive approval for what configuration is exported is contingent on the findings of this assessment. The 'LO/CLOEXCOM' protocol, detailed in a public study authored by then LtCol Matthew Molloy of the School of Advanced Air Power Studies at the Air University at Maxwell AFB, published in June 2000, is a four step 'multi-agency' process[31].

It is known that during the 1999-2001 period the US Defense Department did go through the first step in the four step LOEXCOM protocol, and performed an Integrated Product Team assessment of the F-22's exportability to Australia. It is also known that this assessment, initiated at the request of the then RAAF leadership, concurred with the assessment in Molloy's study that Australia was a safe export target for the F-22A.

The Integrated Product Team study defined two configurations of the aircraft, configuration 'A' with almost full capability, and configuration 'B' with a number of sensitive stealth and software features removed. Australia would have been offered the 'A' configuration, with some features turned off but available to Australia in time of conflict.

The assessment was terminated in late 2001 at the request of Australia's Defence bureaucrats.

Why is the F-22 the best strategic choice for Australia to replace its F/A-18A Hornets?

1. **Capability:** The F-22A is over twice as capable as alternatives, including the F-35 Joint Strike Fighter, in most roles. In some roles it is four or more times as capable.

2. **Strategic Position:** The F-22A is the only aircraft which has the capability to decisively defeat superior numbers of advanced Russian fighters in the region.

3. **Regional Independence and Credibility:** The F-22A confers exceptional capability and thus credibility to the ADF in the region, reducing Australia's dependency on US forces.

4. **Value for Money:** The F-22A has so much more capability than any other alternative, that it is the best value for money buy in the market.

5. **Better Life Cycle Growth Capability:** The F-22A is a large aircraft with greater system growth potential than any alternative.

6. **Longevity and Return on Investment:** The F-22A will remain effective and thus strategically credible much longer than any alternative.

7. **Low Technical and Financial Risk:** The F-22A is a known commodity that is is in production and operational today, unlike the Joint Strike Fighter.

8. **Clearly Defined Schedule:** Acquiring the F-22A in the 2008-2012 time window allows the replacement of the F/A-18A HUG earlier with no capability gap.

The F-22 and Evolved F-111 Force Mix Option

5 The Value of the F-111

The final quarter of 2001 is now marked in history as an important transition point in the development of modern air power. During the three months of the Enduring Freedom campaign, the critical balance in combat effect swung from the lightweight multirole fighter to the dedicated bomber.

Fleeting and emerging ground targets, historically the most difficult challenge faced by air power, were systematically eradicated by the use of 'persistent bombardment' technique, flown by the US Air Force B-1B and B-52H, both armed with near precision JDAM bombs. The application of this technique during the late March, 2003, bombardment of Iraqi Republican Guard formations during the Iraqi Freedom campaign proved to be pivotal in achieving decisive and rapid collapse of Saddam's ground forces.[32]

Why has the lightweight multirole fighter, a mainstay of Western fighter fleets since the 1970s, so well exemplified by the F-16 and F/A-18, performed so poorly?

The answer is simple: size. Mobile and fleeting targets can only be reliably engaged by persistent bombers. Persistent bombardment requires a large payload of fuel, and a large payload of weapons - aerial refuelling of a lightweight multirole fighter might stretch its endurance in a target area, but it cannot replenish expended weapons.

The universal trend since the devastating application of Western coalition air power in the 1991 Desert Storm campaign has been for opponents of the West to adopt mobility and concealment to evade Western combat aircraft. Virtually all sales of new Surface-to-Air Missile systems and ballistic missile systems since 1991 have involved highly mobile systems.

Of no less concern is the ongoing regional proliferation of such highly mobile land based air defence weapons. Within the broader region, nations have acquired, respectively, variants of the capable S-300PMU (SA-10/20 Grumble/Gargoyle) and Tor M1 (SA-15) SAM systems from Russia. Concurrently, we are observing proliferation of cruise missiles and cruise missile technology across the region, many of these available for launch from high mobility ground vehicles.

The proven and most effective strategy for engaging and destroying all mobile ground targets is the 'persistent bombardment' technique, as the bomber can position itself for an engagement within minutes of the mobile ground target being detected. With current generation stand-off weapons such as the AGM-142 Popeye, AGM-158 JASSM/JASSM-ER and emerging winged GBU-31/38 JDAM-ER, a bomber with a long range radar can orbit outside of the reach of most mobile air defences and pick off targets at will from a safe position. Refer Figure 22[33].

The trend toward mobility in ground targets is here to stay, since mobility affords the only option for an opponent facing modern precision all-weather air power - as demonstrated convincingly during the 2003 Iraqi Freedom campaign. Inevitably, 'persistent bombardment' techniques will become central to the use of air power, whether the opponent is a highly sophisticated nation state or a Third World militia or insurgent force. The developing trend to urban combat where targets are nearly all mobile and fleeting will drive up the demand for aircraft capable of orbiting urban areas for many hours[34].

The F-22 and Evolved F-111 Force Mix Option

Where opponents have not opted for mobility, they have typically burrowed deep underground to evade aerial attacks. This is a defensive technique first employed *en masse* by Germany and Japan during the 1943-1945 period, and since emulated by Saddam's Iraq and now North Korea and Iran. It is now inevitable that regional nations will adopt this tactic, as the aggregate number of smart bomb delivery capable combat aircraft across the region builds up. At this time only two genuine deep penetrating smart bomb designs exist, both US designs. Of these, only the GBU-28/EGBU-28 is in production, and it is cleared for carriage only by three aircraft types, one of which is the F-111. No F/A-18 variant or the F-35 Joint Strike Fighter will ever be able to carry this two tonne bomb operationally, as they are simply too small. In strategic terms Australia needs this capability, but to date no effort has been made to procure it.

For Australia, these developments are of critical importance, since regional conflicts in the 21st century may involve opponents in either category. With considerable long term uncertainty in the availability of runway access in South East Asian nations, the ADF will require the capability to cover large distances to strike at high value military assets, and also the ability to support ADF ground forces with persistent bombers[35].

The central question for the ADF, in the context of the recapitalisation of the RAAF fighter fleet, is the sizing of aircraft chosen to replace the F/A-18A/B Hornet and the F/RF-111C/G. The ability to robustly perform long range strikes and support of ADF ground forces using 'persistent bombardment' techniques will be the operational determinant of whether the aircraft chosen are of significant combat value or artifacts of history, designed and built around Cold War European theatre design assumptions.

If we test the RAAF's existing combat aircraft against the sizing criteria for long range strike and 'persistent bombardment', the F/A-18A/B Hornet fails miserably, as proven in Afghanistan and Iraq, while the F/RF-111C/G fits well. This is no accident. While the F/FB-111 family is described by some as a 'tactical fighter', in current US Air Force force structuring terms it is a 'medium' or 'regional' bomber, a unique class of aircraft which falls in between large multirole tactical fighters and heavy bombers. With around 2 to 2.5 times the internal fuel capacity of small to medium sized multirole fighters, the F-111 is today in a class of its own. Refer Figure 23, 25 and 26.

> The F-111 is today, by virtue of its basic airframe sizing, configuration and fuel capacity, the single most valuable combat asset in the ADF inventory. As the decade unfolds and the trends in target mobility further develop, the relative value of the F-111 against smaller combat aircraft will grow. The well maintained airframes and properly managed fatigue life of the F-111 fleet allow Australia to further exploit this valuable asset.

This assessment of the value of the F-111 is centred in the fundamental physics of flight and there is nothing within the existing technology base which could in any manner provide a much smaller aircraft with the same basic aerodynamic capability. Any assertion otherwise is little more than marketing 'fluff'[36]

There is another important consequence of the sizing equation, which is the question of 'operational economics'. In simple terms, how many dollars are expended in fuel, plus flying hours on airframes and personnel, to achieve a given combat effect.

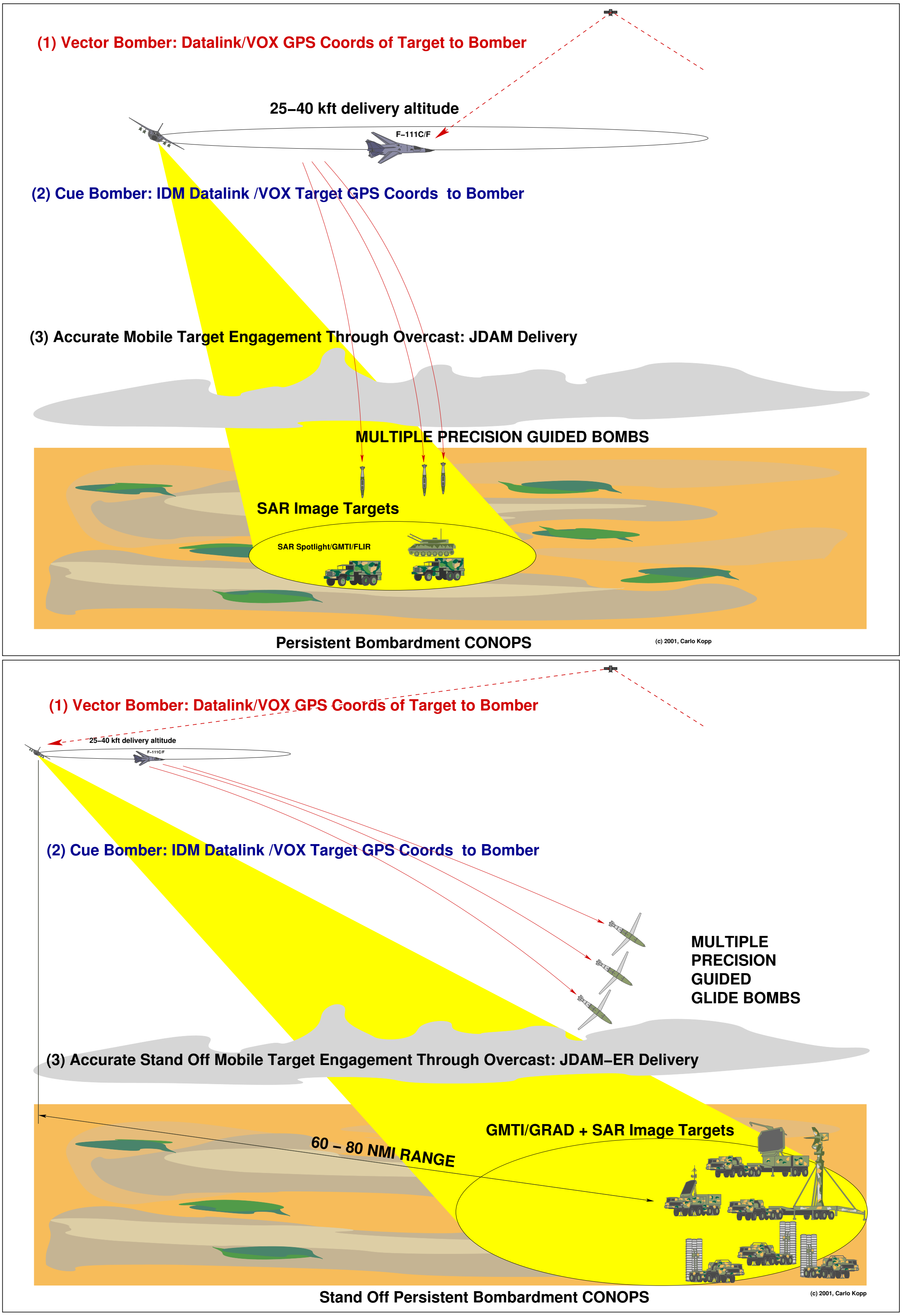

Figure 22: *Persistent bombardment techniques (C Kopp).*

The F-22 and Evolved F-111 Force Mix Option

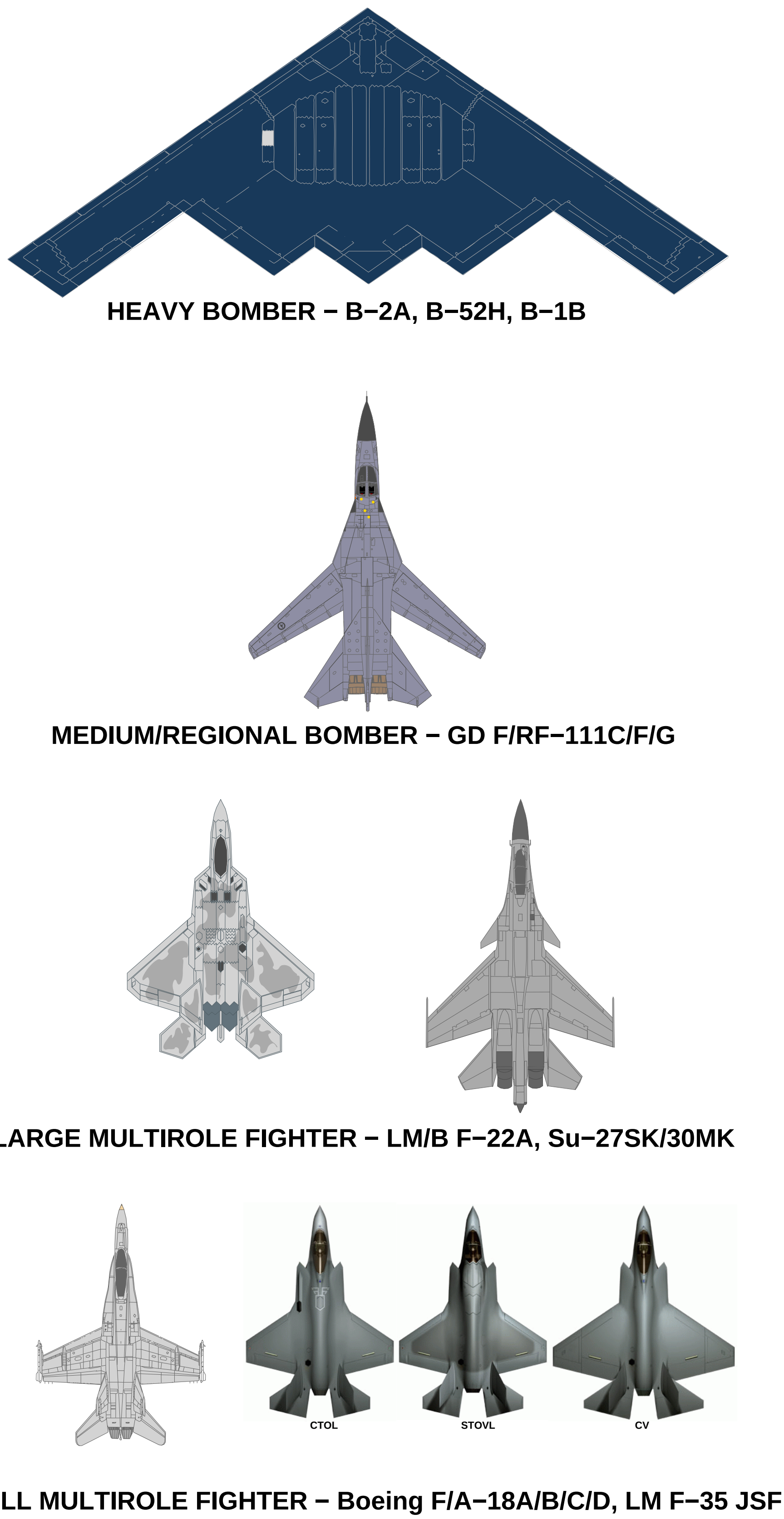

Figure 23: *Comparison of representative combat aircraft sizes (C Kopp, Lockheed-Martin).*

The F-22 and Evolved F-111 Force Mix Option

Figure 24: *One of the valuable consequences of the F-111's size is its capability to carry large special purpose munitions like this GBU-28/B 'Deep Throat' bunker busting bomb. Smaller aircraft are unable to operate with weapons of this size. Despite the vital importance of this capability, the RAAF has no plans to introduce it and will lose that option if the F-111 is retired (US Air Force).*

The F-22 and Evolved F-111 Force Mix Option

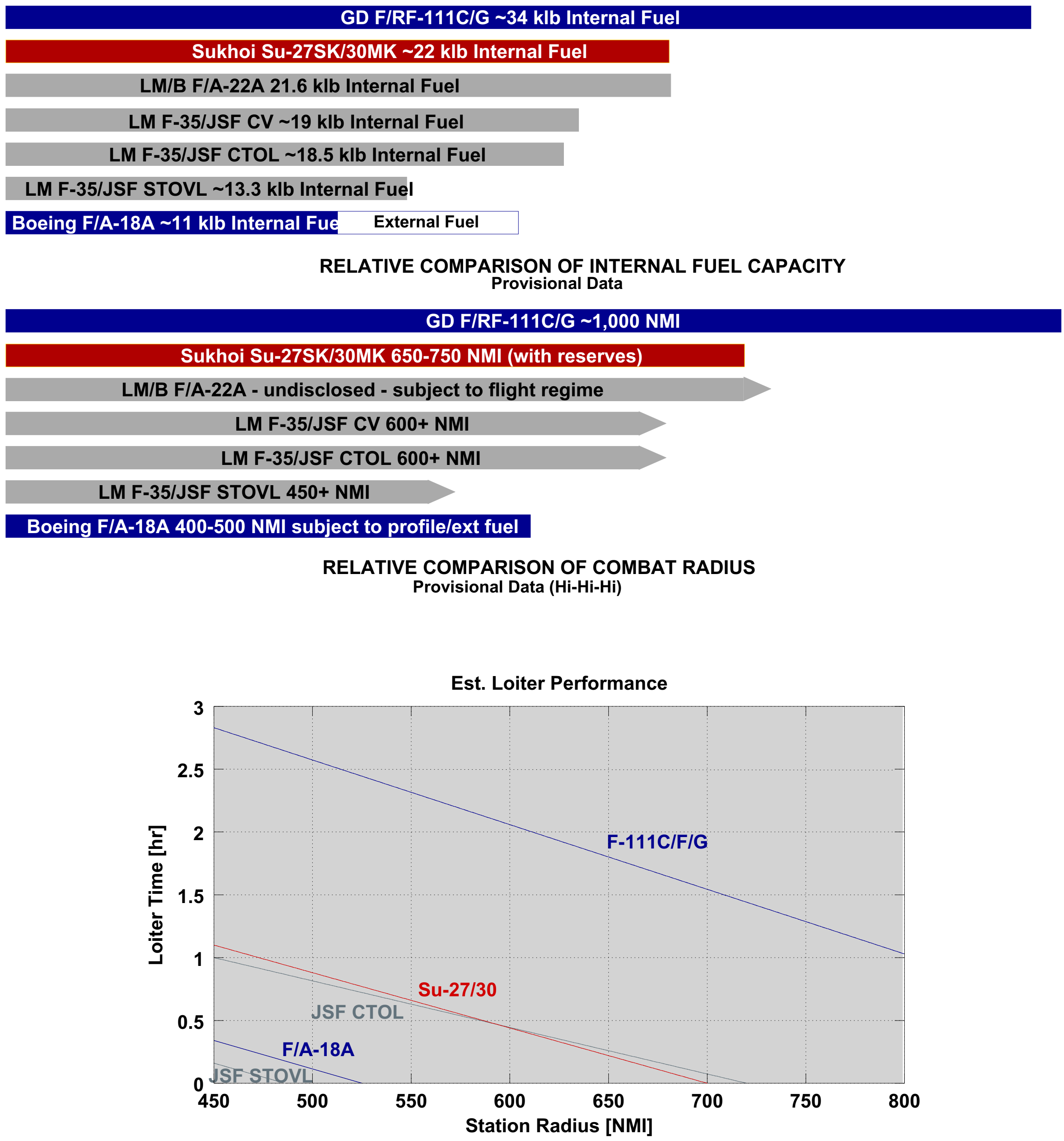

Figure 25: *Comparison of representative combat aircraft internal fuel, radius, and loiter performance. Loiter time assumes internal fuel only for F-111 and Su-27/30 variants (C Kopp, Lockheed-Martin, KnAAPO, Boeing data).*

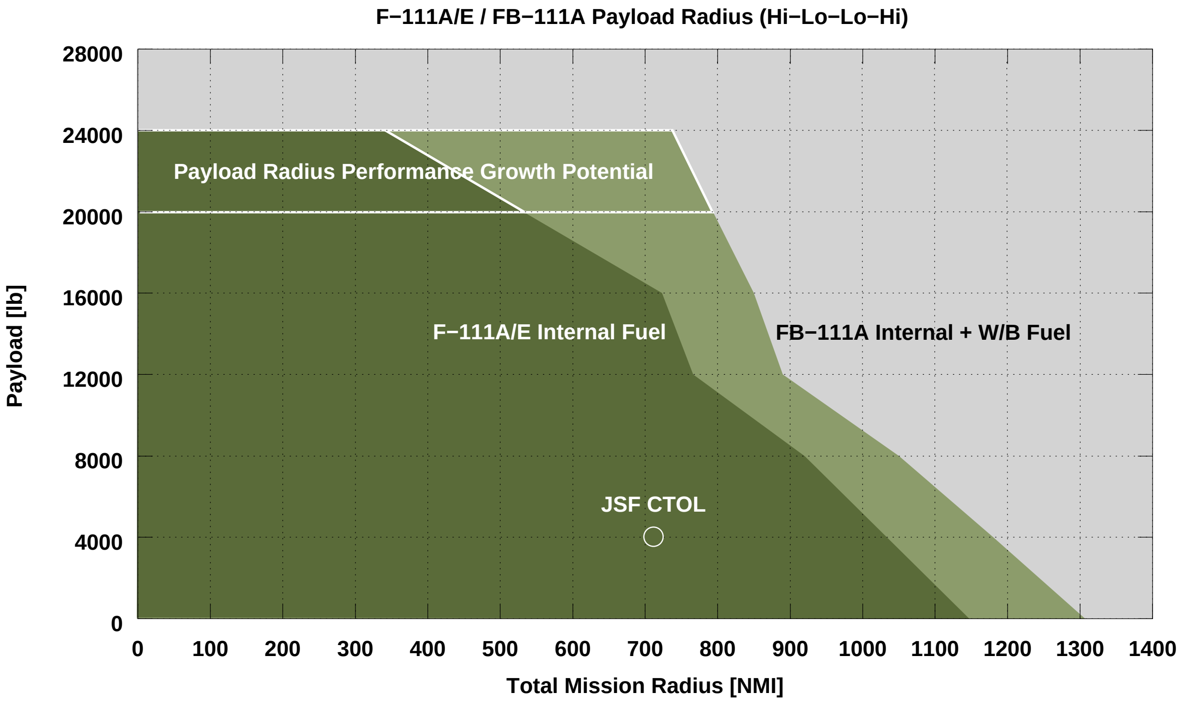

Figure 26: *Payload radius chart for the F-111A/E and FB-111A. This chart was published during the 1980s by General Dynamics in a technical brochure on the F-111 family of aircraft, and assumes low drag external munitions rather than high drag munitions - an assumption consistent with the current and planned operating regime of the aircraft. The single and rather optimistic data point for the CTOL F-35 is based on published Lockheed-Martin data and underscores the reality that the F-111 remains unchallenged as the most capable load carrier in the current market. The original GD chart included payloads to 24,000 lb, which requires use of the outboard fixed wing pylons (Authors, General Dynamics, Lockheed-Martin).*

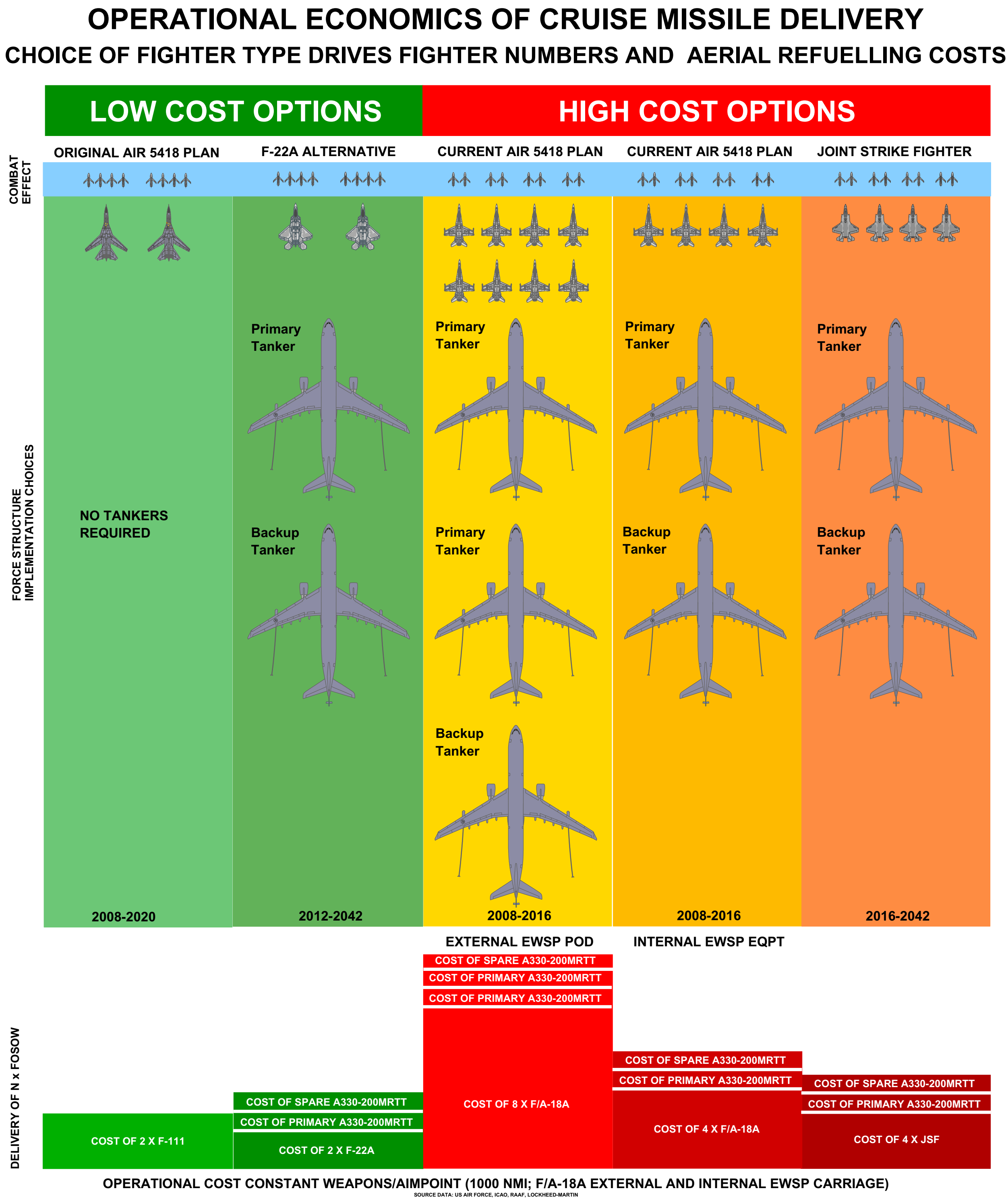

Figure 27: *The Joint Strike Fighter, F/A-18A and F/A-18F are not operationally economical alternatives to the F-111 in the delivery of smart weapons, especially cruise missiles. This chart compares the delivery cost making the assumption that the F/A-18A or F/A-18F can carry two cruise missiles and uses internal electronic countermeasures, or one cruise missile and external electronic countermeasures equipment. The same analysis applies to 1,000 kg class smart bombs (C. Kopp).*

The F-22 and Evolved F-111 Force Mix Option

Consider the use of a cruise missile such as the AGM-158 JASSM, a standard GBU-24 or GBU-31 ‘smart bomb’. All of these munitions weigh just over 1,000 kg.

What is the effort required to deliver a fixed number of such weapons against a ground target?

Figure 27 compares the total number of assets required to effect the delivery of exactly eight JASSM cruise missiles to a target at about 1,000 nautical miles of distance, using either the F-111, or the F-22A, F/A-18 variants, and F-35 Joint Strike Fighter, the latter supported by aerial refuelling[37].

The F-111 is by far the operationally most economical solution, as it requires no aerial refuelling, followed by the F-22A Raptor. The F/A-18A/B HUG is the most expensive, and both the F-35 Joint Strike Fighter and F/A-18F Super Hornet incur similar operational costs to the F/A-18A/B HUG. As recent and ongoing US experience shows, operational economics can have crippling medium to long term effects even in ‘low intensity conflict’ contingencies.

While environmental impact is seldom considered as a criterion in comparing combat aircraft, it is worth observing that the production of exhaust gas emissions by any package of combat aircraft is directly proportional to the total fuel burned. In environmental terms, the F-111 produces significantly less exhaust gas than smaller fighters, such as the F/A-18 variants or F-35 Joint Strike Fighter, as these require extensive support by aerial refuelling tankers.

A third consideration related to aggregate fuel burn and operational economics is the underdeveloped fuel replenishment infrastructure and limited on base fuel storage capacity of Australia’s northern chain of airfields. The significantly higher fuel burn incurred by tanker supported F-35 Joint Strike Fighter and F/A-18F Super Hornet aircraft compared to the F-111 results in a much lower achievable operational tempo, or a shorter duration of operations, before fuel stockpiles are exhausted and sortie rate is limited by the rate at which additional fuel can be delivered to these sites[39].

6 The Evolved F-111

The US Air Force, cognisant of the value of dedicated large bomber aircraft, plans to operate the 1962 built B-52H and 1985 built B-1B until the 2040 timescale. Survivability will be ensured by ongoing upgrades in defensive avionics, guided weapons and by the provision of the lethal F-22A escort fighter. To support this paradigm, the US Air Force will perform the necessary structural relifing of key components in these aircraft, and an ongoing program of new technology insertion to reduce operating costs and improve capability[40,41].

There is no fundamental or sound reason why Australia cannot pursue a similar strategy with the

F-111, operating it into the 2030 to 2040 timescale in parallel with a capable escort fighter, such as the F-22A. The 'Evolved F-111' concept is a model for accomplishing exactly this, through a force structure mix of the F-22A and 'Evolved F-111' aircraft. It incorporates a wide range of feasible technological growth paths for the F-111 which exploit 5th generation fighter technology to retain survivability and lethality, while progressively reducing support costs.

These F-111 growth paths include a glass cockpit, 'phased array' AESA radar, advanced high speed datalink, advanced imaging chips, high performance computers, supersonic cruise propulsion, internal 'small diameter bombs', significant radar cross section reduction through the application of advanced composite and laminate materials, and liquid cooling of future avionics. The underlying aim of these upgrades, other than stated improvements in supportability and basic capability, is to provide a highly evolvable sensor architecture capable of meeting the needs of future information intensive and network centric combat. Like the F-22A, the Evolved F-111 is intended to be an 'information gathering asset', capable of achieving 'information superiority' over opposing forces[42].

Importantly, replacement of the existing legacy TF30 series engines would result in economically significant improvements in fuel burn, long term support costs and also performance, including endurance and range. Engineering studies show this is a low risk effort, choices including the GE F110 and P&W F119 series engines[43].

Notably, the system architecture of the F-111 fleet following the 1990s AUP (Avionics Upgrade Program) and the BUP (Block Upgrade Program) programs as undertaken by Boeing Australia Limited is well suited to such upgrades. This is because future growth had been taken into account in the development of these designs - designs done by Australians for Australians.

As a mothballed stockpile of 70+ F-111F, 50+ F-111D and around thirty EF-111A aircraft reside in the US AMARC storage facility and are available at very low cost, the opportunity exists to not only stockpile significant quantities of structural spare components in Australia, but to also expand the existing F-111 fleet at a very low incremental cost[44].

By doing so, Australia would retain and enhance its most lethal combat asset, and extract dividends in a number of key areas:

1. A program of ongoing small incremental technology upgrades does not incur the large peaks in annual defence expenditure characteristic of new aircraft purchases.
2. Current estimates would indicate that the retention of an upgraded and much cheaper to maintain F-111 would allow a larger fraction of the planned fighter replacement funding package to be invested into the replacement of the F/A-18A/B aircraft. This would permit the introduction of a genuine 5th generation air superiority fighter - the stealthy supercruising F-22A.

   Rather than adopt a technologically obsolete evolved third generation fighter like the F/A-18F Super Hornet, or the narrowly optimised F-35 Joint Strike Fighter which represents a hybrid of third, fourth and fifth generation design philosophies, the taxpayer could be given a robust capability which retains its combat value over the longer term[45].
3. An Evolved F-111 could be very precisely tuned in capability to the ADF's unique geographical

and strategic needs, thereby avoiding the fundamental losses in capability which result from adopting 'off the shelf' production fighters *optimised for European, Middle Eastern or other less demanding, short range, strategic environments.*

4. The depth of ADF and Australian Aerospace Industry experience with the F-111 allows risks in force expansion and upgrades to be very precisely estimated in comparison with new types of combat aircraft.

5. The political risks, at home and abroad, in the retention and upgrading of the F-111 fleet are significantly lower than in the deployment of alternative aircraft types which are newer by airframe design, and thus attract attention.

6. A wholly domestically supported F-111 weapon system allows the ADF to respond very quickly with technological adaptations to a changing environment, examples being new weapons or radar modes. Any alternative aircraft choice queues ADF adaptation needs behind those of larger overseas clients.

7. A series of ongoing upgrades and support work for the F-111 would provide Australia's Aerospace Industry with a core activity to sustain personnel and facilities, thereby facilitating future growth into other areas.

8. As the F-111 has the endurance and combat radius to perform many roles with little or no aerial refuelling support, important operational economies could be realised in comparison with a smaller multirole aircraft which cannot function effectively without continuous tanker support.

9. Judicious choices in radar/datalink and electro-optical upgrade technology and architecture would enable a genuine dual role strike/recce capability in every Evolved F-111 aircraft.

10. The provision of supersonic cruise propulsion in the Evolved F-111 would result in a *doubling of achievable combat sortie rates in long range strike/recce operations, against every alternative fighter other than the F-22A, while providing engine commonality with the F-22A*.

11. There is greater potential for the cost effective insertion of advanced technologies, such as sensor fusion software and systems, into the Evolved F-111 than could be achieved on smaller, foreign designed fighters. This in turn facilitates maintenance of the 'Knowledge Edge' throughout the life cycle of the aircraft.

12. The Evolved F-111 has significant growth potential in a number of Defensive Counter Air roles, such as cruise missile defence and the intercept of long range/heavy aircraft. Therefore some economies could be realised in numbers of F/A-18A/B replacement air combat fighters.

13. As a 'coalition warfare asset' the F-111 offers considerable firepower and persistent bombardment capability, yet does so with comparable demands in scarce ramp footprint to less capable third generation multirole fighters. In many geographical environments, it imposes modest or little demand on scarce aerial refuelling assets.

7 Australian Industry Involvement

A key aspect of the F-22A and Evolved F-111 Force Mix concept is the future path it creates for Australia's high technology industrial base, which would directly contribute to the program, yet also benefit from it. The F-22A and Evolved F-111 Force Mix concept yields, by far, the largest Australian Industry Involvement (AII) packages of any of the conceivable fighter replacement options under consideration. More over, it leaves the management, co-ordination and timing of these AII packages under Australia's control, while providing an evolutionary path that relieves the pressure of the impending block obsolescence situation. It provides Australia with means of significantly reducing the support costs of the F-111, while maintaining and enhancing Strike Capabilities out beyond the previously planned Life Of Type (2015-2020). Concurrently, it offers flexibility in the decision time line for the Air Combat and Strike Capability components of the fighter replacement effort.

A key aspect of the F-22A segment of the F-22A/Evolved F-111 Force Mix Option is the effect this will have on the Australian Aerospace Industry and for reasons that do not exist nor can be developed in any of the alternative solutions. These reasons include, *inter alia*:

1. Australia would be a member of a very exclusive club as opposed to one of many partners in one of the most difficult entities to manage and sustain - a collaboratively based international team of many players with disparate needs. These needs must be satisfied by a single supplier who, in turn, must retain total control using 'Cost as An Independent Variable' in order for this model to succeed while having affordability, reliability and interoperability sustained.

2. Australia would have over 20% of the world fleet of F-22A aircraft - a position Australia has never been in before, providing greater benefits akin to those that accrue from sitting on a three person Board of Directors of the Holding Company when compared with sitting on the ten seat board of a subsidiary.

3. As the international launch customer for the F-22A capability with a releasability risk status equivalent to that of the USAF, Australia and its Industry would be in a position to make valuable contributions to the further development of the F-22 capabilities as well as the development of modifications for any further export versions of the aircraft and related capabilities.

4. An acquisition strategy based upon strategic reasoning would see procurement of the F-22A actually contributing to the Australian economy while reducing the normally negative effect defence materiel purchased from overseas has on Australia's trade balance.

Australia's contributions to the F-22A Program would bring with them the world recognised expertise of Australia's specialists in stores separation, data fusion, aircraft structures, risk management and T&E. Then there are those assets unique to Australia including the low ELINT risk / low EMI expanses of our test ranges and, of course, the F-111 with its ability to keep up with the F-22 given its comparable flight envelope. By taking delivery of the five attrition aircraft at around the time of the F-22 mid life upgrade (circa 2020), this would enable these aircraft to be used as developmental vehicles in these upgrades and thus make a valuable contribution to the Program.

Other benefits that flow from the Evolved F-111 in relation to the industry component of the Australian Defence Community include, *inter alia*:

1. Performing these upgrades in Australia, including the design, development, integration and Test & Evaluation (T&E), does not damage the balance of payments, while it reduces vulnerability to fluctuating exchange rates in the international currency markets.
2. Performing these upgrades in Australia, including the design, development, integration and T&E, retains the expertise developed within Australia. This facilitates long term domestic support of the capability while providing a base of experience exploitable across a wide range of ADF programs.
3. Performing these upgrades in Australia, including the design, development, integration and T&E, exploits the considerable intellectual capability, workforce capacity, and infrastructure investment made to date in the F-111 capability, thereby enhancing the taxpayer's return on past expenditure.
4. Performing these upgrades in Australia, including the design, development, integration and T&E, opens the way for applying 'a whole of Australian economy' approach to Defence spending and recognition/achievement of the value addition and economic multiplication effects of such spending in Australia[46].
5. Performing these upgrades in Australia, including the design, development, integration and T&E, reflects the core capabilities resident in the Australian aerospace and related high technology industry base which are identified as the six Defence Industry Capability Priorities in the Defence 2000 White Paper[47].
6. In particular, the Evolved F-111 draws upon and further develops capabilities in the areas of systems integration, repair, maintenance and upgrades of major weapons and surveillance platforms which are key capabilities identified in the Defence White Paper as required to meet the needs of Australian Defence. Such capabilities are essential if the Australian Defence Community is to maintain the 'knowledge edge' and maintain currency with the new strategic paradigms of 'transformation' and 'evolution'[48].
7. A series of ongoing upgrades and support work for the F-111 would provide Australia's Aerospace Industry with a core activity of sufficient size to sustain personnel and facilities, thereby facilitating future growth into other areas, including export which is vital to the growth of Australia's industrial base.
8. The Evolved F-111 provides a program vehicle, on a whole of Australian economy basis, for buffering the Australian Industry against the global down turn in the aerospace industry. Such a program also provides a series of project vehicles of sufficient size, scope and importance to apply and exercise the post Defence 2000 White Paper re-invigorated Defence Industry Policy of Government in a cost effective, value for money manner.

No discussion on AII would be complete without a consideration of risk. In the Evolved F-111, the three main mitigators of risk are:

- The F-111 airframes and components currently available in the AMARC.
- The size and exceptionally robust aerodynamic and structural design of the F-111 airframe, produced in the halcyon days of the US aerospace industry.
- The considerable investment already made in the science, technology and operation of this capability.

The availability of the extensive F-111 assets stored in AMARC, currently in good condition, coupled with the robust design of the platform itself, provides Australia with a unique opportunity to retain and enhance a capability that has no peer in our region, and few equivalents worldwide. The conjoint evolution of this capability with requisite industry development, will ensure this remains the case for a considerable period of time.

The ongoing support costs of the F-111 fleet of strike and reconnaissance aircraft has been a major consideration in Defence for quite a number of years. The issues are complex, particularly when the F-111 element is woven into the risk rich tapestry of force structure challenges relating to the New Air Combat Capability (NACC). One of these challenges is how to cost effectively transition the structure from the existing force of F-111 and F/A-18 aircraft to the yet to be determined and delivered capability mix which will be the NACC, while managing the associated risks of which there are many.

Much has been said on this subject. Evidence provided to the Parliament on Wednesday 08 May 2002 is but one recent example:

Lt Gen. Mueller: *In the most recent discussions I have had with the Defence Science and Technology Organisation - and I might make the observation that the Aeronautical and Maritime Research Laboratory at Maribyrnong are world leaders in the management of fatigue in airframes - they are of the opinion that at this point the airframe could be managed through to the period 2015-20. The issue with the F111s between now and the planned withdrawal date is more likely to be a question of avionics, sensors and weapons systems. That is not to say, however - as is often the case with ageing aircraft - that there will not be surprises.*

In terms of 'risk management', the Evolved F-111 Option provides the means to manage any and all of these possible 'surprises'. In addition, the Evolved F-111 Option and the four innovative proposals from Industry (UPIs), submitted around the same time, provide Defence with the means of modelling and addressing all the risks associated with and that may arise in the New Air Combat Capability Project (NACC)[49].

Such modelling to achieve more realism, transparency and improved risk management, is a natural extension of one of the key recommendations, for managing major project procurement risks, arising from the Macintosh/Prescott report into the Collins[50].

In essence, in terms of Capability Systems Life Cycle Management and its intrinsic need for effective risk management strategies, the aims of the Evolved F-111 Papers and the four UPIs may be summarised as follows:

The F-22 and Evolved F-111 Force Mix Option

a. Provide innovative, cost effective ways to achieve between a 10 to over 100 fold improvement in the system reliability being experienced with the current legacy avionics sub-systems in the F-111 fleet, with commensurate reductions in the maintenance costs for these sub-systems. At the very least, this would generate a five to ten fold reduction on the current recurring supportability costs for these sub-systems. Conservatively, this could equate to real savings and improvements in capability performance levels totalling in the vicinity of $40m to $80m per annum. An additional benefit is that longer term 'Life of Type' supportability issues arising from current legacy sub-systems disappear with the replacement of these sub-systems.

b. Provide enhanced capabilities in these systems, especially in relation to the ability of the F-111 to fully support and exploit the latest generation of digital 'smart' weapons, such as the AGM-142E, AGM-158 JASSM, GBU-31/38 JDAM/JDAM-ER and EGBU-10/12/22/24. While the current F-111 Block C-4 and C-5 upgrade configurations will permit delivery of such weapons, they will be very limited in providing autonomous all weather targeting capabilities for such weapons. The proposed upgrades would enhance the utility of the aircraft in its established roles, while also improving its effectiveness as a contribution to coalition warfare campaigns.

c. Provide an organic all weather reconnaissance capability in every F-111 aircraft. This not only enhances the overall strike capability of the ADF in a Network Centric Warfighting (NCW) environment, but provides an effective tool for supporting national efforts in the War on Terror with a rapid response long range broad spectrum imagery intelligence (IMINT) gathering capability.

d. Provide a low incremental cost tri-service electronic reconnaissance and attack capability for the DEF 224 Bunyip project, utilising refurbished and upgraded EF-111A airframes, currently mothballed in the AMARC storage facility in the US. Such a solution offers significant economies over the purchase of small numbers of a new and unique aircraft to perform the roles envisaged in DEF 224.

e. Provide a cheap and known risk alternative for dealing with fatigue problems in the RAAF's F/A-18A/B fighter fleet, through replacement of fatigue lifed F/A-18A/B aircraft with refurbished and upgraded F-111s, using F-111 airframes currently mothballed in the AMARC storage facility in the US. Refurbished and upgraded F-111s would provide a cheaper and lower risk alternative to newly manufactured 'interim fighters' and structural rebuilds of the existing F/A-18A/B fleet.

f. Rebalance the RAAF force structure in a manner which better fits the evolving strategic environment, as has more recently been defined in 'Australia's National Security: A Defence Update 2003'. A higher fraction of F-111 aircraft in the RAAF air combat fleet enhances the capability to support coalition warfare, yet also enhances long endurance air intercept, strike and reconnaissance capabilities, central to the 'Defence of Australia' concept.

g. Mitigating risks in the NACC program. Late deliveries, under performance, price increases, capability trade offs to achieve CAIV , exchange rate variations, balance of payments problems and defence funding difficulties could individually or collectively compromise the currently intended capabilities and timelines in the NACC project. The 'Evolved F-111' provides a robust means of filling the predicted capability gap until the NACC can be implemented in a manner consistent with national strategic needs[51].

h. Provide a credible, alternative force structure model for use as the principal IV&V tool for the NACC Project. In line with one of the recommendations for major projects from the MacIntosh/Prescott Report, such a tool could be used as a virtual model and as a comparator for all aspects of the project, including price negotiations. A negotiation position, which does not have a credible alternative or, at least, such a comparator tool would be sub optimal.

i. Provide an opportunity for a reduction of several billion dollars (US$ in 2001 dollars) in offshore expenditures for the NACC project. Adoption of the innovative acquisition strategies in the 2001/02 Industry Proposal would see this figure enhanced significantly.

j Provide a significant boost to the Australian Aerospace Industry while establishing the in-country capability to support the NACC to meet the needs of the ADF. While reducing the balance of payments effect of the NACC Project, adoption and development of these proposals would see about AUD$1.5B (2007 dollars) injected into the Australia economy in the form of productive work with the resulting productivity and upskilling incentives which attract a *flow-on-effect* factor currently estimated at greater than 1.7.

THE GREAT DEBATE: COMPARISON OF TOTAL PROJECT COSTS – DEFENCE PLANS VS INDUSTRY PLANS
UPDATED 20 JANUARY 2008

Defence Plans (Launched 2002, Changed 2003, 2004, 2006, 2007)	COST (A$ million) Then Year	AIR COMBAT CAPABILITY FORCE STRUCTURE ACTIVITY Total Project Costs	COST (A$ million) Then Year	Industry Plans (Submitted in 2001/02)
F/A-18 HUG Program plus	$3,952.0	Upgrade Existing Capabilities	$1,650.0	Evolved F-111S (iv) plus
Deeper Level Maintenance plus	$791.0		$825.0	Defence Programmatic Risk Margin plus
10 Years of Contractor and Defence Ops/Support Costs (viii)	$1,529.6 $2,949.5	Support and Operate Existing Capabilities	$1,311.3 $1,385.4	10 Years of Contractor and Defence Ops/Support Costs (viii)
			$560.0	Procure Ravens (28)
		NEW CAPABILITY TAC/JAMMER Capability also Australian Contribution to Coalition Forces	$1,100.0	Upgrade Qty 10 to 3rd Generation Jammers
			$550.0 $580.0	10 Years of Contractor and Defence Ops/Support Costs
Procure 24 x F/A-18Fs (i) including 10 years Support and Operational Costs	$6,600.0	Avoid Air Combat Capability Gap		
			$9,133.4	Procure 50 x F-22As (v) (ix) plus
Procure 100 x JSFs (ii) (ix) plus	$16,770.0	NACC Project Procurement	$1,500.0	10 Year Weapons Buy plus
Basing & Infrastructure	$5,130.0		$3,200.0	Basing & Infrastructure
MOUs & Project Office Costs (iii)	$1,176.9	NACC Project Management Costs	$327.0	FMS Administration Fee (vi) plus
			$66.0	Project Office Costs
Total	$38,899.0	Comparative Project Costs *Savings thru Industry Plans* $16,776.9	$22,122.1	Total
Post 2010 Outcomes 1. Lose Air Superiority 2. If required to go into combat - (i) Young people will die, and (ii) Australia's sovereignty at risk.				*Post 2020 Options* 1. Keep F-111S operational, or 2. Replace with a proven JSF capability at learned out production cost, reportedly US$58m per aircraft.

Notes:
(i) Being undertaken at the direction of the Minister for Defence, figure based upon Ministerial Press Release Tuesday, 6 March, 2007-MINDEF 017/2007
(ii) Based on NACC Budget of $15,500 million in 2006 dollars.
(iii) Expenditures committed under SDD and PSFD MOU agreements plus estimate of Project Office expenditures (eg, personnel, travel, overhead costs). Updated to include the cost (US$690 million) of the PSFD MOU signed by the Minister on 12 Dec 06.
(iv) Current year dollars over 5 – 6 year program, starting 2008 (Refer proprietary cost estimates under F-22/Evolved F-111 Industry Proposals). Even if the greatly overstated upgrade costs stated by CAF to JSCFADT (31Mar06) of "between five to eight billion" were true, savings that would accrue would still range between $9.9Bn to $12.9Bn.
(v) Current year dollars (aka Year of Expenditure): 2008 - 2012. This figure is conservative and does not consider benefits of lease/buy option. If based on Average Unit Procurement Cost (AUPC) of current USAF build at the US$153 million stated by CDF to Parliament in 2004, this figure is $10,200.0 million. If based on current unit flyaway cost (UFC) that USAF is paying (US$137 million), this figure is $9,133.4 million. If based on AUPC for F-22 # AF4210 (average of aggregate for F-22# AF4185 to AF4235 buy), this figure is $8,400.0 million.
(vi) Foreign Military Sales Case – Administration Fee capped @ 3.58% (negotiable and can be in cash or in kind or combination).
(vii) If F-22 buy cost $10,200.0Bn, then projected savings would be $15.1641Bn. If F-22 buy costs $8.4000Bn, then projected savings would be $17.0285Bn.
(viii) Refer ANAO Performance Audit No 27 _ 2006-07.
(ix) Life cycle costs for the F-22 and the JSF are not included in this table. The JSF life cycle costs are not yet available, at this time. Suffice to say, the 50 airframes required plus the twin engine configuration would result in the F-22 fleet life cycle costs being around 65% those for a fleet of 100 x JSFs.

Figure 28: *The cost savings from the adoption of the F-22A and Evolved F-111 Force Mix are considerable, and using a very conservative estimate exceed A$16 billion (P A Goon).*

8 Cost Savings From the F-22A and Evolved F-111

There is no doubt that the adoption of the F-22A and Evolved F-111 Force Mix over the legacy plan to introduce the F-35 Joint Strike Fighter and F/A-18F Super Hornet provides a superior capability to perform across the whole range of roles the RAAF may be required to undertake, while offering much lower strategic, technological and budgetary risk.

The extent of these capability advantages in the F-22A and Evolved F-111 Force Mix proposal become very apparent when they are scored using a quantitative method. Annex B, Figure 3 provides a tabular representation which compares no less than seven capability metrics, four cost metrics, and seven risk metrics. This provides an unequivocal measure of how inferior the legacy F-35 Joint Strike Fighter and F/A-18F Super Hornet plan actually is. Using a scoring technique which actually favours the legacy plan, the result is 7 nett gains for the F-22A and Evolved F-111 Force Mix proposal and 28 nett losses for the legacy plan[52].

The capability and risk advantages arising from F-22A and Evolved F-111 Force Mix proposal are a byproduct of using 'Tier One' high capability aircraft rather than 'Tier Two' low capability aircraft, as the legacy plan does.

What may seem counterintuitive at first is that the legacy plan incurs in total almost A$17 billion greater outlays of taxpayer's funds than the F-22A and Evolved F-111 Force Mix proposal, if implemented. Refer Figure 28.

A closer examination of the funding structures of both models shows, however, that the legacy plan, constructed by accreting arbitrary choices of aircraft in a 'bandaid' fashion, is indeed much costlier for what are clearly obvious reasons:

1. The legacy plan sees the acquisition and overseas contractor support of 24 x F/A-18F Super Hornet aircraft as gapfillers to cover the associated premature retirement of the F-111 fleet.
2. The legacy plan sees the acquisition of up to 100 x F-35 Joint Strike Fighter aircraft, during the most expensive first half of the production program.
3. The legacy plan sees the expenditure of nearly A$3 billion on life extension upgrades to the non-viable F/A-18A/B HUG to keep them in service until the intended F-35 Joint Strike Fighter is delivered.
4. Because the F-35 Joint Strike Fighters are being delivered before 2020, their Unit Procurement Costs are very similar to the costs of the more capable, but also more mature F-22A Raptors.
5. The retention and life extension of the F-111 reduces outlays significantly since it is an in-service asset, and upgrades to its systems cost much less than the procurement of brand new aircraft.
6. Additional F-111 and EF-111A airframes acquired from mothballed US stocks incurs around 10 percent of the cost, per airframe, compared to brand new aircraft.

7. As the F-22A and Evolved F-111 Force Mix retains the existing F-111s, only 50 + 5 F-22A Raptors must be acquired to replace the non-viable in-service F/A-18A/B HUG fleet.

In short, the legacy plan is predicated on the high risk procurement of the F-35 Joint Strike Fighter which will be available too late for the timelines required to replace the legacy F/A-18A/B HUG fleet. This in turn requires two very expensive 'bandaid' measures in the F/A-18A/B HUG life extension and the F/A-18F Super Hornet procurement, neither of which provide good return on investment to the taxpayer. The legacy plan is further penalised by the premature loss of billions of dollars of accrued investment in the existing F-111 fleet and its support infrastructure, a cost metric not even included in this comparison.

Producing a force structure plan as expensive and cumbersome as the legacy F-35 Joint Strike Fighter and F/A-18F Super Hornet plan from a clean sheet of paper would indeed be a challenging task for a competent planner. The reactive accretion of arbitrary choices of aircraft, responding to short term political imperatives, does achieve this effect with no undue difficulty.

The cost comparisons employed here and resulting savings are conservative. They favour the legacy F-35 Joint Strike Fighter and F/A-18F Super Hornet plan, as they include the costs of the electronic attack capabilities of refurbished EF-111A Raven aircraft in the F-22A and Evolved F-111 Force Mix model, a capability absent in the legacy plan[53].

9 Conclusion

The F-22A Raptor and Evolved F-111 Force Mix is a technologically and strategically credible replacement for the existing fighter fleet, comprising the F/A-18A/B HUG and current F/RF-111C/G aircraft configuration. This force mix incurs few of the difficult funding and capability problems characteristic of most current production combat aircraft which were optimised for late Cold War European theatre strategic environments. A force mix which combines the stealthy supercruising F-22A and Evolved F-111 provides for a well balanced and highly flexible force structure.

While the Evolved F-111 may appear to carry some technological risks against the acquisition of an entirely new aircraft, experts in the aerospace field know this not to be true, as evidenced by the JSF Program. The program risks are low and assessed as being well within the capabilities and capacity of the post White Paper Australian Defence Community to mitigate and manage.

The Evolved F-111 does not incur the major budgetary, political, force structuring and strategic risks associated with a new aircraft. As the Evolved F-111 would be largely produced in Australia, it could be supported in a more economical and responsive manner in comparison with a foreign designed and supported aircraft, while yielding important industrial base dividends for the Australian taxpayer.

The Evolved F-111 concept, encompassing a force structure mix of Evolved F-111 and F-22 aircraft, offers Australia a 'system-of-systems' option for meeting the fighter replacement requirement which surpasses the affordability, lethality, survivability and supportability criteria of all other options.

In conclusion, the F-22A Raptor and Evolved F-111 Force Mix offers flexibility in decision making and related budgeting without incurring an interim loss in combat capability. Concurrently, the F-22A Raptor and Evolved F-111 Force Mix addresses these challenges and associated risks in an innovative and cost effective manner, consistent with the Australian tradition of self reliance.

Future wars will be won by those players most able to rapidly evolve their capabilities in response to an uncertain and complex environment. The F-22A and Evolved F-111 Force Mix fits this basic need.

10 Related Documents

1. Kopp C, **Supercruise and the F-111 (SCU)**, White Paper, Rev 1.59 2002/01/26, 120 pages.

2. Kopp C, **F/RF-111C/G: Cockpit Supportability Upgrade (CSU)**, White Paper, Rev 1.11 2001/08/29, 53 pages.

3. Kopp C, **F/RF-111C/G: Radar Supportability Upgrade (RSU)**, White Paper, Rev 1.8 2001/08/29, 12 pages.

4. Kopp C, **F/RF-111C/G: RCS Reduction via Honeycomb Replacement (HRU)**, White Paper, Rev 1.17 2001/08/29, 52 pages.

5. Kopp C, **EF-111A/C: Electronic Combat Capability for the Australian Defence Force (ECS)**, White Paper, Rev 1.36 2002/01/26, 54 pages.

6. Kopp C, **DEF 224 Bunyip and the Evolved EF-111 Raven (BER)**, White Paper, Rev 1.9 2002/05/24, 50 pages.

7. Kopp C, **F/RF-111C/G: Radar Capability Growth Options (RCG)**, Briefing Slides (Parts 1, 2-3, 4-6), Rev 1.5 2002/04/7, 45, 22, 68 slides.

8. Kopp C, **AN/AVQ-26 Pave Tack: Technology and Capability Growth Options (PTG)**, Briefing Slides, Rev 1.7 2002/03/18, 41 slides.

9. Kopp C, **AN/AVQ-26 Pave Tack: Imaging Reconnaissance Capability Growth Options (PTR)**, Briefing Slides, Rev 1.4 2002/03/18, 74 slides.

10. Kopp C, **AN/AVQ-26 Pave Tack: Counter Air Capability Growth Options (PTC)**, Briefing Slides, Rev 1.6 2002/03/18, 62 slides.

11. Kopp C, **F/RF-111C/G: Leveraging Radar, Pave Tack Upgrades and Optical Fibre Technology in AIR 5416 EWSP (EWSP)**, Briefing Slides, Rev 1.8 2002/04/15, 16 slides.

12. Kopp C, **The F-111F as an Interim RAAF Multirole Fighter (F-111F)**, Briefing Slides, Rev 1.9 2002/03/11, 37 slides.

11 Annex A - Future RAAF Force Structure Rationale

Achieving air superiority in any strategic context requires that an air force has better capabilities than potential opponents, and in credible numbers relative to opposing capabilities.

The developing regional environment presents Australia with many challenges which have not been seen since the period of the 1940s, when Japanese forces were able to strike at northern Australian targets. Until later in that conflict, Australia had a very limited capability to challenge or defeat Japanese bombers and their supporting escort fighters.

Unlike the period of the 1940s, Australia now derives significant national wealth from natural resources in the north. The North West Shelf and Timor Sea gas and oil industry plant, offshore and onshore, represents a lucrative target for air attack using smart bombs or cruise missiles, and thus is a key strategic vulnerability in a time of conflict.

Other key targets across Australia's north include the chain of RAAF airfields, specifically Learmonth, Curtin, Tindal, Darwin and Scherger, and other key ADF facilities such as radar and communications sites, including the JORN antenna arrays. Relatively isolated, repair and reconstitution of most of these facilities following attacks could present genuine difficulties.

In any serious conflict, initial attacks would be directed at RAAF bases and where opportunities arise, RAN surface warships in the area. The aim would be to at least cripple operations, and if possible render the basing unusable and inflict attrition on aircraft and other assets. The weapon of choice for such attacks would be the cruise missile, launched in large numbers. For instance, a Sukhoi Su-27/30 fighter supported by aerial refuelling has the capacity to carry up to four conventional cruise missiles, or a smaller number of supersonic cruise missiles. A strategic bomber would carry between four and sixteen cruise missiles, subject to bomber and missile types, and would not require aerial refuelling for such strikes.

The often cited argument that the Air Warfare Destroyers could play a major role in defending against such a strike is nonsense, as each of these vessels could at best defend a circle of about 30 nautical miles diameter against a low altitude cruise missile attack, assuming the warship itself does not become the focus of an attack. The operational and propaganda effect of sinking one or more of the Air Warfare Destroyers makes them an attractive target, one which is implicitly susceptible to a saturation attack with anti-ship cruise missiles[54].

Given these considerations, defining key capabilities to achieve and maintain air superiority within Australia's areas of interest is not unusually difficult. Developing regional capabilities provide a very clear and easily understood benchmark for future RAAF capabilities. NATO and United States experience during the Cold War era provides a wealth of applicable case studies.

In practical terms, the force structure modelling process amounts to matching capabilities to required roles, these in turn being defined against strategic and operational objectives, and opposing capabilities.

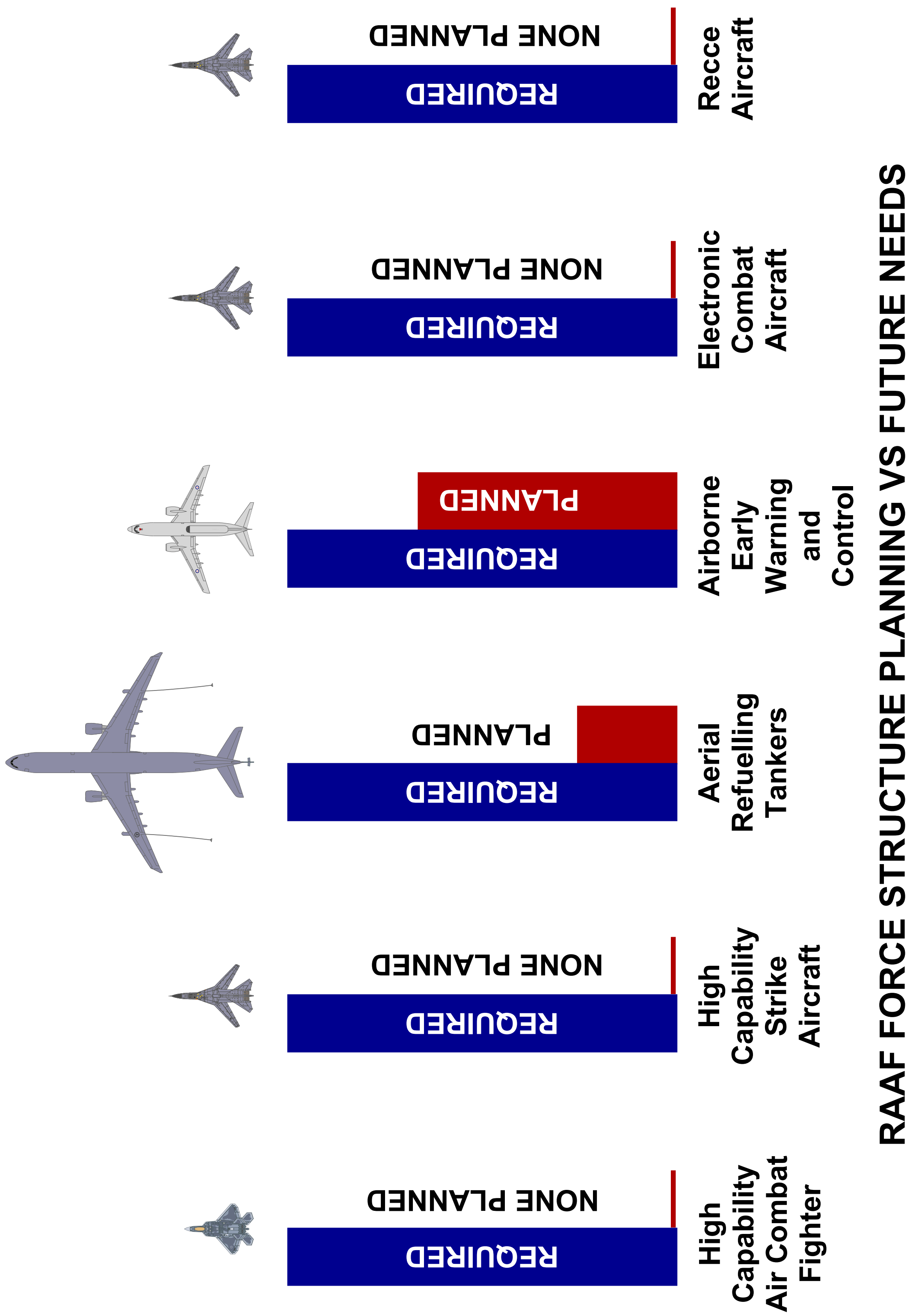

Figure 29: *This chart displays planned RAAF force structure investment vs needs arising from regional capability growth, current as of December, 2007. Of the six key areas of investment, two involve inadequate investment and four no investment at all (C. Kopp).*

'Key capabilities' which Australia must acquire can be summarised thus:

1. Capability to defeat Sukhoi Su-27SK, Su-27SMK, Su-30MK, Su-35BM/35-1 Flanker, PAK-FA and future growth variant fighters, including models equipped with supersonic cruise engines. The Sukhoi must be defeated in both Beyond Visual Range and close combat, the latter to account for situations where Beyond Visual Range combat is not feasible.

2. Capability to defeat strategic bombers such as the H-6K Badger, Tu-95MS Bear and Tu-22M3 Backfire. Fighter aircraft must have the supersonic performance to effect intercepts against supersonic bombers, and be supported with sufficient refuelling capability to engage the bomber before it can launch cruise missiles.

3. Capability to defeat cruise missiles, including the Tomahawk-like Kh-55SM, and supersonic weapons like the Yakhont. Fighters must have the aerodynamic performance, radar performance and weapon payload to credibly intercept low flying cruise missiles in flight. Sufficient aerial refuelling must be available to provide the necessary persistence in an area of operations.

4. Capability to perform long range 'counter-force' strikes to pre-emptively defeat regional offensive capabilities in a crisis. This capability can be implemented by delivering cruise missiles, or by employing a penetrating stealth aircraft, or both. Sufficient aerial refuelling capability must be available to permit a significant number of aircraft to reach targets at distances of 2,500 nautical miles or greater.

These basic 'key capabilities' must exist, and sufficient numbers of aircraft be available for the capability to be credible. For instance, having the capability to strike to 2,500 nautical miles using only eight aircraft is not a credible capability.

The RAAF will understandably need to provide a much broader spectrum of capabilities than these 'key capabilities' alone. However, the combat survivability of assets required to provide other capabilities is predicated upon having these 'key capabilities', without which opposing air power would wreak havoc.

Additional and important considerations include:

1. Achieving sustainability in operations - the RAAF must be capable of sustaining these capabilities, at a credible rate of effort, for at least two months. This means not only having sufficient aircrew and ground personnel, but also having the airfield aviation fuel replenishment capability and critical munitions warstocks to sustain the effort.

2. Achieving survivability in operations - the RAAF must be capable of surviving sustained combat operations, both in the air and on the ground. The former is addressed by appropriate choices in aircraft, the latter by base and infrastructure hardening.

3. Achieving persistence and reach - aerial refuelling aircraft of suitable size must be available in credible numbers to support persistent air combat and battlefield support tasks, but also to permit credible numbers of aircraft to strike at long range, or sustain Combat Air Patrols over the sea air gap.

The F-22 and Evolved F-111 Force Mix Option

4. Achieving situational awareness - sufficient numbers of intelligence, surveillance and reconnaissance systems must be available to provide persistent coverage of areas of operation. Having world class systems like the Wedgetail AEW&C is not adequate if the number of aircraft is not sufficient to cover all key Australian territorial targets.

5. Achieving network robustness - while networking capabilities are highly valuable in combat, they represent a single point of failure for the force if they are degraded or crippled by hostile jamming. Sufficient redundancy must exist within networks to provide high resilience to hostile jamming.

6. Jamming opposing networks and intelligence, surveillance and reconnaissance systems. All successful air campaigns executed over the last three decades have included intensive jamming of an opponent's radar and communications systems. This capability is both essential and highly profitable given developing regional capabilities[55].

7. Coalition interoperability issues - communications, digital networks, radars and jamming equipment must be interoperable with United States forces.

Current planning for the RAAF, articulated in a range of public documents, is wholly unrealistic given the developing strategic environment, and regional capabilities.

If we test planned capabilities against the previously stated criteria, several key inadequacies become immediately apparent.

1. The F/A-18A/B HUG and F/A-18F are outclassed by the latest Sukhoi fighters on a number of key criteria, including combat radius, aerodynamic performance, radar range and weapon carrying capabilities.

2. The Joint Strike Fighter is outclassed by the latest Sukhoi fighters on a number of key criteria, including combat radius, aerodynamic performance, radar range and weapon carrying capabilities. The United States intend to use the F-22A to defeat Sukhoi fighters in air combat.

3. The F/A-18A/B HUG and F/A-18F lack the supersonic performance to reliably effect intercepts against high performance strategic bombers like the Tu-22M3 Backfire.

4. The Joint Strike Fighter lacks the supersonic performance to reliably effect intercepts against high performance strategic bombers like the Tu-22M3 Backfire - the United States intend to use the F-22A for this role.

5. The F/A-18A/B HUG and F/A-18F lack the persistence and weapon carrying capability to be effective cruise missile defence assets, and the F/A-18A/B HUG radar lacks the range performance to perform this role effectively.

6. The Joint Strike Fighter lacks the persistence and weapon carrying capability to be an effective cruise missile defence asset - the United States intend to use the F-22A for this role.

7. Current planning to acquire five KC-30/A330-200 aerial refuelling tankers represents about 25% of the developing capability needs of the RAAF.

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8. Current planning to acquire six Wedgetail AEW&C aircraft addresses around 66% to 75% of the developing capability needs of the RAAF.
9. There is no planning to acquire a long range ground surveillance platform with capabilities similar to the US E-8 JSTARS, vital both for cruise missile defence and the support of ground forces.
10. There is no planning to acquire a long range electronic and signals surveillance platform with capabilities similar to the US RC-135V/W Rivet Joint or proposed EP-8A.
11. There is no planning to acquire electronic attack (support jamming) aircraft to suppress opposing radar, network and communications systems.
12. Basing lacks adequate fuel replenishment infrastructure to sustain a credible deployed force size.
13. Basing lacks adequate hardening to withstand attacks, even by cruise missiles with limited warhead sizes.

> It is abundantly clear that current planning for the future of the RAAF is predicated on unrealistic and obsolete assumptions about regional capabilities and their impact. As a result it should be wholly revised to account for the evolving region and developing strategic risks. To retain the existing plan for future air force capabilities is to invite significant strategic problems for Australia over coming decades.

For an air force to be successful in achieving air superiority against a given opponent, it must have suitable capabilities. Improper choices in planning can and usually do result in unsuitable types of combat aircraft, with inappropriate numbers in operation.

Much is often made of the issue of aircrew proficiency and indeed talent, as a key factor in an air force's capability to achieve air superiority. Historical experience indicates that aircrew abilities are important, but are not a substitute for suitable combat aircraft in appropriate numbers. The unavoidable reality, demonstrated repeatedly since 1914, is that the performance and capabilities of combat aircraft used is the dominant factor in determining success in aerial combat. In simple terms, there is no substitute for having more capable and better performing fighter aircraft.

Should a conflict develop in the region, it is more likely than less likely that the ADF would have to confront the full spectrum of capabilities used to fight for air superiority. As a result there are no real shortcuts available in developing and maintaining the RAAF's force structure.

> The ADF has no choice, if the intent is to maintain Australia's strategic position in this region, than to properly develop the full spectrum of capabilities for achieving and maintaining air superiority, in credible numbers. Any other approach to this problem creates significant medium and long term weaknesses which will leave Australia at a disadvantage in the regional strategic context.

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Figure 30: *Potent electronic reconnaissance suites are now available in the market. This Israeli G550 system is an example (upper). The RAF's new Sentinel R.1 is a compact affordable X-band ground surveillance radar system (IAI, RAF).*

Australia will have to invest in all of the key capabilities required to achieve air superiority:

1. A high capability category air combat fighter capability, rather than the low capability category small fighters operated since the 1940s.
2. A high capability category strike capability, enhancing the capability currently provided by the F-111.
3. A robust aerial refuelling fleet in numbers matched to the numbers of combat aircraft, in a ratio of at least one medium sized tanker aircraft per four combat aircraft.
4. Robust Airborne Early Warning and Control capability, in greater numbers than the currently planned six aircraft.
5. Robust capability for imagery intelligence, other than satellite imagery, with sufficient capacity to support combat operations in the areas of interest.
6. Robust capability for electronic and signals intelligence gathering, with sufficient capacity to support combat operations in the areas of interest.
7. Robust capability for electronic combat, using dedicated electronic attack (support jamming) aircraft, with sufficient capacity to support combat operations in the areas of interest.
8. Robust capability to support aircraft, systems, weapons, infrastructure, both deployed and at permanent basing.
9. Fuel storage and replenishment infrastructure at northern Australian bases to sustain a credible rate of effort using all RAAF combat aircraft, aerial refuelling tankers and other supporting assets.
10. Air base hardening to withstand attacks by cruise missiles and other stand off weapons available in the region. Hardening should include shelters for deployed aircraft, fuel storage and distribution, munitions storage and other 'mission critical' base infrastructure.

It is necessary to include airfield fuel replenishment infrastructure for aircraft and essential services as prerequisites in order to achieve air superiority. Where insufficient capacity exists to replenish consumed aviation fuel, the air force using these facilities will be severely limited in how many sorties it can fly. The useful size of the force would be limited by the fuel replenishment infrastructure rather than the number of aircraft in service. Hardening of key airfield facilities, and Hardened Aircraft Shelters (HAS) must also be counted as a prerequisite, as an opponent will attack basing.

The need for a high capability category air combat fighter derives from the simple reality that most regional operators are acquiring high capability category air combat fighters, specifically the Sukhoi Su-27/30 series and the Boeing F-15. Indeed, within the region only Australia, New Zealand, Bangladesh, Burma and Taiwan neither operate nor plan to operate a high capability category air combat fighter capability.

At this time there are only three high capability category air combat fighter designs in production - the Sukhoi Su-27/30, the legacy Boeing F-15 and the Lockheed-Martin F-22A Raptor.

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> High capability category air combat fighters are characterised by the best aerodynamic performance possible from the available technology base, as well as the most powerful radars and other sensors available. This trend has existed since the Great War, and has always seen major powers push the envelope of technology to provide the most capable designs achievable.

The Boeing F-15 Eagle has been in production since the 1970s and remains the most numerous US built high capability category fighter globally. The Sukhoi Su-27SK was developed during the 1970s as a counter to the F-15, and outperforms the F-15 in many key parameters. The Lockheed-Martin F-22A was developed to replace the legacy F-15, but with important new capabilities such as all aspect stealth, supersonic cruise and advanced radar and avionics.

Low capability category air combat fighters are only produced by the Europeans at this time, in the Eurofighter Typhoon and Dassault Rafale. The US is manufacturing the F-16E and F/A-18E/F, both of which were originally developed during the 1970s as low cost low capability category air combat fighters, but both of which no longer have the performance to be credible against opponents such as the Sukhoi Su-27SMK and Su-30/35 series, thus shifting their primary role to bombing battlefield targets. The Joint Strike Fighter is being developed primarily as a small bomber to support ground forces over the battlefield, and is expected to only match at best the performance of the legacy F-16 and F/A-18 designs.

While all modern fighters are now built as multirole aircraft, capable of delivering smart bombs against surface targets, what distinguishes air combat fighters is their high performance and long range radar capability.

> High capability category strike aircraft, like high capability category air combat fighters, are designed to the limits of the available technology, to maximise speed, range and weapon carrying capability. Such aircraft typically carry twice the weapon load of smaller multirole fighters, usually to almost twice the distance. The F-111 is a good example, providing a capability equivalent to a pair of F/A-18s or Joint Strike Fighters, the latter supported by one or more aerial refuelling tankers.

In terms of maintaining a high capability category strike capability, Australia already possesses such a capability in the F-111 fleet. At this time there is only one high capability category strike aircraft in production, the Russian Sukhoi Su-34 Fullback, derived from the Su-27 Flanker.

The US Air Force was tentatively planning for the new FB-22A after 2015, but at this time no significant funding has been made available to develop this F-111-sized enlarged derivative of the F-22A Raptor. The FB-22A would be an exact replacement for the F-111 but remains at this time a paper design.

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> Aerial refuelling is the critical enabler for modern air power, providing both range and persistence in combat. The practical reality is that in Australia's geography, the number and size of available tankers sets hard limits on how many fighters can be used effectively in combat. Whether Australia deploys 60, 80, 100 or 130 fighters, the range and endurance limitations of these fighters means that only the number for which aerial refuelling support is available can perform tasks other than defending the immediate vicinity of their home base.

Statistical analysis of air campaigns since the 1960s, as well as extensive mathematical and computer modelling, indicate that a single medium sized tanker, in the size class of the KC-135R, KC-767 or KC-30/A330-200MRTT can typically support between two and six fighters in combat operations. Larger tankers, such as the KC-10A or KC-747-400 can support roughly twice as many fighters, due to much larger fuel payloads.

There is no substitute for aerial refuelling tanker aircraft, and the notion that a modern air force can be operationally viable with a token number of tanker aircraft is demonstrably no more than wishful thinking.

The notion that Australia can always rely upon the provision of US aerial refuelling tankers in a crisis is not credible, given the significant budgetary pressures the US Air Force is currently being subjected to, especially in funding recapitalisation of the existing and badly overstretched US tanker fleet.

No less importantly, heavy tanker aircraft such as the KC-747-400 can address other vital needs for the ADF, such as strategic airlift and humanitarian disaster relief, if acquired in suitable numbers. The acquisition of twelve or more dual role 747 derivative tankers to provide a full strength tanker and strategic airlift fleet is both technically feasible, and affordable, but to date has not been adopted in planning[56].

> Airborne Early Warning and Control aircraft are critical enablers in operations aimed at achieving air superiority. These aircraft combine a high power long range radar, passive electronic surveillance sensors, comprehensive digital and voice communications, networking equipment, and a battle management staff to control fighter operations. Airborne Early Warning and Control aircraft provide situational awareness over a radius in excess of 200 nautical miles.

Australia's Wedgetail AEW&C system is the most sophisticated design yet to be developed, and sits ahead of the US Air Force's E-3C AWACS by a generation of radar technology. Australia currently plans to field six aircraft, which provides a limited capability. A genuinely robust force structure would have eight to nine aircraft, to provide coverage for three areas of operations and sufficient redundancy to cope with aircraft unavailability and potential combat losses.

It is important to distinguish the very different functions of the Wedgetail AEW&C system, against the Jindalee Over The Horizon Backscatter (OTH-B) high frequency radar system (JORN). JORN provides long range wide area surveillance, but lacks the precision and high rate tracking capabilities of the Wedgetail AEW&C system, and its passive surveillance and battle management capability.

Therefore JORN and the Wedgetail AEW&C system are complementary.

While Wedgetail provides radar and some passive electronic surveillance, it represents only one of three core capabilities for Intelligence, Surveillance and Reconnaissance (ISR).

> Imaging and electronic Intelligence, Surveillance and Reconnaissance capabilities provide the means of establishing what the opponent's activities, deployment and capabilities are. Without these capabilities it is extremely difficult if not impossible to determine what the opponent's strength is, and what activities they are pursuing at any given time. All deployable imaging and electronic Intelligence, Surveillance and Reconnaissance systems combine a sensor package to gather information, and vehicle to deploy the sensor package. Such vehicles can be aircraft, uninhabited aerial vehicles or satellites in orbit.

It is important that Australia has to date invested very poorly in imaging and electronic Intelligence, Surveillance and Reconnaissance capabilities. While some electronic Intelligence, Surveillance and Reconnaissance capability exists in the Wedgetail, the AP-3C Orion, and some modified AP-3C and C-130 signals intelligence aircraft, Australia lacks any specialised and dedicated system comparable to the US RC-135V/W Rivet Joint, EP-3C Aries, proposed EP-8A, the UK's Nimrod R.1, or Israeli, European, Russian or Chinese equivalents.

Australia's only genuine imaging Intelligence, Surveillance and Reconnaissance capability resides in four RF-111C aircraft equipped with 1960s technology wet film camera systems. Australia has experimented with the DSTO Ingara high resolution imaging radar system, but has no plans to acquire a substantial capability in this area, comparable to the US E-8 JSTARS, E-10 MC2A, UK ASTOR Sentinel R.1 or European equivalents.

> While much has been said about the adoption of networking and the 'system of systems' model, unfortunately this model only works properly if there is an abundance of Intelligence, Surveillance and Reconnaissance capabilities to feed digital data into the network. A networked 'system of systems' which is starved of data from Intelligence, Surveillance and Reconnaissance system sensors is effectively deaf and blind.

The notion that Australia can largely rely upon US Intelligence, Surveillance and Reconnaissance products is simply not realistic, unless Australia is only ever engaged in coalition operations with the US.

US satellites have global tasking, and retasking them to address time critical Australian needs could prove very difficult in a crisis. Moreover, optical imaging satellites cannot penetrate cloud cover, and with all satellites, timeliness of product depends on orbital position. While satellites can provide valuable product, they can only address part of the capability need.

Figure 31: *The US Air Force mothballed its fleet of EF-111A Raven electronic attack aircraft in 1999 as a result of losing a long running dispute over which service would provide this capability. For Australia, these superb aircraft provide an opportunity to introduce this capability at a very modest incremental cost, primarily that of updating the existing ALQ-99E Tactical Jamming System installation to the newer ALQ-99 ICAP III configuration now being supplied to the US Navy. All EF-111As were upgraded to the Avionics Modernisation Program (AMP) configuration, identical to Australia's existing F-111Gs, shortly before being mothballed (US Air Force).*

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Long endurance Uninhabited Aerial Vehicles (UAV), such as the RQ-4 Global Hawk, provide many capabilities similar to satellites, and many which are unique to such UAVs, such as the ability to persistently orbit in an area of interest for many hours. Such UAVs fly high enough to defeat many fighter aircraft and surface to air missile defences, but not all such defences. Another consideration is that such UAVs rely heavily on communications satellites to transfer imagery product to user ground stations, which will impose some limitations in capability.

An idea which has been widely propagated in Australia is that the internal sensor package in the Joint Strike Fighter can be used to provide critical imaging and electronic Intelligence, Surveillance and Reconnaissance capabilities. This argument is not credible, given the limited surveillance footprint and resolution of the these sensors, compared to specialised and dedicated sensors built for Intelligence, Surveillance and Reconnaissance platforms.

If Australia has any future intention of conducting independent military operations in the region, and achieving air superiority in a regional conflict, significant investments need to be made in both imaging and electronic Intelligence, Surveillance and Reconnaissance capabilities. Networking systems without adequate supporting Intelligence, Surveillance and Reconnaissance capabilities is not a credible solution to this problem.

While the ability to surveil and analyse an opponent's electronic sensor, communications and networking capabilities is vital in combat, it alone does not confer the capability to deny an opponent the use of these capabilities. That is the role of electronic combat capabilities.

Electronic combat or electronic attack capabilities, comprising the ability to surveil, track and jam an opponent's radar, voice communications and networking, are critical capabilities in modern conflict. In recent conflicts the US has used this capability to not only jam the systems used by opponents with modern capabilities, but also to jam battlefield radio communications used by the Taliban, Al Qaeda and Iraqi insurgents. Importantly this capability has been a key feature of every significant conflict involving air power since the 1940s, and not uniquely a US capability, as demonstrated by the Israelis and Soviets.

Australia has never operated aircraft equipped with high power jamming equipment. US approaches during the mid to late 1990s, offering surplus US EF-111A Raven jamming aircraft, were not received with any official interest in Australia, despite the high combat value of these systems.

With the advent of modern capabilities like Airborne Early Warning and Control, digital networking, advanced radars and missiles across this region over the last decade, the notion that electronic combat capabilities are an 'overkill' is no longer true. These capabilities are now becoming essential to achieving success in any conflict involving modern capabilities. Indeed, Russia is developing such a capability to be carried by the Sukhoi Su-34 Fullback aircraft, and regional nations will be the primary export target for such a system.

> Provision of the full suite of operational capabilities required for air superiority may not produce the intended effect, if these capabilities are not properly supported, both by organic service support capabilities, and broader and deeper industrial base capabilities. Australia has seen a considerable reduction in such capabilities both within the ADF, and across the industry, over the last decade. Unless this trend is reversed, a shortage of technical, engineering and analytical skills will severely impact the future ability of the RAAF to maintain, upgrade and adapt what capabilities it does possess.

While a number of causes have contributed to the current decline in the support base, notable contributing factors include the realignment of RAAF engineering into logistics over a decade ago, focussing skills away from technical to management, often poorly managed outsourcing, which depleted service skills without providing a replenishment mechanism via training, and ongoing difficulties with the retention of highly experienced and trained personnel. These factors arise in confluence with a decline in many key areas of the industrial skills base.

It is important to observe that air power is a technologically centred capability, where the ability to use machines in combat is the determinant of capability and operational success. Historical case studies have shown repeatedly that problems or limitations in the technological support base, or in the pool of knowledge and understanding within a service, can have a direct and critical impact on operational capabilities as well as the ability to appreciate and understand developing trends, both of which are essential for future planning.

The radical de-skilling of the RAAF and many applicable sectors of industry must be reversed in coming years, to ensure that the RAAF has the capability to support its force, as well as adapt and modify systems at short notice, and perform accurate analyses of technological problems related to capability.

The final capability elements required to achieve air superiority in a regional context are those of sufficient aviation fuel replenishment capability and base hardening for Australia's northern chain of airfields, especially RAAF Learmonth and Tindal.

> It takes very little analysis to establish that a deployment to northern bases of most of the RAAF's combat aircraft, supporting assets such as the Wedgetail, appropriate numbers of tanker aircraft, and subsequent intensive flight operations commensurate with an effort to achieve air superiority over the north and northern approaches, would result in the consumption of up to 3,000 tonnes of aviation fuel per day. Current storage and fuel replenishment capabilities cannot credibly sustain such a rate of effort.

Moreover, the limitations of existing replenishment capabilities would preclude the effective deployment of a US Air Expeditionary Force if Australia opted to wholly rely on deployed US capabilities to acheive air superiority in northern Australia.

These limitations in infrastructure exist despite the very modest costs of additional fuel storage, and pipelines to offshore jetties, or at Tindal, a railway siding at Katherine on the new Alice Springs to

Darwin railroad. Of all of the capability limitations Australia has in using what air power it has, the problem of aviation fuel replenishment infrastructure is the least expensive to solve.

Figure 32: *Hardened Aircraft Shelters (HAS) require considerable effort to defeat, often needing multiple bunker busting bombs. Smaller smart bombs and cruise missiles are typically unable to penetrate effectively (US DoD).*

The problem of base hardening is one which has not been addressed to any great extent in the past. Dispersal areas, revetments and redundant taxiways have been employed for recently constructed bases such as RAAF Curtin. Unfortunately, the proliferation of smart bombs and cruise missiles across the region, many with precision guidance capabilities, much reduces the effectiveness of dispersal in base hardening.

More specifically, hardened aircraft shelters will be required for aircraft and hardening will also be required for critical base infrastructure, especially fuel and munitions storage facilities.

The value of hardened shelters was denigrated after the 1991 Desert Storm campaign as the US Air Force were able to penetrate most of these and destroy or damage the aircraft therein. What is less appreciated is that much effort was required to do so, usually multiple large 1,000 kg smart bombs were required to penetrate each shelter. Smaller munitions, such as cruise missiles and 500 kg smart bombs will have difficulty with all but the least robust shelters.

The RAAF will need to construct hardened aircraft shelters for geographically critical bases such as RAAF Tindal, RAAF Learmonth, RAAF Curtin and RAAF Darwin, to ensure that an opponent cannot destroy RAAF combat aircraft on the ground with minimal effort, such as a pre-emptive cruise missile strike. This effort should include the Cocos Islands and Christmas Island.

Hardening of northern bases involves a number of specific measures[57]:

1. Runway improvements to provide at least one 10,000 - 12,000 ft length runway for each base.

Figure 33: *The absence of proper base hardening measures, especially Hardened Aircraft Shelters (HAS), presents a major strategic vulnerability in this era of widely available cruise missiles and smart bombs. Depicted the strategically vital RAAF Learmonth and Tindal sites (Google Earth).*

This is required to accommodate the full spectrum of aircraft types, including tankers and heavy airlifters, but also to force an opponent to cut the runway in several places to disable it.

2. Runway surfaces will need to be rated to PCN 100 to 150 so as to provide durability with repetitive use by heavy aircraft, and also to provide damage tolerance.

3. Each base requires a 10,000 to 20,000 tonne capacity hardened concrete underground fuel storage farm (for instance multiple dispersed cylindrical 2,000 tonne tanks)[58].

4. Bases located at coastal sites will require an offshore fuel loading jetty or seabed pipeline to permit rapid replenishment of aviation fuel supplies. Tindal will require provisions for replenishment by rail from Katherine.

5. Redundant hardened munitions bunkers with redundant access roads will be required.

6. A buried hardened command bunker for C3, ops, and ATC. Underground air raid shelters for personnel should be constructed for other areas of each base.

7. 'Wagon wheel' and other redundant taxiway arrangements should be introduced, where not extant.

8. Hardened Aircraft Shelters capable of resisting at least a bunker busting 1,000 lb class supersonic cruise missile warhead in the class of the US Advanced Unitary Penetrator series will be required not only for fighter aircraft, but also for KC-30 tankers, C-17s, Wedgetails, AP-3C/P-8 LRMPs and other large aircraft. This does offer the added benefits of denying satellite recce visibility and protecting the aircraft from the harsh environment.

9. Concrete pads for the requisite number of tents or prefab housing modules needed to support an extended deployment.

10. Underground water and electricity distribution to areas to be used to house personnel, redundant desalination plants and electricity generation of necessary capacity. Sewerage facilities of required capacity.

11. A stormwater drainage system to handle monsoonal weather conditions, including runways, taxiways, shelters, carports, concrete housing pads, bunkers etc.

12. The recent emergence of electromagnetic pulse (EMP) and microwave (HPM) weapons requires that all shelters be hardened against this form of attack. Recent materials advances such as electrically conductive concrete make this a much cheaper proposition than a decade ago.

13. Provisions should be made for the deployment of air defence systems, especially search radars and defensive missile batteries.

There exist a large number of well hardened NATO and former Warsaw Pact bases which can be used as templates for the design of a robust base hardening package.

Tables 1 and 2 provide a basic force structure model for the RAAF which has been optimised to deal with now extant and developing regional capabilities. This model has been optimised for minimal cost and risk, and best achievable capability. Supporting research for the model was initiated in 1998, providing a decade to test assumptions against regional capabilities, and availability of technology.

The principal combat capability in this model is provided by the F-22A Raptor and 'Evolved' F-111S Force Mix.

Proposed Future RAAF Force Structure Model

Category	Roles and Missions
Tactical Fighter, Air Combat	Air Superiority, Air Defence, Precision Strike, Cruise Missile Defence, Reconnaissance
Tactical Fighter, Strike Recce	Precision Strike, Battlefield Strike, Maritime Strike, Imaging Reconnaissance, Cruise Missile Defence
AEW&C	Airborne Early Warning and Control
SIGINT/ELINT	Signals and Electronic Intelligence
ISR	Intelligence Surveillance Reconnaissance
Electronic Attack	Radar, Communications, Network Jamming
LRMP	Long Range Maritime Patrol
LRCR	Long Range Communications Relay
AAR	Air to Air Refuelling
SAL	Strategic Air Lift

Table 1: Force structure model categories. While two multirole tactical fighter categories are defined, each can assume specialised tasks where its capabilities are better suited.

Type	Number	Unit	Category
F-22A Raptor	50	3, 75, 77 SQN, 2 OCU	Tactical Fighter, Air Combat
F-111S	36	1, 6 SQN	Tactical Fighter, Strike Recce
EF-111S Raven	8	6 SQN	Electronic Attack
Wedgetail	8	2 SQN	AEW&C
EP-8A	4	2 SQN	SIGINT/ELINT
AP-3C/P-8A	12	11 SQN	ISR, LRMP
RQ-4B Global Hawk	12	10 SQN	ISR, LRCR
KC-747-400	12	33 SQN	AAR/SAL
KC-30	5	33 SQN	AAR/SAL

Table 2: Force structure model designed to ensure air superiority in the future regional environment, dedicated airlift and training capabilities, and attrition aircraft. This table details the results of a decade of research aimed at solving this capability need.

12 Annex B - Capability, Cost and Project Risk Metrics

This annex contains a detailed tabular breakdown of the comparative scoring performed between the legacy Defence F-35 JSF / F/A-18F plan and the F-22A and Evolved F-111 Force Mix proposal. For convenience, the summary table in Table 3 is replicated here.

Proposal Metric	F-22A and Evolved F-111 Plan Score	F-35 JSF / F/A-18F Plan Score
Combat Capability Subtotal	+2	-9
Supersonic Cruise	0	-2
All Aspect Stealth	-1	-1
Phased Array Radar	0	-1
Internal Weapons 2 klb	0	-1
Max External Payload	+1	0
Int Weapons Payload	+1	-1
Combat Radius (Int Fuel)	0	-2
Cost Metrics Subtotal	+3	-6
Acquisition Cost	+1	-2
Acquisition Model	+1	-2
Life Cycle Costs	+1	-1
Return on Investment	0	-1
Risk Metrics Subtotal	+3	-13
Acquisition Risk	0	-2
Cost Risk	0	-2
Design Risk	0	-1
Strategic Risk	0	-2
Strike Capability Gap	+1	-2
Air Sup Capability Gap	+1	-2
Air Def Capability Gap	+1	-2
Net Assessment	+8	-28

Table 3: Summary table of assessment scoring for current defence NACC and interim planning against the 2001 Australian Industry solution.

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.

Score	Australian Industry Solution (Proposed 2001)	Capability, Cost, & Project Risk Metrics	Current Defence Plans (Launched 2002, Changed 2003, 2004, 2006, 2007)	Score
+1 0 -1	*2008 Onwards*		*2010 to 2018*	+1 0 -1
			2018 Onwards	
Brief Description of Two New Air Combat Capability (NACC) Models for Australia				
+8	**55 x F-22A** IOC by 2010, PLUS **36 x F-111s** Evolved by Australian Industry to F-111S configuration <u>THROUGH</u> incorporation of Incremental Block Upgrades <u>PLUS</u> additional aircraft and parts from the AMARC. This model meets needs for: - Defence Capability Needs – Manpower challenges – Economy/Balance of Payments – Industrial Base Development – Minimising Dependency Risks – Leaving a 'Better Australia'	Air Combat Force Structure Model	**71 x HUG F/A-18As** **24 x F/A-18F BACC** Assumes completion of Hornet Upgrade Program (HUG) <u>PLUS</u> Fuselage Centre Barrel Replacement (CBR) <u>PLUS</u> multiple Minor Item Submission (MIS) upgrades <u>PLUS</u> Air 5418 (FOSOW) <u>PLUS</u> Air 5409 (Bomb Improvement Program)	-16
			60 to 100 x JSFs Low Rate Initial Production aircraft (Block 1, Block 2 and Block 3) <u>PLUS</u> ongoing upgrades to incorporate war fighting capabilities. Combat UAV option in Tranche 3, though wildly speculative at this stage. [1]	-12
TOTAL NUMBER OF METRICS = EIGHTEEN (18) A score of zero (0) means the air combat capability system meets or achieves all the defined metrics. A negative score means the air combat capability system fails to meet one or more of the metrics. A positive score means the capability system significantly exceeds the requirements of one or more of the metrics.				
+8	2008 Onwards SUPERIOR OUTCOME	**RESULTS** NETT ASSESSMENT SCORE TOTALS	INFERIOR OUTCOME-: 2010 TO 2018	-16
			INFERIOR OUTCOME : 2018 Onwards	-12

Score (+1 / 0 / -1)	Australian Industry Solution (Proposed 2001) — 2008 Onwards	Capability, Cost, & Project Risk Metrics	Current Defence Plans (Launched 2002, Changed 2003, 2004, 2006, 2007) — 2010 to 2018 / 2018 Onwards	Score (+1 / 0 / -1)
2	Sub Total	Combat Capability Metrics	Sub Total	**-9**
0	F-22A : Standard	Supersonic Cruise Capability	F/A-18A HUG, F/A-18F BACC : None and never will have.	-1
0	Evolved F-111S : Achieved via engine upgrade (F110 ex F-14D or F119)		JSF : None and never will have.	-1
0	F-22A : Standard	All Aspect Wideband Stealth Capability	F/A-18A HUG, F/A-18F BACC: None	-1
0	Evolved F-111S : Not required. Primarily stand-off missile carrier and cruise missile interceptor. Air dominance fighter and strike capabilities provided by F-22A		JSF : None Optimised for 'Forward' and 'Side' aspect Best performance limited to X-Band, only. Target KPP downgraded to LO from VLO – an order of magnitude change.	-1
0	F-22A : AN/APG-77 [2]	Phased Array Radar Capability	F/A-18A HUG : None	-1
			F/A-18F BACC: AN/APG-79[3]	0
0	Evolved F-111S : AN/APG-80 or AN/APG-81[5] via upgrade. Could be done with funded NRE in support of mitigating risks on JSF Program		JSF : AN/APG-81 [5]	0
0	F-22A : Not required, due F-111	Internal Carriage 900 kg Weapons	F/A-18A HUG / F/A-18F BACC : None	-1
0	All F-111 (excl. RF/F-111) : Standard		JSF : Yet to be demonstrated	0

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Score (+1 / 0 / -1)	AUSTRALIAN INDUSTRY SOLUTION (PROPOSED 2001) — 2008 Onwards	CAPABILITY, COST, & PROJECT RISK METRICS	CURRENT DEFENCE PLANS (LAUNCHED 2002, CHANGED 2003, 2004, 2006, 2007) — 2010 TO 2018 / 2018 Onwards	Score (+1 / 0 / -1)
0	F-22A : 9,000 kg	Maximum External Payload (Any Weapon Type)	F/A-18A HUG: 6,800 kg F/A-18F BACC: 8,050 kg Typical for generic small tactical fighter	0
+1	Standard F-111 : 13,600 kg		JSF : 6,800 kg Typical for generic small tactical fighter	0
0	F-22A : 2 x 450 kg or 8 x 175 kg	Internal Weapons Payload (Smart Bombs)	F/A-18A HUG / F/A-18F BACC: None Does not have a weapons bay.	-1
+1	F-111 : 2 x 900 kg Evolved F-111S: 8 x 175 kg		JSF : 2 x 450 kg or 8 x 175 kg	0
0	F-22A : 700+ NMI - PLUS long range asymmetric sub sonic cruise for strike, ISR and electronic attack roles as well as ferry - > 1,000 NMI	Combat Radius on Internal Fuel Suited to Australian Island Continent Status	F/A-18A HUG : 450 NMI F/A-18F BACC: 580 NMI (Requires external fuel tanks to achieve range with any weapons load and effectiveness)	-1
0	Standard F-111 : 1,000+ NMI Evolved F-111S : >1,300 NMI Asymmetric, long range cruise capability for strike, ISR, cruise missile intercept, and electronic attack roles as well as ferry.		JSF : 650 NMI Note: Combat radius yet to be demonstrated in clean configuration and carrying external stores. Expect this will occur some time after 2008, in test program.	-1

Score	Australian Industry Solution (Proposed 2001)	Capability, Cost, & Project Risk Metrics	Current Defence Plans (Launched 2002, Changed 2003, 2004, 2006, 2007)	Score
+1 0 -1	2008 Onwards		2010 to 2018 / 2018 Onwards	+1 0 -1
3	Sub Total	Cost Metrics	Sub Tot	-6
+1	F-22A: (in 'then year' dollars) 50+5 Systems $US6,800.0 m (Subject to negotiation on model - potential for significant reduction) Estimate in Australian Dollars @ 2010 exchange $A9,855.3 m	Value for Money/Cost Effective Acquisition Cost	F/A-18A HUG : $A3,000+ m PLUS Minor Item Submission (MIS) Project costs, Estimate (MIS) $A100m to $A200m These figures are what Defence calls 'cash dollars' which would appear to be 'then year' dollars. F/A-18F BACC: $A3,600m	-1
0	Evolved F-111S: (in 2004 dollars) Upgrades $A1,760.5 m 10 x Attrition Acft $A 133.3 m (PLUS spares eg. wings, etc.) Total : $A1,893.8 m		JSF : $A15,000 m+ NACC Budget - (Assumed 'then year' dollars) Often Stated $US45m per aircraft is Avg Unit Recurring Flyaway Cost in 2002 dollars not Price in 2012+	-1
+1	F-22A : FMS purchase or Lease/Buy or combination of both, with strategic offsets available. Negotiation Win Themes: - Strategic Importance to US - Support for USAF buy/need	Value for Money /Cost Effective Acquisition Model	F/A-18A HUG : large block upgrades and multiple Minor Item Submission (MIS) Projects. F/A-18F BACC: purchase plus contractor maintenance.	-1
0	F-111 : incremental upgrades to existing fleet, acquire attrition reserve from AMARC at less than 10% of book value, as has been achieved previously.		JSF : Tier 3 partner purchase PLUS large Loss/Lead and high government overhead Industry Involvement Program with no assurity of work.	-1

Score +1 0 -1	**Australian Industry Solution (Proposed 2001)** **2008 Onwards**	**Capability, Cost, & Project Risk Metrics**	**Current Defence Plans (Launched 2002, Changed 2003, 2004, 2006, 2007)** **2010 to 2018** **2018 Onwards**	Score +1 0 -1
0	**F-22A : Integrated avionics, 4th generation engine.** **Requirement for life cycle costs to be less than 60% those of F-15.** **Demonstrated in Initial Operational Test and Evaluation to be on target.** **Australia being more than 20% of world fleet provides great opportunity, combined with using attrition aircraft, for Australian Industry involvement in life cycle upgrades. Also, stronger buying and negotiation position.**	**Value for Money/Cost Effective Life Cycle Costs** (Note: Present Value Analysis methods used to provide valid basis for comparison. Same escalation and discount factors used for both models, where applicable.)	**F/A-18A HUG: Legacy federated avionics; aircraft undergoing first time deeper maintenance in conjunction with large suite of modification/refurbishment projects to be done in parallel. Figures derived from analysis of Defence Annual Reports 1999 to 04, Defence Capability Plan to 2015, and previous [4]. PRESENT VALUE $'s in 2004 :** **F/A-18A HUG et al** **Capital Costs (DCP, MIS) >$A2,241.7 m** **F/A-18A HUG (to 2015 [5])** **Total Operating Costs >$A3,002.7 m** **Total : >$A5,244.4 m** **Note : Costs to 2015[4] vs 2020 for F-111S** **F/A-18F BACC: aerodynamically uncompetitive aircraft provides little useful capability in primary roles.**	-1
+1	**F-111 : Mostly integrated avionics, 4th generation engine via upgrades. Figures derived from RAAF Air Combat Capability Paper to Parliament. [6] PRESENT VALUE $'s in 2004 :** **F-111 to 2020 (RAAF)** ***Total Cost of Ownership*** **$A2,224.5 m** **Evolved F-111S (Industry)** ***Total Cost of Upgrades*** **$A1,090.5 m** **Total : $A3,315.0 m**		**JSF: Integrated avionics, 4th generation engine, CAIV and international partnering.** **To be demonstrated in Initial Operational Test and Evaluation presently projected to occur circa 2012.** **Presumed will meet and achieve metric.**	0

Score	Australian Industry Solution (Proposed 2001)	Capability, Cost, & Project Risk Metrics	Current Defence Plans (Launched 2002, Changed 2003, 2004, 2006, 2007)	Score
+1 0 -1	**2008 Onwards**		**2010 to 2018** **2018 Onwards**	+1 0 -1
0	F-22A : Expected life of 40+ years	Minimum of 10 Year Return on Investment Period After Acquisition / Upgrade	F/A-18A HUG : Planned to be completed sometime after 2010. Further upgrades / rebuilds would be required to go beyond 2015.	-1
0	F-111 : 2005-2025+ (Could be extended, or replaced with FB-22 or later build JSF or other capability).		JSF : Expected life of 30+ years subject to approval for full rate production sometime after 2012.	0
3	Sub Total	Risk Metrics	Sub Tot	-13
0	F-22A : LOW	Low Acquisition Risks	F/A-18A HUG : LOW in Avionics; HIGH in Centre Barrel Replacement (CBR); overall HIGH in schedule since multiple element project with close interdependencies which, in turn, is part of a 5 project CAPSTONE Program which has yet to be managed as a CAPSTONE. HIGH risk exposure on aircraft availability. F/A-18F BACC:	-1
0	Evolved F-111S : LOW Due to extensive research, knowledge and experience on aircraft now resident in Industry, DSTO and, to lesser extent, the RAAF (latter due to downsizing and deskilling).		JSF : HIGH Potential for significant variations in capability, cost and schedule timelines with high likelihood of current risks materialising and further risks arising eg. software problems, partners leaving program, Congressional intercession	-1

Score (+1 / 0 / -1)	AUSTRALIAN INDUSTRY SOLUTION (PROPOSED 2001) — 2008 Onwards	CAPABILITY, COST, & PROJECT RISK METRICS	CURRENT DEFENCE PLANS (LAUNCHED 2002, CHANGED 2003, 2004, 2006, 2007) — 2010 TO 2018 / 2018 Onwards	Score (+1 / 0 / -1)
0	**F-22A : LOW** Since mature, inproduction design with buy at end of current production (low cost end when NRE recovery and recurring engineering (RE) costs are at lowest levels). Increase of USAF buy to 300+ units	Low Cost Risks	**F/A-18A HUG : HIGH** High probability of additional structural refurbishing costs, more extensive rectifications arising from first time deeper maintenance, and avionics/ weapons upgrades as further delays development challenges arise in JSF program	-1
0	**F-111 : LOW**		**JSF : Very HIGH** – uncertainties in total numbers will persist until at least 2015	-1
0	**F-22A : Nil**	Low Design Risk	**F/A-18A HUG : MEDIUM LOW**	0
0	**F-111 : LOW** Incremental upgrades of legacy avionics (cockpit, radar) and legacy systems (Pave Tack) PLUS an engine upgrade in the 2010 to 2020 time window.		**JSF : HIGH** Remains in development with difficulties in performance, weight and cooling capacity PLUS significant software and system integration challenges.	-1
0	**F-22A : LOW** No comparable type exists	Low Strategic Risks	**F/A-18A HUG : HIGH** Outclassed by Sukhoi Su-27/30/35 fighters in aerodynamic and radar performance	-1
0	**F-111 : LOW** Proven Tier 1 strike platform		**JSF : HIGH** – Tier 2 aircraft outclassed by larger Tier 1 Sukhoi Su-27/30/35 fighters in aerodynamic performance	-1

Score (+1 / 0 / -1)	AUSTRALIAN INDUSTRY SOLUTION (PROPOSED 2001) — 2008 Onwards	CAPABILITY, COST, & PROJECT RISK METRICS	CURRENT DEFENCE PLANS (LAUNCHED 2002, CHANGED 2003, 2004, 2006, 2007) — 2010 TO 2018 / 2018 Onwards	Score (+1 / 0 / -1)
0	**F-22A : None**	No Strike Capability Gap	**F/A-18A HUG : Significant Gap** Reduction of precision munitions delivery capability by up to 62.5%. Refer Figure 3 of Parliamentary Submission, "Air Combat Capability", by A G Houston, 04 June 2004. Defence decision to exclude F-111 from Air 5418, has made gap deeper and wider. F/A-18F BACC: limited range/payload performance and poor survivability. Two or more aircraft required to match range/payload of single F-111.	-1
+1	**F-111 :** Already has MIL-1760 smart weapons bus making integration of Air 5418 FOSOW and JDAM easy (and cheap). Is not dependent on refuelling tankers to provide long range strike capability to 1,000 NMI.	No Strike Capability Gap	**JSF : Ongoing Gap** Up to 37.5% reduction compared with Defence 2000 White Paper guidance.	-1
+1	**F-22A : None** Superior in all respects to all opposing aircraft [7] out to 2025 and beyond.	No Air Superiority Gap	**F/A-18A HUG / F/A-18F BACC:** inferior speed, agility, range vs Sukhoi Su-27/30/35; significant dependency on AEW&C and tankers to provide useful capability	-1
0	**F-111 :** Requirement met by F-22A air dominance fighter capabilities	No Air Superiority Gap	**JSF :** Inferior speed, agility, and range when compared against Sukhoi family of aircraft, particularly post 2010 configurations; definitely post 2015 evolved growth variants	-1

Score	AUSTRALIAN INDUSTRY SOLUTION (PROPOSED 2001)	CAPABILITY, COST, & PROJECT RISK METRICS	CURRENT DEFENCE PLANS (LAUNCHED 2002, CHANGED 2003, 2004, 2006, 2007)	Score
+1 0 -1	***2008 Onwards***		***2010 TO 2018***	+1 0 -1
			2018 Onwards	
+1	F-22A : None *"The F/A-22 will be the most outstanding aircraft ever built. Every fighter pilot in the Air Force would dearly love to fly it."* Air Chief Marshall Angus Houston, August 2004	No Air Defence Gap	F/A-18A HUG / F/A-18F BACC: Considerable Gap Unsuited for bomber and cruise missile defence due to limited endurance, limited missile payload and limited supersonic speed	-1
0	F-111 : Evolved F-111 capability suitable for bomber intercept, cruise missile defence and ISR/Electronic Attack in addition to established strike roles due to excellent endurance, superior payload, high speed and advanced radar capability[8].		JSF: unsuited for bomber and cruise missile defence due to limited endurance, limited missile payload and limited supersonic speed. The operational JSF is intended to be a battlefield strike interdiction / close air support aircraft with some self defence capabilities[9].	-1
TOTAL NUMBER OF METRICS = EIGHTEEN (18) A score of zero (0) means the air combat capability system meets or achieves all the defined metrics. A negative score means the air combat capability system fails to meet one or more of the metrics. A positive score means the capability system significantly exceeds the requirements of one or more of the metrics.				
+8	2008 Onwards SUPERIOR OUTCOME	NETT ASSESSMENT SCORE TOTALS	INFERIOR OUTCOME-: 2010 TO 2018	-16
			INFERIOR OUTCOME : 2018 Onwards	-12

ENDNOTES :

1 Since the computer science experts can't agree on when the capability for safe and effective autonomous operation of high risk, lethal assets in demanding, hostile environments (such as experienced in air combat) is going to be possible, with predictions ranging from 15 years to 50 years time to never, it would be fanciful and wasteful let alone naïve for the non expert to commit their integrity and public resources to a date in time.

2 The F-22A's APG-77 radar and the JSF's APG-81 radar share transmit-receive module technology, computer processing technology, packaging technology, and multimode capabilities, however, the F-22A's APG-77 is much more powerful, providing twice the detection footprint of the JSF's APG-81 radar. While the F-22A's APG-77 radar provides excellent bombing capability, it remains the most capable air to air radar ever built. Conversely, while the JSF's APG-81 radar provides respectable air to air radar coverage capability, it is being optimised as a bomber radar to meet the Joint Operational Requirements Document (JORD) and CAIV.

The F/A-18F Block II is equipped with the APG-79 AESA which is a competitive design, however in its key metric of detection range performance it has already been outclassed by the Tikhomirov NIIP Irbis E designed for the Su-35BM/Su-35-1 Flanker E Plus, and available as an upgrade for the regional Su-30MKI and Su-30MKM Flanker H.

4 Defence Annual Reports 1999 to 2004 inclusive, statutory financials; Defence Capability Plan 2001-10 and subsequent including analysis of activities in current draft; RAAF Air Combat Capability Paper – A Houston, 04 June 2004; ASPI Strategic Insight – 'Is the JSF good enough' – A Houston, August 2004; Air Power Australia -
A FAREWELL TO ARMS - REVISITED, P A Goon., Jan 2005; ADA Defender - Winter 2005 – 'Affordability and the new air combat capability', P A Goon.

5 Analysis and present value (2004) calculations of total operating expenses for the F/A-18A HUG only taken out to 2015 since fleet numbers start to drop off due to fatigue and maintenance related lifing issues shortly after 2014 (on the basis of historical flying rate and fatigue damage accrual rates which, if reduced, will effect preparedness).

6 RAAF Air Combat Capability Paper – Air Force Submission to Joint Standing Committee on Foreign Affairs, Defence and Trade dated 04 June 2004. Refer Figure 2 – F-111 Cost of Ownership (Cash) and Table 1 – Ten Year Cost of Retaining F-111 in Service. Cash flow profile figures are discounted to Present Value (2004) dollars using the same discount factors (having applied escalation factors, where appropriate) in the analysis and comparison of both models.

7 The design aims of the original F-22A, defined in the 1980s, provided capabilities to defeat opposing next generation fighters and bombers. By the early 1990s these aims expanded to include high survivable strike capabilities, resulting in redesignation to the F-22A. Over the last five years these capabilities have been further expanded to include intelligence, surveillance and reconnaissance in high threat situations – the F-22A will thus absorb much of the role performed until the 1990s by the SR-71A.

8 The earliest design aims of the original F-111 program, defined during the early 1960s, were to provide a bomber for the US Air Force and an interceptor for the US Navy, to protect naval forces from Soviet bombers and cruise missiles. As the F-111 proved too large for aircraft carrier deployment, only the bomber variants were built.
The F-111 thus retains the endurance, payload and high speed required to provide defence against bombers and cruise missiles. The Evolved F-111S proposal exploits this inherent capability to expand the utility of the F-111. Refer Parliamentary Submission entitled 'Evolving Force', C Kopp and A Cobb, October 2003 and 'Rationale'.

9 While the JSF is often loosely described as 'multi-role', its performance and avionics capabilities are mostly weighted to provide battlefield support capabilities for ground troops rather than capabilities to defeat opposing air superiority fighters, opposing bombers and provide long range strike. In US service, the JSF is planned to replace the AV-8B Harrier and A-10 Thunderbolt II, as well as F-16s and early model F/A-18s, all aircraft types used exclusively or mostly for supporting ground troops since 1995.

13 Endnotes

[1]URL: http://www.austrade.com/Overseas-Defence-capability-overview/default.aspx.

[2]The Soviet buildup commenced during the late 1970s, as a range of new military technologies were introduced. In part these included systems patterned after US designs introduced during the 1970s, and in part systems based on US technology acquired from Vietnam and Iran. Of significance is that the Soviets deployed hundreds of new generation Su-27 and MiG-29 fighters, S-300 Surface to Air Missile systems, new radar systems like the 64N6 series, and a wide range of land and naval warfare systems. The current buildup across Asia rivals the last decade of the Cold War in quantity, but exceeds it in quality.

[3]During the 1980s and 1990s Australia operated the F/A-18A and F-111C, while no regional nation operated comparable capabilities until the introduction of limited numbers of the MiG-29 Fulcrum, comparable to the F/A-18A. During the mid to late 1990s hundreds of Su-27 and Su-30 Flanker fighters were ordered across the region, with orders ongoing since.

[4] Hale provides an exhaustive survey and analysis in 'China's Growing Appetites', The National Interest, also see Kenny in 'China and the Competition for Oil and Gas in Asia', Asia-Pacific Review.

[5] This is the new 'Second Island Chain' strategy, which sees the PLA actively and if deemed necessary pre-emptively striking at any basing within the 'Second Island Chain' radius, which includes Northern Australia. Refer US DoD, Military Power of the People's Republic of China 2006, URL: http://www.ausairpower.net/China-Report-2006.pdf and Kopp C., People's Liberation Army Air Force and Naval Air Arm Air Base Infrastructure, http://www.ausairpower.net/APA-PLA-AFBs.html, January, 2007.

[6]Cliff R et al, *Entering the Dragon's Lair; Chinese Antiaccess Strategies and Their Implications for the United States*, MG524, RAND Corporation, Santa Monica, January, 2008, URL http://www.rand.org/pubs/monographs/2007/RAND_MG524.pdf.

[7] India's close relationship with the Soviet Union during the Cold War, and more recent disagreements with the United States over nuclear weapons policy, should be accepted as good indicators of India's independent pursuit of national goals.

[8] Refer
Kopp, Carlo, Goon, Peter A. Inquiry into Australian Defence Force Regional Air Superiority: Attaining Air Superiority in the Region, Submission, JSCFADT, 17th February, 2006,
URL: http://www.aph.gov.au/house/committee/jfadt/adfair/subs/sub20.pdf;
Kopp, Carlo, Goon, Peter A. Inquiry into Australia's Regional Strategic Defence Requirements: Meeting the Regional Challenge, Submission, JSCFADT, 13th April, 2006
URL: http://www.aph.gov.au/house/committee/jfadt/esstrends/subs/sub1.pdf;and
Kopp, Carlo, Goon, Peter A. Inquiry into Australia's Relationship with China: China's Rise as a Regional Superpower, Submission, SFADT , 10th April, 2005,
URL: http://www.aph.gov.au/senate/committee/fadt_ctte/china/submissions/sub39.pdf.

[9] The problem was caused by fuselage longerons which were manufactured below specification. Properly built this component has a life of 30,000 hrs, yet the defective examples have been shown to fail at around 20 percent of this usage.

[10]These undisputably radical changes in US military circumstance, and the inevitable consequences for US Defence contractors, should be properly seen as a warning sign that Australia's long-term support contracts through US Prime contractors may be impacted by unforeseen US policy decisions in reaction to major strategic events. A US contractor may be able to plead *force majeure* in legal terms, but it could leave Australia, having destroyed its Defence industrial base, in a highly vulnerable situation. No 'risk reduction' clauses in a contract can either foresee nor remedy such a possibility. In short, there is no substitute for local expertise and capabilities, and unquestioning reliance on overseas support represents a high strategic risk.

[11] The RAAF has previously been embarrassed by regional nations improving capabilities. One retired RAAF officer observed: "As for the Malaysians, I had the displeasure of being on the first dissimilar air combat meet shortly after they got their F-5Es - only 14 weeks after they had left for the States for conversion. We got waxed big time. At the time, we were experimenting with rudimentary jamming and chaff pods - which completely negated the radar and the Matra 530 [missile], so all they had to do was carry a jamming pod and hack us to pieces."

[12] Two considerations come into play. The first is that nations on the Asian continent are acquiring the strategic reach to hit targets in Australia by virtue of technological advancement. Another less visible development is the forging of new 'alliance of convenience' relationships, to gain basing access in South East Asia. An example of the latter is the Chinese 'Chain of Pearls' strategy, which has seen access gained to basing in Burma.

[13] It is known that the Australian DoD has used the baseline Su-27S/SK Flanker B as a measure of 'Flanker capability' in the region, despite this model having been largely superceded by more advanced variants. This is tantamount to using a 1939 Spitfire Mk.1 as a capability benchmark in 1945, by which time the Spitfire Mk.24 with around twice the engine power, a largely redesigned airframe and weapon system was being used. For all intents and purposes early Flankers share at best basic airframe design features and a name with current production variants.

[14] The overwhelming defeat of the Syrians in 1982 by Israel presents an interesting example, where the Israelis had a basic performance and capability advantage in the US supplied F-15 and F-16 fighters, further enhanced by Israeli electronic warfare equipment. The Israelis lost two aircraft in this conflict, the Syrians no less than 79. Where a large gap in fighter capabilities exists, disproportionate losses may be incurred by the inferior side.

[15] There are numerous public reports of ongoing Russian efforts to market the advanced Pero, BARS and Irbis E radars to China as block upgrades to the Su-27SK, Su-27SKM and Su-30MKK models operated by the PLA Air Force and Navy.

[16] The current state of the art in Russian electro-optical packages for fighters is the NII PP designed multispectral Optical Locator System (OLS) of MiG-35, which has a boresighted semiconductor pumped laser, thermal imaging and TV package, in a compact turret, with COTS processor technology. It is technologically comparable to the F-35 EOTS, including the use of sapphire window technology.

[17] Refer Kopp C, Bypassing the National Missile Defence System - The Cruise Missile Proliferation Problem, Asia Pacific Defence Reporter, 2005, URL: http://www.ausairpower.net/APA-Cruise-Missile-Proliferation.html.

[18] Much of the stealth capabilities seen in combat aircraft and missiles depends on a basic aspect of radio frequency physics. Where the wavelength of the radar is much shorter than the size of a shaping feature, it can be shaped to reflect energy away so that little is scattered back to the radar. This is why stealth aircraft display so many straight and aligned edges, flat surfaces, and shallow curvatures. Where the wavelength is comparable to or greater in size to the shaping feature, this mechanism breaks down. Russian industry has exploited this by re-engineering a generation of VHF band radars developed decades ago, enhancing them with digital processing and capable software.

[19] This discussion is scoped to cover air combat and strike capabilities and does not address other areas, such as airlift and maritime patrol, in detail.

[20] Please refer Annex A for detailed discussion.

[21] Russia intends to introduce both of these capabilities in the planned PAK-FA design.

[22] Refer previous endnote discussion of stealth and shaping.

[23] While a Sukhoi Flanker with a supercruise engine might match the F-22's supercruise speeds, it will burn considerably more fuel to do so as its aerodynamic design and external stores carriage are not optimised for this demanding flight regime.

[24] The significance of this is that the F-15 is the nearest equivalent to the Sukhoi Flanker, and thus similar results would occur were the F-22 pitted against numerically superior Flanker numbers.

[25] Refer C Kopp: Considerations on the Use of Airborne X-band Radar as a Microwave Directed-Energy Weapon, *Journal of Battlefield Technology*, vol 10, issue 3, Argos Press Pty Ltd, Australia, pp. 19-25.

[26] For all intents and purposes this is the same internal payload typically envisaged for the planned Joint Strike Fighter, which is a purpose designed bomber.

[27] The high power rating of the F-22's APG-77 radar makes it the most difficult US fighter radar to jam by opposing defences, and the radar's power also allows it to surveil or map ground targets from greater ranges than any other fighter radar.

[28] Refer David Jensen, Radar Transmitting Data, *Avionics Magazine*, August 1, 2006, URL: http://www.aviationtoday.com/av/categories/military/1056.html; Lynch D, Jr, and Kopp C, Multifunctional Radar Systems for Fighter Aircraft, Chapter 5, in Skolnik M, *Radar Handbook*, Third Edition by McGraw-Hill, 2008; and C. Kopp; *The properties of high capacity microwave airborne ad hoc networks*, Ph.D. dissertation, Monash University, Melbourne, Australia, October 2000.

[29] The ALR-94 is widely considered to be the most capable such system ever built, providing the F-22 with a significant and highly survivable electronic reconnaissance and defence suppression capability. Historically such capabilities were confined to specialised types such as the F-4G Wild Weasel equipped with the APR-38/45 passive detection system.

[30] This comparison applies also to the Joint Strike Fighter, which is being designed around the limited performance and speed capabilities of legacy fighters, specifically the F-16 and F/A-18.

[31] The 'LO/CLOEXCOM' protocol, detailed in a public study authored by then LtCol Matthew Molloy of the School of Advanced Air power Studies at the Air University at Maxwell AFB, published in June 2000, was described as a four step process:

1. An Integrated Product Team comprising Air Force, defense department and defense contractors examines export issues for a specific ally.
2. Integrated Product Team findings are then submitted to a Defense Department Tri-Service Committee for review.
3. The Integrated Product Team and Tri-Service Committee findings are submitted to the Low Observable Executive Committee (LOEXCOM) for review.
4. These findings are then submitted to the State Department for an Exception to National Disclosure Policy Committee review.

After the State Department has approved the export, the Foreign Military Sales [FMS] sales protocol would apply, which is that Congress must approve the sale."

Cited: "Air-exports with advanced or stealth technologies, such as are found on the F-22, require a specialized, component-by-component review as specified by export regulation. This process starts at the service level (in the F-22's case it would be the USAF) who will initiate an export feasibility evaluation through a four-step process. First, an "Integrated Product Team," consisting of members from the Air Force, DOD, and defense contractors, will be created to examine potential export issues specific to the aircraft under consideration. Next, the Product Team will notify the Tri-Service Committee on their findings. This committee reviews the weapon system and its technologies comparing them to the Critical Military Technologies List, the Low Observabilities (LO) List, and the Counter-LO List and then makes a decision whether the aircraft needs to be reviewed by the Low Observable Executive Committee (LOEXCOM), the third step in the process. For aircraft as advanced as the F-22 and JSF, LOEXCOM review is required."

"Once the weapon system has been approved by LOEXCOM for export, the review process moves to the State Department which forms an Exception to National Disclosure Policy Committee. This committee is comprised of the CIA, the NSA and other senior government representatives."

"After the State Department approves the export, state-to-state negotiations between the U.S. and the importing country may begin. Since the F-22 sale will be under the auspices of FMS, negotiations remain at the government level (including USAF inputs)."

U.S. MILITARY AIRCRAFT FOR SALE: CRAFTING AN F-22 EXPORT POLICY, Matthew H. Molloy, Lt Col, USAF,
URL: https://research.maxwell.af.mil/papers/ay2000/saas/molloy.pdf

[32] Persistent bombardment is also frequently termed 'loitering bombardment', or 'killbox interdiction'. The technique was originally developed by AVM P.J Criss, then a Wing Commander, at

82 WG Amberley, during the early 1980s, and then migrated to the US 48th TFW via an exchange officer.

[33] Given the range of the weapon used in 'stand-off persistent bombardment', tens of nautical miles of distance are readily achievable.

[34] The US Air Force are integrating and deploying thermal imaging targeting pods on both the B-52H and B-1B heavy bombers, and intend to integrate a variant of the JSF EOTS system on the B-2A. This is an unprcedented development as such optical targeting equipment was historically reserved for fighters.

[35] The 'Regional Denial Strategy' espoused in the Defence 2000 White Paper articulates the former model, the latter is a reflection of the evolving environment.

[36] A less apparent consequence of a large airframe is that it permits the installation of larger radar and optical sensor apertures, in turn improving the information gathering capability of the aircraft. Information gathering capability is the other important prerequisite for dealing with target mobility.

[37] The simple economic reality is that whenever a tanker is used to provide fuel, the fuel burned by the tanker has to be factored into the fuel burn expenditure of the operation. The greater the dependency on tanker aircraft, the greater the cumulative operational costs.

[38] Refer Kopp C, No Fuel, No Air Power, Defence Today, July, 2006, URL: http://www.ausairpower.net/DT-Fuels-06.pdf

[39] Refer Kopp C, No Fuel, No Air Power, Defence Today, July, 2006, URL: http://www.ausairpower.net/DT-Fuels-06.pdf

[40] Refer *U.S. Air Force White Paper on Long Range Bombers*, Department of the Air Force, March 1, 1999, http://www.af.mil/lib/bmap99.pdf i.e. 'USAF Bomber Roadmap Paper'. The US Air Force will make use of ≈180 mothballed B-52s to support a combat force of 44 B-52H aircraft - a large pool of mothballed airframes representing an important risk mitigator in the long term support of a 'legacy' aircraft.

[41] The recent US Quadrennial Defence Review mandated the introduction of a new strategic bomber by 2018, but ongoing funding problems present serious risks for this program.

[42] Providing a supersonic cruise capability would produce a large payback in survivability and sortie rates, refer John Stillion, David T. Orletsky, *Airbase Vulnerability to Conventional Cruise-missile and Ballistic-missile Attacks*, Project Air Force (U.S.), RAND Corporation, 1999.

[43] The applicable case study is the replacement of the US Navy F-14's TF30 engines with the current technology F110-GE-400 engine, common to the F-16 and some F-15 variants. This upgrade saw the aircraft's combat radius improve by 62 percent, and time to altitude reduced by 61 percent. These engines and their TF30 engine bay adaptor kits are now mothballed in the US. The US Air Force contracted engineering studies to modify the F-14's F110-GE-400 adaptor kit for the F-111 in 1992.

[44] The Aerospace Maintenance and Regeneration Center (AMARC) is the US storage facility for mothballed military aircraft, located at Davis Montham AFB in Arizona. The most recent publicly

available inventory summary indicates a total of ≈250 airframes of the following variants: F-111A - 8 airframes; EF-111A - 33 airframes; F-111D - 52 airframes; F-111E - 65 airframes; F-111F - 76 airframes; F-111G - 15 airframes; FB-111A - 15 airframes.

[45] The 'generational' nomenclature for describing fighter aircraft is often interpreted very broadly - both the F-22A and F-35 are frequently labelled in either category. In terms of a generational 'jump' only the F-22A truly qualifies as a 'fifth' generation fighter as it incorporates sustained supersonic cruise, genuine all aspect stealth and integrated avionics. No other aircraft qualifies in all three categories.

[46]ISONET Report on 'Impacts of New and Retained Business in the Australian Manufacturing Sector', June 2001 identifies a 'whole of economy' contribution through value addition and economic multiplication (flow on) effects of 179.2%.

[47] Refer Defence White paper 2000, Section 9.8. More specifically, the nature of the incremental upgrades to the F-111 would provide high value added domestic work content, in key technology areas such as software, system integration, composite manufacture, advanced radar algorithms, advanced imaging technology, and long range datalink technology. This contracts with the low value added assembly of imported components and incidental component manufacture characteristic of a 'traditional' imported fighter program.

[48] Defence 2000 White Paper Section 10.15 - 'Advanced information and integration technologies provide the ability to upgrade combat capability rapidly. This is particularly the case for our aircraft and ships. Since we operate some platforms that are unique to Australia - such as the Collins class submarines and F-111 aircraft - we need to have available the science and technology skills to support upgrades'.

[49] The four innovative proposals were developed as unsolicited proposals from Industry (UPIs) in line with the UPI Policy announced by the Minister for Defence in June 2001 and endorsed by Cabinet in October of that year. These UPIs were submitted in accordance with the guidance provided in the 'Process for Handling Unsolicited Proposals from Industry', dated 20 June 2001, and that contained in Section 4.4 of the 'Capability Life Cycle Management Guide', dated December 2001. These included the provision of Innovation Evaluation Models (IEM) covering, inter alia, the intellectual property matters and the relationships with existing projects in the Defence Capability Plan. They were submitted to USDM in accordance with the requirements of the 'Capability Life Cycle Management Guide'.

[50] Refer to 'Report to the Minister for Defence on the Collins Class Submarine and Related Matters', MacIntosh/Prescott, June 1999 - Recommendations (pp 33) and discussion on DSTO 'virtual submarine' model (pp 22 et al).

[51] Cost As an Independent Variable (CAIV) is one of the primary drivers of the JSF program. Definition - CAIV methodologies are used to acquire and operate affordable DoD systems by setting aggressive, achievable life-cycle cost objectives, and managing achievement of these objectives by trading off performance and schedule, as necessary. Cost objectives balance mission needs with projected out-year resources, taking into account anticipated process improvements in both DoD and industry. (US DoD Acquisition Reform Program Glossary).

[52] The scoring method used is in mathematical terms 'ordinal', in that it ranks outcomes, and

this method clearly favours the legacy F-35 Joint Strike Fighter and F/A-18F Super Hornet plan, as it conceals the extent of the capability advantages offered by the F-22A and Evolved F-111 Force Mix proposal.

[53] The public debate on future RAAF capabilities has frequently included claims by Defence that the new AESA radars on the F-35 Joint Strike Fighter will address this capability need. Unfortunately, these radars can be used to only jam radars operating at similar X-band frequencies, such as other fighter radars and some missile engagement radars. The majority of threat radars operate at radio frequencies sufficiently different that the AESA would be ineffective. Indeed, the US would not have invested tens of billions over decades into wideband jamming suites such as the AN/ALQ-99 used in the EA-6B Prowler, EF-111A Raven, and F/A-18G Growler were this the case. The erroneous claims made by Defence on the issue of AESA jamming suggest that the physics of radar are not well understood by the parties making these claims. For a more detailed technical discussion, refer Lynch D, Jr, and Kopp C, Multifunctional Radar Systems for Fighter Aircraft, Chapter 5, in Skolnik M, *Radar Handbook, Third Edition* by McGraw-Hill, 2008.

[54] While modern anti-ship missile defence systems can be highly effective against small numbers of subsonic or supersonic anti-ship cruise missiles, they are all limited in how many inbound missiles they can engage and destroy concurrently. Accordingly, the Soviets developed a tactic during the Cold War based on saturating a warship's defences with more cruise missiles than the system could defend against. This tactic has been actively exported in Asia and is detailed in contemporary Russian marketing materials.

[55] Another consideration is that the US have suffered an ongoing shortage of such aircraft ever since the EF-111A fleet was mothballed, making such aircraft a high value non-lethal contribution to any future coalition operation with the United States.

[56] Refer C Kopp: *A strategic tanker/transport force for the ADF*, Paper Number 82, Air Power Studies Centre Monograph, Air Power Studies Centre, Fairbairn, ACT.

[57] For a more comprehensive discussion refer Kopp C, Hardening RAAF Air Base Infrastructure, *Air Power Australia Analyses* journal, Vol.5 No.2, URL: http://www.ausairpower.net/APA-2008-02.html.

[58] Refer Kopp C, No Fuel, No Air Power, Defence Today, July, 2006, URL: http://www.ausairpower.net/DT-Fuels-06.pdf. This paper also addresses the issue of strategic supply of aviation fuels.

14 Revision Status

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Revision History

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1	May 26 2002	Evolved-F-111-DP.pdf	Initial Document
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3	June 7 2002	Evolved-F-111-DP-V.3.pdf	Revised
4	April 7 2003	Evolved-F-111-DP-V.4.pdf	Revised
5	February 11 2008	Evolved-F-111-DP-V.5.pdf	Revised and expanded

Table 4: