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A Big Deal:

Australia's future air combat capability

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An ASPI policy report

ASPI
AUSTRALIAN STRATEGIC POLICY INSTITUTE

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X-35 Joint Strike Fighter. © Lockheed Martin.

Director's introduction

Australia is in the market for a new fleet of fighter aircraft. Financially and strategically, this is a big deal.

Financially, it will be the most expensive purchase ever made by the Commonwealth. Even allowing for inflation, it will be bigger than any Defence deal in decades. On current estimates, our new fighters will cost each Australian an average of $800 or $3,200 for a family of four.

Strategically, the new fighters will profoundly affect Australia's military strength. Their capabilities will be the single most important factor in determining our capacity to defend our continent from conventional threats, and they will be a key element of our ability to project strategic influence in our region.

Whatever choice we make will shape our capabilities for decades to come, for better or for worse. The right decision will do much to establish Australia's military security and strategic weight over the first half of the new century. Equally, the wrong decision could hamstring our defence—not just in the air but everywhere else as well—throughout the unpredictable and potentially dangerous decades ahead.

Decisions need to be made soon. Under current plans, the F/A-18 and F-111 aircraft that we need to replace will start to leave service in 2010. We have only a couple of years to make up our minds about the new fighter.

The Australian Government has taken an unusual approach to this decision. In 2002, it aborted the usual protracted Defence procurement process and announced a disposition to buy an American plane that is still under development—the Joint Strike Fighter (JSF). Other contenders have been told not to bother bidding.

But the government has given no firmer commitment to buy the JSF, so this is far from the end of the story. The aircraft itself is still taking shape. Key issues—including how much it will cost, how good it will be, and when it could be delivered—are still up in the air. Key decisions have yet to be made before the choice is locked in. And the decision to favour the JSF was made with no very comprehensive analysis of Australia's needs and of the various options for meeting them. Whichever approach is taken, many risks must be managed.

This ASPI policy report on the development of our new fighter capability aims to help Australians understand the choices we have to make, the issues we need to consider, the options open to us, and the risks we might face. We do not advocate any particular option. But we do make some recommendations about how the government might proceed.

This is the first time that ASPI has offered this kind of comprehensive analysis of a major defence capability issue. Deciding to buy a new fighter, or a new class of destroyers, is very important to Australia's security, and costs a lot of money. The choices seem hard for non-specialists to understand. The arguments can be esoteric, the technology is daunting, and the vocabulary is often baffling, and so major decisions are often made with little public comprehension and engagement.

Our aim has been to help by explaining the key issues as simply as possible and with a minimum of jargon. If we have succeeded, we will do the same for other major capability choices, such as the new air warfare destroyer.

This paper has benefited from the contributions of a number of experts in the complex and arcane world of air power. They include Mark Jansen, Greg Hewson, John Cashen and Christian Durant from Booz Allen Hamilton, Air Vice Marshal Brian Weston (Rtd), Australian Business Limited and Gregor Ferguson.

The paper has been prepared with great flair by ASPI's Program Manager for Operations and Capability, Aldo Borgu. I thank him for his efforts.

Of course, none of our contributors will necessarily agree with everything in this report. Nor does it reflect the corporate views of ASPI as an institution. Responsibility for what follows rests directly with Mr Borgu, and with me.

Hugh White
Director
ASPI

Executive summary

Over the past two decades, the RAAF's F/A-18 and F-111 aircraft have provided Australia with potent air combat and strike capabilities. However, the cost of keeping both fleets operating has risen substantially while their effectiveness in the twenty-first century regional threat environment has diminished.

To maintain Australian Defence Force (ADF) capability consistent with government requirements, Project Air 6000 was scheduled to deliver a new air combat capability of up to 100 new aircraft from 2012 onwards, at a total cost of $16 billion.

The project's scope and timing are driven by the need for the new aircraft to enter operational service progressively as Australia's thirty-three F-111 and seventy-one F/A-18 aircraft are withdrawn from service, in 2010 and 2012–15 respectively.

On 27 June 2002, Defence Minister Robert Hill announced Australia's intention to participate in the United States F-35 Joint Strike Fighter (JSF) System Development and Demonstration at an initial cost of some $300 million. He went on to declare that the JSF 'is the aircraft for us in the future'. Project Air 6000 was subsequently renamed the New Air Combat Capability Project.

When announcing the JSF decision, the minister stated that Australia is looking for 'a capability equivalent of 100 aircraft'. Future budgetary restrictions may lead to the purchase of fewer aircraft, particularly if the government believes that advances in information technology can deliver the same capability from 60–70 fighters. It would be premature to make arbitrary decisions on future fleet sizes but cuts of this nature would have considerable implications for the maintenance of our regional capability edge. At this stage the commitment to buy around 100 aircraft should be maintained.

Whether the 'fifth generation' JSF might achieve the government's air combat requirements is determined by complex interrelationships between key factors, such as the future threat environment, JSF weapon system characteristics, supporting and enabling ADF combat capabilities, F/A-18 and F-111 obsolescence, economic considerations, and time. Unfortunately, much about these factors remains uncertain, including the final performance characteristics of the JSF and the immediate future of the F/A-18 and F-111.

The government's strategic intent is to maintain ADF air combat capability qualitatively comparable to any in our region, and with a sufficient margin of superiority to make combat success probable. The most potent threat facing the RAAF and allied regional air forces is likely to come from variants of the Russian MiG-29 Fulcrum and Su-27/30 (Sukhoi) Flanker. These are big, fast, highly manoeuvrable fighters with excellent air-to-air missiles. They are formidable opponents in visual-range dogfights. They are now entering service with a number of countries in the region.

Indonesia's acquisition of Sukhoi fighters will represent a big step from its current generation of fighters. Whether this is a real erosion of Australia's capability edge will depend on whether Indonesia: acquires the intended forty-eight Sukhois; equips the aircraft with the latest Russian air-to-air and air-to-surface missiles; develops supporting and enabling capabilities such as AEW&C and AAR; develops the industry and expertise to support the aircraft in-country; and maintains adequate funding for logistics support and pilot training.

Other capabilities such as air-to-air refuelling (AAR) and airborne early warning and control (AEW&C), larger numbers of fighter aircraft, and better training and logistic support give Australia the edge over most countries in the immediate neighbourhood. The acquisition of JSF should also return to Australia a qualitative advantage in the fighter platform. However, it remains likely that the F/A-18s will have to undergo a further upgrade in structure, avionics and weapons before their retirement in order to remain competitive through to 2015 and perhaps beyond.

The entry into service of Australia's new air combat capability is based on the planned withdrawal from operational service of the F-111 (around 2010) and the F/A-18 (between 2012 and 2015). The withdrawal of the F-111 from service is highly dependent on successful upgrades to the F/A-18. If the F/A-18 upgrades run into trouble, we could face a serious strike capability gap. Therefore, the RAAF needs to develop contingency plans to keep the F-111s in service until at least 2015 if the F/A-18 upgrades don't deliver the expected level of capability.

If the JSF is late, as is usual for new aircraft development programs, Defence will also need to have detailed contingency plans for maintaining Australia's air combat capabilities. If the government needs to extend the life of the F/A-18s, it would need to undertake centre fuselage ('centre-barrel') replacement on at least 40–50 of them. A second option would be to buy an 'interim' platform under the New Air Combat Capability Project. A third option would be to seek the loan or lease of an interim aircraft until the JSF enters service. In the event of delays, the transition between whatever aircraft Australia is operating at the time and the F-35 will have to be carefully planned and managed. Once we have defined our air combat requirements Australia will need to develop a fighter transition plan that ensures there will be no significant or unacceptable capability gap.

In effect, the JSF is still a 'paper plane'. The first production aircraft won't fly until at least 2006 and full production is expected to be reached only in 2008. Arguably, if the JSF delivers everything that has been promised by Lockheed Martin and the Australian and US governments, it will prove to be the best available replacement aircraft for our purposes. It remains to be seen, however, how much of what has been promised by the JSF in terms of its stealth, sensors, cost, general capability, reliability and supportability might be lost in the delivery, and to what degree this will undermine the original effective decision to acquire it. The JSF's Critical Design Review, which will finalise the design of the aircraft and detail progress with ongoing risks, will be an important milestone to monitor in April 2004.

Assuming similar standards of supporting capabilities and weapon systems, it is likely that the JSF will be superior in beyond-visual-range air combat to fourth generation fighters such as the Eurofighter, Rafale and Su-27/30. However, despite its advanced technology the JSF is not optimised for the within-visual-range combat environment, and highly capable fourth generation fighters will pose a significant threat. If the JSF is to use its full stealth advantage over other aircraft and rely on external sensors, it would be even more dependent on systems such as AEW&C aircraft than the F/A-18 is. So the government should exercise its option of buying two more AEW&C aircraft.

The JSF is expected to achieve an 'availability rate' substantially higher than the F-111. The JSF will have far superior sensors and, while the new fighter cannot match the range of the F-111, the Air-to-Air Refuelling project will deliver more capable AAR aircraft to support JSF operations. However, the number of air-to-air refuelling aircraft should be increased to at least six or seven in order to ensure that there is no substantial gap in strike capability once the JSF enters service. Analysis is also required to determine the best balance between the JSF and other ADF air defence projects (land and sea) and what, if any, trade-offs might be made between them.

Risk management is one of the many critical tasks that Defence undertakes within the New Air Combat Capability Project. However, risk mitigation strategies have no public visibility. Until they do, doubts will arise about Defence's ability to manage the project appropriately.

Defence argues that the JSF is the best aircraft to meet the ADF's capability requirements, but the department needs to specify, publicly and in detail, those capabilities of the fighter that make it the preferred choice. A baseline definition is needed now: as the development of the aircraft continues and perhaps as its final performance specifications change, this will allow continuing assessment of the appropriateness of the decision to buy it.

If JSF development does not meet our requirements, Defence does not seem to have any contingency plan other than restarting the capability selection process halted by the JSF decision. When Defence selects a winning tender, normal departmental procurement practice is to have a second-place tender 'on hold', to be called on if the original tenderer falters in negotiations or fails to meet ADF requirements for whatever reason. This principle should also apply to the JSF deal.

To keep JSF costs down and the program on schedule, the US has been progressively narrowing the types of weapons the aircraft can carry when it enters service in 2012. While the JSFs available to Australia in 2012 will have a useful range of air-to-air and air-to-surface weapons, they will lack a stand-off weapon and a dedicated anti-ship weapon. These two gaps need to be addressed. Defence also needs to ensure than any new weapons integrated onto the F/A-18 platform can also be carried by the F-35.

To achieve the best deal on the JSF, we should aim to source our fighters from a mature production run. It is also important that we understand clearly what the baseline conventional variant delivers and what the non-aircraft 'extras' will cost, including training, simulators, spares and logistics, special test equipment, and manuals. Continuing software support, including an in-country support capability, will be a big cost.

Australia cannot influence the ultimate performance of the JSF, but we must be aware of likely warning signs. This program has, from the beginning, been driven by costs and not by requirements. As the design of the fighter matures, user interest will grow, and with it the desire for more capability, resulting in aircraft weight gains. Any increase in weight without a commensurate increase in thrust will erode combat performance. To meet overall weight targets, it is possible that some capabilities of the JSF will have to be removed or degraded.

The JSF's Program Design Review in March 2003 highlighted the ongoing risk involved in a tremendously large and complex software development program. Another substantial area of risk is the fusion and integration of the aircraft's on-board sensors. Both these risk areas were highlighted by Pentagon and Lockheed Martin officials during their briefings on the JSF in Australia mid 2002. Both risk areas were also important problem areas in other Defence procurements, such as those of the Collins Class submarines, the Jindalee Operational Radar Network and the Super Seasprite naval helicopter.

One of the more significant lessons from Australia's experience with the F/A-18 program arose from the unsatisfactory handling of technology transfer from the US, and of intellectual property issues. While it is in the interests of the US to maintain common systems and aircraft with its allies, there is no doubt that Australia will ultimately receive an export version of the F-35. What remains unknown is how the capability and performance of the export version will differ from those of its US counterpart and what technology the US will be willing to transfer to Australia. Defence needs to determine the level and type of technology transfer necessary to operate and support the JSF, and government needs to ensure that we get it.

Australia's decision to participate in the JSF project is also motivated by the opportunity to develop Australia's aerospace industry. However, having Australian firms supplying individual components as part of a global supply chain is no substitute for an active Australian industry involvement program that will build the ability to support the aircraft once it enters service. And in modern strike/fighter aircraft, the mission and software systems have become more important than the airframe, propulsion and flight systems.

To date, twelve Australian firms have received work in the JSF System Development and Demonstration phase. The total value of these contracts is unknown. In cooperation with industry, Defence should specify the size, nature and quality of work that we expect. In dealing with Lockheed Martin and the Pentagon, greater Australian cooperation with other international JSF partners also needs to be developed. The focus should be on developing the infrastructure and expertise we need to support the aircraft once they enter ADF service.

One of the stated intentions behind the JSF program is to lower operational costs through increased reliability. Defence should not rely on estimates that the JSF will require less in-country logistics support as a rationale for not developing the ability to sustain the aircraft within Australia. Two issues stand out: software support; and the measures required to maintain the fighter's stealth capabilities.

The government is also attempting to establish Australia as the regional service hub for the F-35. Given that we are the only Asia–Pacific partner in the JSF System Development and Demonstration phase, there should be no regional competition for the role. A major issue will be how the US determines its global support requirements and whether US aircraft would, in fact, be serviced overseas. Australia is geographically remote, and it could make more economic sense for any JSF aircraft sold to or stationed in Korea or Japan to return to the continental US rather than fly a longer 15-hour flight to Australia.

Complete Australian self-sufficiency over the life of the aircraft is neither feasible nor desirable, but a balance will need to be struck between cost and strategic support requirements. Defence needs to make a realistic assessment of the type of logistic support we truly require in Australia to maintain and upgrade the JSF, how much it is likely to cost, and the ability of Australian industry to supply it.

Recommendations

The Government should:

1. Maintain the commitment to purchase around 100 new combat aircraft to replace the F/A-18 and F-111.
2. Plan on the basis that the F/A-18s will have to undergo a further upgrade in structure, avionics and weapons before their retirement to remain competitive through to 2015 and possibly beyond.
3. Develop contingency plans to keep the F-111s in service until at least 2015 if the planned upgrades to the F/A-18s don't deliver the expected level of capability.
4. Develop contingency plans that ensure no significant or unacceptable gap in air combat capability in the event that the JSF slips behind schedule.
5. Exercise the option of purchasing a further two AEW&C aircraft so that the JSF can fully utilise its stealth advantage over other aircraft.
6. Increase the number of AAR aircraft to allow a total fleet of at least 6–7 aircraft to ensure there is no substantial gap in strike capability once the JSF enters service.
7. Determine the best balance between the JSF and other ADF air defence projects (land and sea) to determine what, if any, trade-offs can be made between them.
8. Give greater public visibility of Defence's JSF risk mitigation strategies.
9. Make an annual report to the Australian Parliament updating progress in developing this capability. The report should cover how Australia is responding to the various elements of risk and opportunity outlined in our study.
10. Specify in detail the ADF requirements and capabilities of the JSF that make it the preferred solution for Australia's new air combat capability, particularly against other contenders.

11. Apply normal Defence procurement practice to have a second place tender on stand-by to call on should the JSF negotiations falter.
12. Address the issue of equipping the JSF with a stand-off weapon and a dedicated anti-ship weapon as soon as feasible. Furthermore any new weapons integrated on the F/A-18 over the next 10 years should also be able to be carried by the JSF.
13. Aim to enter a JSF production run operating at full capacity. It is also important that we understand clearly what the baseline conventional variant delivers and what the non-aircraft "extras" will cost.
14. Determine the level and type of technology transfer we require from the US to operate and support the JSF once it enters ADF service and ensure we get it.
15. Specify—in cooperation with industry—the size, nature and quality of work that we expect from the JSF program. Greater Australian cooperation with other international JSF partners also needs to be developed in dealing with Lockheed Martin and the Pentagon.
16. Ensure that the policy of having Australian firms supplying individual components as part of a global supply chain is not a substitute for the development of an active Australian industry involvement program.
17. Develop an Australian Industry Involvement program for the JSF that focuses on building the infrastructure and expertise needed to support the aircraft once they enter into ADF service. Particular emphasis should be placed on the mission and software systems rather than just the airframe, propulsion and flight systems.
18. Make a realistic assessment on what sort of logistic support we require in Australia to maintain and upgrade the JSF, how much that is likely to cost and the capabilities of Australian industry to do so and strike a balance between all three. Two issues stand out for specific attention: software support; and maintaining the stealth capabilities of the JSF.

Chapter 1

INTRODUCTION

The 2000 Defence White Paper states that air combat is the most important single capability for the defence of Australia. Over the past two decades, the RAAF's F/A-18 and F-111 aircraft have provided Australia with potent air combat and strike capabilities. However, the cost of keeping both fleets operating has risen substantially while their effectiveness in the twenty-first century regional threat environment has diminished.

To maintain Australian Defence Force (ADF) capability at a level consistent with government requirements, Project Air 6000 (since renamed the New Air Combat Capability Project, or NACC) was scheduled to deliver a new air combat capability of up to 100 aircraft from 2012 onwards.

NACC is a phased project to acquire the capability to fulfil operational requirements for air combat and strike, until about 2040. The project is not only about the acquisition of new aircraft. It is about a total combat system using new technologies, especially in avionics, sensors, stealth, weapons, communications and data processing. It also involves a consideration of the emerging role for uninhabited aerial vehicles (UAVs), uninhabited combat aerial vehicles (UCAVs), long-range missiles launched from non-fast jet platforms, and other technological developments to ensure that the project provides a total, credible and affordable air combat capability, fully integrated with other ADF combat capabilities.

Surprises are not necessarily bad. Australia's participation in the JSF SDD phase may provide a substantial boost to the Australian aerospace industry...

The project's scope and timing are driven by the need for the new aircraft to enter operational service progressively as Australia's thirty-three F-111 and seventy-one F/A-18 aircraft are withdrawn from service, in 2010 and 2012–15 respectively. As it now stands, NACC is to be conducted in three phases:

- The first phase envisages a decision in 2006–07, with an in-service date of 2012–14 and a value of more than $4.5–6 billion, to procure up to forty new aircraft as the first F/A-18s are replaced. These aircraft are primarily intended to provide air control capability, but will also fulfil strike, offensive support and other roles.
- The second phase envisages a decision in 2010–2013, with an in-service date of 2015–17 and a value of between $4.5 billion and $6 billion, to procure up to thirty-five new aircraft to replace the remaining F/A-18s in service.
- The third phase envisages a decision in 2014–2017, with an in-service date of 2018–2020, and a value of between $2.5 billion and $3.5 billion, to procure up to twenty-five new aircraft to replace the F-111s in service. These aircraft are primarily intended to provide the strike capability.

These phases form the most expensive acquisition program ever undertaken by Defence, with an estimated cost of $12–16 billion. Until mid-2002 the project was in an early stage of

Defence Minister Robert Hill signing a ministerial exchange of letters for the Joint Strike Fighter Program with US Defence Secretary Donald Rumsfeld, 30 October 2002. © Defence Department.

study, defining requirements and assessing generic options that might satisfy government capability requirements, rather than determining specific platform or weapon solutions.

On 27 June 2002, the Project Air 6000 approach was dramatically altered. First, Defence Minister Robert Hill announced Australia's intention to participate in the United States F-35 Joint Strike Fighter (JSF) System Development and Demonstration (SDD) program at an estimated cost of $300 million. This announcement was expected in some quarters. However, the minister then went on to declare that the JSF 'is the aircraft for us in the future'. The declaration effectively ended the options studies phase of the project, removed the probability of marketplace competition and placed an immediate, and unexpected, emphasis on a single-platform solution. To reflect the JSF decision, Project Air 6000 was subsequently renamed the NACC Project. In November 2003, while releasing the government's Defence Capability Review, the minister also stated 'we are on the path towards the Joint Strike Fighter which will be our principal combat aircraft in due course'.

Surprises are not necessarily bad. Australia's participation in the JSF SDD phase may provide a substantial boost to the Australian aerospace industry and allow the NACC team, as a program participant, to gain a privileged view of JSF characteristics. Although the final NACC acquisition decision will not be made until about 2006 and contracts signed by 2008, the minister made it quite clear that JSF was the expected outcome and that 'it would be unfair to competitors to hold out a carrot that I don't think is really there'.

While the final characteristics and capabilities of the JSF and ADF NACC requirements remain unclear, the government remains confident that JSF will meet the ADF's capability requirements.

The purpose of this policy report is to test the validity of that confidence and provide some suggestions about how it might be sustained.

Fighter generations

Fighter capabilities are frequently addressed in terms of 'generations', which consist of groups of fighters of similar capabilities. The divisions between groups are marked by substantial advances in aerospace technology and capability.

The ***first generation*** started with the World War I fighter and spanned the evolution of wood and fabric biplane fighters into the streamlined, high-performance, all-metal, monoplane fighters of World War II, such as the Supermarine Spitfire and North American Mustang.

The ***second generation*** began with the technological breakthrough of the jet engine, and included swept-wing jet fighters such as the North American Sabre, the Hawker Hunter and the MiG-15/17. It closed with such aircraft as the American 'Century Series' fighters (F-100, F-104, F-105), Dassault Mirage III and MiG-21.

The ***third generation*** was marked by the rediscovery of the need for agility, as a consequence of the difficulties United States fighters experienced in the air over North Vietnam. Pilots were again provided with bubble canopies and fighters were refitted with guns. Aerodynamic advances and digital technology significantly enhanced fighter manoeuvrability. The third generation bred the American 'Teen series' (F-14, F-15, F-16 and F/A-18) and the Dassault Mirage 2000.

The ***fourth generation*** saw a further advance in fighter manoeuvrability and the wider use of digital technology, both in weapons systems and in flight control systems. Software integration became a very serious issue. The Eurofighter, the Rafale and the Sukhoi Su-30 family are typical of the fourth generation, although with the passage of time aviation historians will likely group the third and fourth generations together.

The ***fifth generation*** is defined by low observable technology and the enormous tactical advantage stealth confers. The generation comprises the F/A-22, the F-35 JSF, and perhaps the Chinese XXJ and the Next Generation Russian fighter.

Advancing unmanned platform technology suggests that there might not be a ***sixth generation*** manned fighter: only time and the lessons of operational experience will tell.

Three generations of Australian fighter aircraft: Sabre, Mirage and Hornet over Stockton Beach.

Chapter 2

THE CAPABILITY REQUIREMENT

When he announced the JSF decision, the Defence Minister stated that the government made the decision on the 'basis of advice from the Air Force that they believe it will meet the capability requirements that we are seeking through their [Air] 6000 project'. The minister went on to say that the RAAF had advised government that there was really 'no choice', because the JSF is the only aircraft to meet ADF requirements.

At the time, the Chief of Air Force stated that the JSF was chosen on the basis of:

- its status as a fifth generation aircraft, and therefore a 'capability of the future'
- its cost, which was 'relatively affordable compared to others'
- its stealth characteristics
- its ability to connect into a network-enabled warfare environment
- its capabilities in the air control role and its ability to conduct strike operations.

Before this decision, the Australian Government had specified broad strategic requirements for NACC capability in the Defence 2000 White Paper. In essence, the NACC combat capability must be at a level at least qualitatively comparable to any in the region, and with a sufficient margin of superiority to provide an acceptable likelihood of success in combat. The government's aim in the development of our strike capability is to ensure that we can attack military targets within a wide radius of Australia, against credible levels of air defences, at an acceptably low level of risk to aircraft and aircrew.

Whether the 'fifth generation' JSF might achieve the government's air combat requirements is determined by complex interrelationships between key factors, such as the future threat environment, JSF weapon system characteristics, supporting and enabling ADF combat capabilities, F/A-18 and F-111 obsolescence, economic considerations, and time. Unfortunately, much about these factors remains uncertain, including the final performance characteristics of the JSF and the immediate future of the F/A-18 and F-111.

Whether the 'fifth generation' JSF might achieve the government's air combat requirements is determined by complex interrelationships between key factors … unfortunately, much about these factors remains uncertain.

Starting at the top: government guidance

The need for NACC is born of government's two key strategies: defending Australia's air and sea approaches, and responding effectively to any armed incursion into Australian territory. But there is also an ever-increasing priority placed by the government on ADF contributions to US-led operations in support of Australia's wider interests, and on interoperability with US forces.

It would be ambitious to guess Defence's specific requirements for NACC, which have yet to be made public. However, any new air combat capability will need to fulfil the following broad core air power roles.

- **Air control** is the primary air power role, aimed at achieving control of the air. It can be defensive or offensive and involve airborne and/or ground and sea based assets.
- **Strike** is the ability to use the air power to destroy or neutralise targets and to undermine the enemy's will to fight. Precision strike includes land strike, maritime strike, interdiction and offensive air support.

Air control

Australia's air control capability is based on our fleet of seventy-one F/A-18 aircraft. The fighters are supported by other systems, including air-to-air refuelling (AAR), an integrated command and communications system, and surveillance and command systems such as the over-the-horizon Jindalee Operational Radar Network (JORN) and airborne early warning and control (AEW&C) aircraft. The F-111s also have some limited air-to-air combat capabilities. Australia's broader air defence system also includes ground-based air defence systems operated by the Army and naval air defence systems based on the Navy's surface combatants.

Unlike the government's capability goal for land forces, which states that the Army will be structured to sustain a brigade deployed for extended periods while maintaining a battalion group for deployment elsewhere, the aim for air control is more general. The Air Force is to maintain capability:

- at a level at least comparable qualitatively to any in the region, and with a sufficient margin of superiority to provide an acceptable likelihood of success in combat

- large enough to provide a high level of confidence that we could defeat any credible air attack on Australia or in our approaches
- capable enough to provide options to deploy an air combat capability to support a regional coalition
- with the capacity to provide air defence and support for deployed ground and maritime forces in our immediate region.

Modern air control may take place within-visual-range or beyond-visual-range and Australia's future air combat aircraft must be able to operate in both environments:

- **Within visual range (WVR)**—air-to-air engagements that generally take place within the range of human eyesight, typically within 10 nautical miles (nm). WVR combat is often characterised by high-stress flying manoeuvres (dogfighting) using all available weapons and appropriate countermeasures to defeat the threat.
- **Beyond visual range (BVR)**—air-to-air combat that takes place outside visual range, typically beyond 10 nm. Early detection is critical to success in BVR combat, and is a function of the stealth characteristics, electronic warfare systems and sensor performance of the aircraft, as well as the sensor performance of supporting systems and the ability to provide this data to the pilot. BVR combat is founded on the principle of 'who sees first, shoots first'. With modern, radar-guided air-to-air missiles, BVR combat is possible at ranges greater than 40 nm.

Most experts believe that future air combat will mainly be fought beyond visual range. This is not only because of developments in stealth, sensor and weapons technologies: it is also based on the desire and ability to avoid the highly lethal WVR environment, in which technical advantages in radar and stealth are less pronounced where less sophisticated opponents are likely to achieve greater success.

The increased lethality of WVR combat has been due to the development of helmet-mounted sights (HMSs), which allow for a pilot's helmet to incorporate a heads-up display to cue weapons and sensors to the target, and high 'off-boresight' WVR missiles. In past WVR combat, pilots had to align their aircraft or radar to shoot at a target, but HMSs allow them to use their helmets to simply look and shoot. The HMS also displays aircraft performance information, enabling pilots to monitor it without interrupting the field of view. Modern high off-boresight WVR missiles can be targeted in an envelope typically greater than 60 degrees from the straight (boresight) axis of the aircraft.

Some distinctions between WVR and BVR environments are becoming increasingly blurred, particularly with the improved performance of WVR missiles providing ranges beyond 10nm, into the BVR environment. In the longer term, BVR missiles can be expected to develop greater speeds (more than mach 5), increased ranges and greater lethality. While the Air Force's preference will be to conduct air combat at BVR, we still need our future combat aircraft to retain a WVR capability. Factors including loss of situational awareness, Rules of Engagement identification criteria or operational necessity will continue to drive pilots to WVR engagements.

F/A-18 head up display with F/A-18 in sight.
© Defence Department.

Strike

Australia has maintained a specialised fast-jet strike capability since the early 1970s. Strike operations can be conducted by F/A-18 and P-3C aircraft, surface ships and submarines, and Special Forces, but our current specialised strike capability consists mainly of some twenty-eight F-111 aircraft (plus five in long-term storage).

The government's Defence White Paper calls for the maintenance of a strike capability that ensures we have:

- the capability to contribute to the defence of Australia by attacking military targets within a wide radius of Australia, against credible levels of air defences, at an acceptably low level of risk to aircraft and crew
- a capability focused on an ability to attack those militarily significant targets that might be used to mount or support an attack against Australia—we do not intend to seek a strike capability large enough to conduct sustained attacks on an adversary's wider civil infrastructure
- the capacity to mount sustained strike campaigns against a significant number of military targets, as well as the capacity to strike targets with sufficient accuracy to minimise the risk of collateral damage
- the ability to provide options to contribute to regional coalitions against more capable adversaries at acceptable levels of risk to crew and aircraft.

It's unlikely that there will be any comparable specialised strike with the range and payload capacity of the F-111. However, there is a range of alternatives that may fulfil part or all of Australia's future strike requirement:

- specialised strike versions of aircraft purchased to replace the F/A-18s
- multi-role strike fighter aircraft, such as the JSF, equipped with appropriate weapons
- long-range missiles fired from non-fast jet aircraft
- naval platforms, such as the new air warfare destroyers and/or submarines using land attack cruise missiles
- unmanned combat aerial vehicles
- some combination of these.

An important consideration to bear in mind is that we need to be able to strike not only targets on land but also naval ships at sea and targets in the littoral area. And attacking land targets doesn't involve only strike missions: it also covers close air support, which is air force support of friendly ground forces, usually against targets close to those ground forces. While in Australia the strike role has mainly been undertaken by the F-111s (backed up by F/A-18s and P-3Cs), the close air support role has more often been filled by the F/A-18s (backed up by the F-111s and armed helicopters).

Other requirements

Within the broad requirements set out above are a number of other, more specific—but not necessarily specified—requirements. These include range, payload, overall numbers, cost, weapons and sensors, stealth capabilities, and industry and support issues. All these factors can be expected to influence the nature of the future air combat capability.

Range and payload

One of the more fundamental measures of the effectiveness of an air combat system is the range–payload performance of the aircraft. Combat radius is the radius of action of an aircraft flying a defined altitude and speed profile, with a specified payload, configured with a set number of external fuel tanks and weapons, with a specified combat fuel allowance for combat contingencies, and with a stated fuel reserve.

Aircraft of the same type exhibit wide variations in combat radius depending on payload, the tactical demands and flight profile of the mission. Invariably an aircraft's practical combat radius is well short of the claimed combat radius. Yet the need for operational reach is self-evident. Control of the air can only be achieved if you have the range to find and fight the enemy and the persistence to maintain superiority. Precision strike is impossible unless you have the range and endurance to reach and strike the target.

Air-to-air refuelling is frequently posed as a solution, but it can't compensate for inadequate range in the air platform. Fighters are not like the family car whose fuel tank can almost be exhausted. Fighters must leave their patrol and transit to the tanker, so that they arrive with sufficient fuel remaining to divert to a friendly airfield if the fuel transfer fails. Because friendly airfields are often hundreds of kilometres away, short-range fighters spend most of their time topping up and not patrolling. Moreover, tankers are large, vulnerable and, being expensive to acquire and operate, inevitably scarce.

The need for Australia to be able to strike at long range is dictated by geography. As a guide, the combat radius of the F-111C using realistic flight profiles and payloads is around 1,000 nm. The F-111C achieves this remarkable range by virtue of its large size, excellent internal fuel capacity, and the aerodynamic efficiencies flowing from its variable-geometry wing. Australia's F/A-18As, like most current fighters, cannot get close to the range performance of the F-111C. The F/A-18A under the most favourable conditions may achieve a combat radius approaching 400 nm, although more realistic flight profiles will reduce this to about 250–300 nm.

While Australia may arguably require an aerospace combat capability with range performance approaching that of the F-111C, most candidate aircraft will have considerable difficulty meeting this requirement.

Weapons

An obvious yet critical element of Australia's future air combat and strike capability will be the number and type of air-launched weapons that can be carried. These range from the air-to-air missiles used for air combat to the air-to-surface missiles and bombs used for strike missions.

While Australia may arguably require an aerospace combat capability with range performance approaching that of the F-111C, most candidate aircraft will have considerable difficulty meeting this requirement.

Air-to-air

Air-to-air missiles (AAMs) are rocket-powered with a variety of guidance systems. WVR AAMs are relatively short-range weapons—less than 10nm would be typical, depending on altitude and aircraft-relative geometry and speed at launch. These are almost invariably infra-red (IR) guided weapons that home in on warmer parts of the target aircraft, such as the jet exhaust. Modern WVR AAMs do not need to be launched from rear of the target in order to lock on to it.

Modern BVR AAMs can have ranges exceeding 60nm under the right conditions (although a typical effective range is less than 40nm). They use active radar (AR) guidance and, typically, some form of positional information transferred from the launch aircraft before the missile is fired. An aircraft with the right radar can detect and track multiple targets simultaneously, and transfer the location details of specific targets to individual missiles. Once launched, the missiles receive target updates from the fighter until they reach the general target area, and then activate their own radar seekers and home in on the individual targets they've been allocated. With further technology improvements most modern fighters (including late-model and upgraded Hornets) will, if required, be able to conceal themselves by keeping their radar shut down and using target data passed to them via data link from an AEW&C or another fighter.

Australia's future air combat aircraft will be able to be equipped with the following air-to-air missiles that are either operational or currently being fitted to the RAAF's F/A-18s:

- AMRAAM (Advanced Medium Range Air-to-Air Missile) AIM-120C: Current generation AR-guided BVR AAM, will arm RAAF and Canadian Hornets, Singaporean and Thai F-16s and South Korean F-15s. Today's benchmark for BVR AAM capability and performance.
- ASRAAM (Advanced Short Range Air-to-Air Missile) AIM-132: European-designed (by MBDA) AIM-9L/M replacement. Very fast and agile, designed for HMS, uses similar very wide field of view imaging IR seeker head to AIM-9X. Will arm British Eurofighter, Tornado and Harrier and also the JSF (F-35). RAAF is the first export customer and first Hornet operator to order ASRAAM.

Air-to-surface

The decade immediately following the 1991 Gulf War saw a near-revolution in the way air power is applied. In 1991, only 9% of munitions dropped by the US were precision-guided. The vast majority of ordnance delivered on Iraqi targets by US and coalition air forces consisted of unguided 'dumb' munitions—albeit delivered from sophisticated platforms.

F-111 with full weapons display. © Defence Department.

Subsequent air campaigns in the Balkans and, more recently, Afghanistan and Iraq have seen the balance swing towards guided munitions, and especially stand-off munitions, of different types. In Iraq in 2003, 68% of munitions dropped by the US were precision-guided; for the United Kingdom, the proportion was 84%.

There are several reasons for this. When guided munitions are employed correctly, their greater accuracy makes them more lethal and greatly reduces the risk of collateral damage. Their accuracy also makes them more economical: fewer sorties and weapons are needed to destroy specific targets. Delivery from stand-off ranges reduces the risk to platforms and aircrew from enemy defences. Smart weapons also significantly cut down the logistics footprint and support requirements for an operation.

However, an accurate stand-off weapon requires accurate fire control and target data appropriate to its particular guidance system. There are several generic guidance systems, depending on the role of the missile.

- Anti-radiation missiles home in on hostile radar emissions.
- Laser-guided bombs (LGBs) and missiles home in on laser energy reflected off the target. The laser device may be on the launch aircraft, on a separate aircraft or in the hands of a ground-based observer. Use of LGBs can be limited by poor weather or visibility.
- Bombs and missiles guided by signals from the satellite-based Global Positioning System (GPS) use predetermined target coordinates, giving users a high accuracy, all-weather, autonomous, conventional bombing capability. However, GPS-guided weapons rely on precisely defined target coordinates and have limited use against mobile targets.
- IR-guided land attack and anti-ship weapons home in on heat sources. Many now use imaging IR sensors, which send a sight picture via data link to the operator, who uses the same link to steer the missile to its target.
- TV-guided and electro-optically (EO) guided weapons typically have a camera in the nose and a data link to transmit sight pictures to an operator on the launch aircraft, and steering instructions back to the missile.

The RAAF currently operates a limited range of precision air-to-surface weapons that can be used by the F/A-18 and F-111:

- GBU-12 500 lb LGBs;
- GBU-10 2,000 lb LGBs;
- GBU-24 2,000 lb LGBs;
- AGM-84 Harpoon anti-ship missiles (which can also be carried on the P-3C Orion aircraft); and
- AGM-142 stand-off missiles (currently being fitted only to the F-111, but not yet operational because of ongoing integration difficulties that have proven expensive to overcome).

Defence also has a number of projects planned in the Defence Capability Plan to further enhance the ADF's precision-guided weapons capability. These weapons should also be compatible with the JSF, or whichever future combat aircraft replaces the F/A-18 and F-111. These projects include:

- Bomb Improvement Program. To be decided in 2004–05, with an in service date of 2008 and a cost of some $75 million, this project is a relatively low-cost option to improve the stand-off capability and accuracy of the ADF's current inventory of unguided 'dumb' bombs by adding GPS guidance kits.

- Follow-on Stand-off Weapon Capability. To be decided in 2004–05, with an in service date of 2007 at a cost of some $400 million. This project is meant to supplement the earlier (but not yet realised) purchase of AGM-142 missiles through the acquisition of an anti-radiation/anti-radar missile, a longer range cruise missile, and an anti-ship missile for coastal areas.

Sensor performance: 'First see, first shoot'

Sensor range is another fundamental operational requirement. Although a fighter could expect to receive supporting off-board tactical data, tactical manoeuvring and weapons launch are normally carried out autonomously using the fighter's air intercept radar. The intent is 'first see, first shoot'.

The aim is to achieve greater situational awareness—the ability to understand the orientation, capability and disposition of your forces, the enemy's forces and the environment you're operating in. Having superior situational awareness enables you to move faster than your opponent, get 'inside' their decision cycle—make a decision and act before they can—and defeat them. But situational awareness isn't a function only of the aircraft's radar and sensors. It's also determined by input from many off-board sensors, such as from AEW&C aircraft and other sources, delivered to the fighter aircraft via voice communications or data links.

With BVR missiles developing impressive ranges, the fighter radar must be optimised for long-range detection and engagement. Long-range engagements allow fighters to shoot and survive, and to avoid the dangerous close-in air combat arena.

The sensor requirement should reflect the demands of the air combat tactical environment and the ability to operate autonomously in the vast airspace of the Australian region. It requires an integrated sensor suite built around a modern radar with the ability to detect and classify airborne targets at long range. The radar needs to be supported by a passive infra-red search and track system and an electronic warfare capability optimised to detect the electronic emissions of opposing aircraft. The sensor capability is likely to be as far in advance of that currently carried by the F/A-18A as was that system when compared to the Mirage.

These three sensor systems need be adapted to provide the surface target detection necessary to execute precision strike. Advanced digital processing of radar signals allows the development of a high resolution surface picture. The infra-red search and track complements the radar and allows precise targeting by day or night in clear weather. The electronic warfare system warns against air- and surface-based threats. These technologies were pioneered by aircraft such as the multi-role F/A-18A, but recent advances have allowed far greater sensitivity, range and resolution.

Stealth technology

Stealth aircraft reduce the probability of radar detection both by absorbing radar energy and by reflecting incident radar energy away from the transmitting radar. Radar absorbent material can be applied after design to make an aircraft low observable, but very low observable aircraft (true stealth) such as the F-22 and B-2 are specifically designed to reflect incident radiation away. Stealth doesn't make an aircraft invisible to radar, but it may reduce the detection range to such an extent that it provides the stealth aircraft with a decisive operational advantage.

Being stealthy is not just a product of the aircraft's structure. A true stealth aircraft also has a low infra-red signature and radiates electronic emissions with a low probability of interception. Making electronic emissions unlikely to be intercepted is particularly important because it helps limits the detection of the stealth aircraft by enemy electronic warfare systems. However, new digital electronic warfare systems are making it increasingly difficult to hide transmissions in the electromagnetic spectrum.

There is a significant difference between systems that have a reduced radar cross-section or have low observability and those that are truly stealthy (also referred to as a very low observability systems). A low observable aircraft uses elements of stealth technology, but even those with reduced radar cross-section are not stealth aircraft. Their radar cross-sections are orders of magnitude greater than truly stealthy aircraft.

Two USAF true stealth aircraft are currently operational: the F-117 Nighthawk and the B-2 Spirit. The F-117 demonstrated the effectiveness of stealth technology against older generation air defences in the Gulf War; the B-2 is the billion-dollar 'stealth bomber'.

However, by the time the JSF enters service with the RAAF the absolute advantage of radar stealth may be smaller.

The F/A-22 Raptor and F-35 JSF are stealth aircraft under development. The F/A-22 is expected to have substantially lower radar cross section and infra-red signatures than the F-35. Because of the need to keep costs down, the F-35, while stealthier than all fourth generation fighters, does not have the same stealth capabilities as the F/A-22.

Stealth technology provides enormous tactical advantage and enhances aircraft survivability. However, by the time the JSF enters service with the RAAF the absolute advantage of radar stealth may be smaller because of advances in sensor technology that will enable better detection of stealth aircraft. Nevertheless the relative advantage of stealth is expected to still apply as better sensors will detect higher signature targets at even greater ranges.

Cost: how much is it?

There is no simple way to fix the price of an aerospace combat capability. For example, the advertised price of a F-16C is US$25 million 'fly-away', but this does not mean that a combat force of 100 F-16Cs can be bought for US$2.5 billion. Unit or fly-away price does not include spare parts, software, ground handling equipment, specialist servicing equipment, test equipment, training support, flight simulators, mission planning systems, publications and so on. As a rule of thumb, fly-away price can be doubled: a more realistic F-16C project price would be US$50 million per aircraft.

To the cost of the aircraft must be added the cost of the weapons that convert the platform into a weapons system, the cost of integrating these weapons into the platform, and the cost of modifications necessary for any specifically Australian requirements. Buying a

Operational costs: old versus new aircraft

It seems to be generally accepted that the cost of operating ageing aircraft is becoming increasingly prohibitive, while the introduction into service of newer aircraft will lead to less being spent on service and maintenance. In February 2003, the Chief of Air Force told a Parliamentary Committee that once the F-35 is brought into service the Air Force will be looking at costs that are 'about half the cost of operating F-111s and F/A-18s'.

While this may eventually be demonstrated, the opposite can also occur, with new aircraft being more expensive to maintain in service than those they replace. For example, twelve new C-130J Hercules transport aircraft were bought in the late 1990s to replace twelve older C-130E Hercules originally bought in 1966–67.

The 2003–04 Defence budget had an allocation for additional expenditure on C-130J logistics funding of some $40.7 million per year over the next five years. Defence stated that the increased complexity of the aircraft, especially its software support costs, were the major cost drivers. The J model is a very software-intensive aircraft, while the preceding E and H models were not. Also, according to Defence, the J model is for all intents and purposes a different aircraft from the E model it replaced and the H model still in service. Previously, the RAAF was able to support the E and H models with one infrastructure, one set of spares, one set of inventory and so on. The C-130J, being a different aircraft, requires new sets, and Defence underestimated the difference.

As in the case of the C-130J, the F-35 JSF is very software intensive compared with the aircraft it is to replace. While the F/A-18 uses some five million lines of software code, the JSF uses 15 million lines.

mature system is cheaper because earlier customers will have paid the major non-recurring development costs; buying a newly developed platform requires a significant contribution to the development costs.

In the long run, the only price that matters is the total project cost per aircraft. Having covered the capital acquisition and initial logistic support package, on-going through-life support costs must be addressed. These will include consumables, replacement stocks of spare parts, the regular overhaul of systems and components, the rectification of systems and components following failure, and the upgrade of software and test equipment.

Aircraft numbers: how many is enough?

Strategic and operational factors rarely determine the number of platforms the ADF acquires. More often, this is determined by budget allocation and sometimes even by the whims of political decision making. For example, Australia ordered an extra squadron of F/A-18 aircraft because of the Soviet invasion of Afghanistan in 1979.

The Defence White Paper indicates that Australia's future air combat and strike capability will comprise up to 100 new aircraft. Arriving at that number was not rocket science: it's simply based on the need to replace seventy-one F/A-18s and about thirty F-111s. The wording of the White Paper was quite deliberate in this respect. It specifies 'up to' 100 aircraft. When announcing the JSF decision, the Defence Minister stated that Australia is looking for 'a capability equivalent of 100 aircraft'.

However, when replacing existing aircraft with others far more capable, technologically advanced and expensive, it's been rare to replace them one for one, for cost reasons if nothing else. Traditionally, new aircraft replace old at a rate of about 75%, so in replacing around 100 aircraft in the next decade it might be reasonable to expect to buy about 70–75 aircraft in total. But while it's true that new generations of equipment bring higher capability, in the air combat arena the threat has generally grown as well. Therefore, it's not necessarily true that fewer aircraft are required.

Aircrew are also a critical component of the NACC, and ideally there should be sufficient numbers of aircrew to maximise the high mission availability of the JSF. However, over the last few decades, the Air Force has generally struggled to sustain the number of operational fast jet aircrew to man the present F-111 and F/A-18 fleets, despite focused retention and recruitment programs. An issue for NACC is that while the ideal operational aircrew to aircraft ratio will likely exceed 2:1, a lack of aircrew could affect the overall capability required.

The government's recently released Defence Capability Review (DCR) saw an increased requirement to 'position the ADF to exploit current and emerging Network Centric Warfare advantages'. Defence is still working through the development of an Australian network-centric warfare concept and how to achieve it. However, a number of the cuts and savings in the 2003 DCR stem from the principle that you can get the same level of capability or greater through the networking of a reduced number of systems. Unfortunately, this ignores the practical reality that greater networking and advances in information technology still cannot adequately substitute for a lack of mass and numbers, as in one sense the US is finding in Iraq today.

F-111 eleven ship formation flypast over RAAF Amberley. © Defence Department.

Sometimes quantity has a quality all its own. Having adequate numbers of people and platforms is important in running concurrent operations, as well as in sustaining a deployment through the rotation of units and platforms. Having four AEW&C and four AAR aircraft means you couldn't run more than one operation or deployment at any one time. The risk remains that similar 'networking' arguments will be used to justify reducing the overall purchase of JSFs to about 60–70 aircraft, rather than the 100 aircraft the government is presently committed to. This is even more likely as pressures mount on the overall defence budget and the department looks for areas where savings could be made.

It would be premature to make any arbitrary decision on future fleet sizes but a sharp cut in fleet numbers could have a number of implications. One of the significant factors in our relative air combat capability edge over our regional neighbours is our greater number of aircraft. This is especially so when we are faced with the relative equality in capability between modern Russian aircraft and weapons systems and their US counterparts. We may not always be able to count on superior training and logistics support in the future. It may come down to simple arithmetic.

Furthermore, as our numbers decrease, so too does our ability to support concurrent operations. With a smaller inventory of modern combat aircraft we may have to choose between conducting coalition operations outside our immediate neighbourhood, and operations closer to home.

Interoperability

Ever since the terrorist attacks of 11 September 2001, the issue of the ADF's interoperability with the US military seems to have taken on even greater importance than it has in the past—and it was fairly important then. Indeed, judging from various statements made, the government seems to have determined that the primary military response to the threat of terrorism and the proliferation of weapons of mass destruction is greater involvement in US-led military operations outside our immediate neighbourhood.

This means that any new weapons platform and system chosen by the ADF will have to be highly interoperable with the US. Australia's future air combat capability is unlikely to be any different, a point reinforced by the recent deployment of RAAF F/A-18s in Iraq. Both the Minister for Defence and the Chief of Air Force have highlighted the JSF's ability to operate with US forces as an important factor in its choice. A recent decision by the government about the Collins Class submarines has gone so far as to stipulate that US equipment must be chosen to confirm such a degree of interoperability.

But this doesn't mean that the ADF must buy US equipment in order to be interoperable with US forces. The United Kingdom's armed forces are considered to be even more interoperable with the US than Australia, and continue to use British-designed and built aircraft, ships, submarines and missiles. During the 2003 Iraq War, a German-designed Australian frigate with a Swedish-designed combat system provided naval gunfire support to coalition ground troops in southern Iraq.

Interoperability with the US is much more than buying US equipment: it's about shared training and doctrine, among many other issues. However, from a solely technical perspective, any new ADF platform needs to have appropriate communications and data links to allow the ADF to operate alongside US forces and plug into US networks.

A RAAF F/A-18 aircraft waits to refuel with US aircraft during combat mission over Iraq. © Defence Department.

Industry, logistic support and technology transfer

Since the 1940s, Australia's aerospace industry has played a significant role in the manufacture (under licence) of military aircraft, and the maintenance of both civil and military aircraft, especially 'deeper' maintenance of airframes, engines and components. In broad terms, the Australian aerospace industry employs some 12,000 people, has a turnover of more than $1.5 billion and annually exports more than $870 million in goods and services. However, most of this trade is in the commercial aviation sector. Defence has stated that some $29 billion will be spent for the support, upgrade and acquisition of aircraft over the next decade. The new air combat capability accounts for almost half of that expenditure. Of the $29 billion, some $11 billion will be spent in Australia.

While reality dictates that the design and manufacture of military aircraft will continue to be sourced overseas, current government policy does seek to support and upgrade these aircraft in-country, within the bounds of cost and technical capability. The government has released an Australian Defence Aerospace Sector Strategic Plan, which seeks to consolidate the defence aerospace industry and is supposed to help industry sustain the strategic capabilities essential to support ADF self-reliance.

The government is also determined to increase the integration of Australian aerospace companies into global supply chains, but this is no substitute for an active Australian industry involvement program. Making individual components for an aircraft might be a 'nice earner' for the industry concerned, but it's no substitute for the development of capabilities that will be able to support the aircraft once it enters service. And it's the mission systems that have become more important than the airframe, propulsion and flight systems in modern strike/fighter aircraft.

Rather than self-sufficiency, Australia seeks industry capabilities for repair, maintenance and modification of platforms and systems. Within this framework, areas attracting high priority for support from industry are:

- combat and systems software and support
- data management and signal processing
- command, control and communications systems
- systems integration
- repair, maintenance and upgrades of major weapons and systems
- provision of services to support the peacetime and operational needs of the ADF.

There are a number of lessons to be learnt from the experience of industry involvement in the F/A-18 program. When the government committed to that program, it invested $713 million (1992–93 prices) in plant, facilities, machinery, tooling, test equipment and associated training. This represented about 17% of the total cost of the F/A-18 acquisition program.

One of the first lessons was that component manufacturing and airframe assembly capability doesn't necessarily produce the wherewithal for through-life maintenance. The establishment and enhancement of facilities was successful, but the ongoing workload was so low relatively early in the aircraft's life that some key capabilities either ceased to exist or were under threat. As a consequence, the return on investment was not realised. The linkage between the industry program and the needs of the RAAF for through-life support of the F/A-18 was also given inadequate attention in the F/A-18 program.

There are a number of lessons to be learnt from the experience of industry involvement in the F/A-18 program.

Another lesson emerged from reliance on the maintenance workload anticipated for through-life support of the airframe, engine and some system components, but with no significant consideration of the software update program, which relied on the US Navy for software releases. Experience in obtaining changes to software to meet Australian operational needs has demonstrated the need, in the initial acquisition program, to give more careful consideration to the development of this capability within industry and research and development organisations.

A further significant hangover from the F/A-18A program was caused by the unsatisfactory handling of technology transfer and of intellectual property. Australia had expectations that, as a consequence of our large capital outlay, significant technology relating to manufacture and support of the aircraft would be transferred to Australia and access would be granted to software source code. Australia's expectations were not met, although when considered against our ability to usefully exploit the software code they may have been unrealistically high. Perhaps the core of the software issue was our lack of access to the source code needed for a full understanding of the aircraft radar, and an inability to reprogram the electronic warfare system in accordance with Australian requirements.

This is even more critical for the F/A-18's replacement because of the high dependency of new aircraft on software. The sensors offered for situational awareness and targeting will be tied together in a way not previously demonstrated. This highlights the need to consider support for software and electronic systems, perhaps before the more traditional concerns for airframe, engine, mechanical components and so forth. The lessons from the F/A-18A were that Australia could not expect to cope with all aspects of the aircraft's technology and its five million lines of on-board software code. In the purchase of the JSF, Australia needs to identify the key technologies we want to develop and ensure that intellectual property for relevant technologies is transferred. The support of selected electronic subsystems that are critical to operational success in the Australian theatre should be scrutinised especially closely.

Chapter 3

THE THREAT ENVIRONMENT

The force structure of the ADF has traditionally been based on the broad capabilities of regional neighbours, rather than on any specific threat. The rationale for this has been that other nations' intentions towards Australia can change relatively quickly, but significant changes in force structure take much longer, providing a reasonable amount of warning of any direct threat to Australia.

The government's strategic intent is to maintain ADF air combat capability at a level at least qualitatively comparable to any in our region, and with a sufficient margin of superiority to make combat success probable. Because capability is relative, the evolution of the threat environment is as fundamental to the NACC as the JSF aircraft itself.

Furthermore, alliance obligations have seen repeated 'out of area' deployments to trouble spots such as the Middle East as part of multinational coalitions. There is a continuing ADF requirement for combat aircraft able to deploy at short notice, operate effectively and survive in much higher-threat environments than have been the norm within our region. The ADF has to assume that it will face some kind of short-notice air threat at some point in the future within the region, and conversely that it will have to make a worthwhile contribution alongside friendly air forces as part of a coalition either within the region or further afield.

Until the mid-1990s, Australia's F/A-18s had the only BVR air combat capability in South East Asia, and our F/A-18s and F-111s gave us unrivalled strike and offensive air support capability. The transformation since that time has been remarkable. The introduction of modern types, such as the F-15J/K Eagle, F/A-18C/D Hornet, F-16C/D Fighting Falcon, MiG-29 and Su-27/30, and upgrades to older types, such as the F-5E/F, MiG-21 and MiG-27, have eroded or eliminated the substantial capability edge we enjoyed within the region as recently as 5–10 years ago. The combat effectiveness of these aircraft types is further enhanced by modern air-to-air and air-to-surface missiles and the leverage afforded by effective air defence command and control systems, AEW&C aircraft and AAR tankers.

While Australia maintains a reasonably balanced force … the relative survivability of the F/A-18 and F-111 will deteriorate in step with regional capability improvements.

The Defence White Paper assessed that by 2005 at least nine regional countries other than Australia will have developed BVR air-to-air capabilities. By 2010, some seven regional countries are expected to have acquired various levels of AEW&C capability. The White Paper concluded that these developments, and others including AAR and relatively low-cost stealth modifications to aircraft, will mean that across the region—including in some countries of South East Asia—there are going to be significant increases in air combat capability over the coming decade.

While Australia maintains a reasonably balanced force with key advantages in capabilities such as surveillance and intelligence, the relative survivability of the F/A-18 and F-111 will deteriorate in step with regional capability improvements.

Key developments: air combat weapons

By 2015–20, nations in our region will be operating a mix of platforms comprising manned aircraft (possibly including the JSF) and UAVs, and possibly UCAVs and cruise missiles. The sophistication of these capabilities will be determined by economic factors, political will, technology transfer (particularly from the US, Russia and Europe) and the ability of the armed forces to operate and maintain the weapon systems.

A Malaysian Air Forces soldier patrols near a MIG-29. AP via AAP/Vincent Thian © 2003 The Associated Press.

Low observable technology will have been present in the region for nearly twenty years, with most nations possessing a mature understanding of its capabilities and employment. There will also be a comparable growth in the capability of missiles, with a mixture of increasingly lethal WVR and BVR missiles available from a range of suppliers, including the US, Europe, Israel, South Africa, Russia and China.

The performance of ground-based air defence systems will also improve, fuelled particularly by the availability and relatively low cost of latest-generation Russian and Chinese systems. Improvements to supporting capabilities such as command and control, intelligence, surveillance, reconnaissance and electronic warfare are likely to parallel improvements to air combat systems.

Technology leaders

Japan, South Korea and Singapore will probably remain at the forefront of regional technology. They will mainly buy US weapon systems, but are also likely to purchase Western European systems when US technology is inferior, unavailable or too expensive. They are the lead contenders for JSFs and UCAVs within the region. Both Singapore and South Korea currently operate aircraft with reduced radar cross-sections.

In early October 2003, Singapore shortlisted three bidders in a competition to supply its air force with up to twenty-four new combat aircraft later this decade. The competing aircraft are the US Boeing F-15T (a derivative of the F-15K ordered by South Korea), the French Dassault Rafale, and the European Typhoon. The Republic of Singapore Air Force requirement is for an initial squadron of eight aircraft with an additional twelve to sixteen aircraft to be delivered later. Final platform selection is expected in late 2004 or 2005. Delivery of the first aircraft is expected in 2008–09.

By 2015, Singapore will have had wide experience with reduced radar cross-section platforms, including the F-5S/T, F-16C/D and new fourth and fifth generation combat aircraft. Singapore would also have substantial experience with UAVs, and could choose to purchase a dedicated UCAV, possibly of Israeli origin if one becomes available, for air-to-surface missions. While cruise missiles will be widely available in defence markets, Singaporean political concerns may constrain the purchase of this capability until another South East Asian nation acquires it.

China and India

China also has an indigenous fighter program, the XXJ, although technologically the platform will lag behind Western systems of the same era. The XXJ is likely to be a dedicated air-to-air fighter with a low observable signature. In any event, by 2010 China may have a total of 400–500 Su-27, Su-30 and J-10 aircraft in service, giving it the largest fourth generation fighter-bomber force in the Western Pacific.

In the light of its light combat aircraft experience, India would probably buy Russian platforms rather than developing its own aircraft. Some forty Su-30MKs were ordered in the late 1990s; a further 140 will be manufactured in India under license over the next 10–15 years.

China and India will remain reliant on Russia for a broad range of technologies, although each has indigenous low observability programs that could leverage Western European technology transfer, particularly through France. By 2015, if Russia can realise its fifth generation fighter program, the Next Generation Russian Fighter, it is likely that both China and India would be lead customers. In fact, India is likely to provide direct funding for the development of the Russian fighter, which is reportedly similar in design concept to the JSF. First flight is scheduled for 2009, with production to commence prior to 2015. Both China and India have cruise missile capabilities and will probably invest in UCAV capabilities, albeit at a slower pace than the US.

South East Asia

Thailand, Indonesia and Malaysia will continue to invest a substantial portion of their defence budgets in aerospace capabilities. Thailand will probably maintain a US-sourced air order of battle, with the F/A-18E/F or F-16C/D likely additions to its present fleet of F-16As.

The Malaysian and Indonesian order of battle will probably be a mix of US, other Western, and Russian fourth generation platforms. In the past six months, both Indonesia and Malaysia have announced orders for advanced Russian Sukhoi combat aircraft.

In April 2003 during her visit to Moscow, President Megawati Sukarnoputri signed a US$193 million deal for two Su-27SK air superiority fighters, two Su-30MK multi-role aircraft and two Mi-35 armed helicopters. The support package is said to include training for at least six Indonesian pilots. The aircraft arrived in Indonesia in late August and the Sukhois are understood to have been deployed in South Sulawesi. At the time, the Indonesian Air Force Chief spoke of Indonesia's intention to acquire a total of forty-eight Sukhoi aircraft over the next four years. Negotiations are continuing with Russia over the purchase of an additional six Su-27 and two Su-30 aircraft in 2004. Indonesia is also believed to be interested in acquiring new air defence surveillance radars from Poland to modernise its air defence system.

In May 2003, the Russian and Malaysian defence ministers announced that the Royal Malaysian Air Force would purchase eighteen Su-30MKMs for about US$900 million. The aircraft are scheduled to be delivered from mid-2006 and the delivery should be concluded

A Sukhoi Su-27 warplane is unloaded at Iswahyudi Air Base in Indonesia. AP via AAP/Tatran Syuflana by the end of 2007. Part of the deal is suspected to include the development of a joint venture facility to service the aircraft and provide some components. The Malaysian air force currently operates eight F/A-18D and nineteen MiG-29N/NUB aircraft.

Malaysia also has plans to acquire an AEW&C aircraft, and a competition is under way. The exact roles of the aircraft and the number Malaysia would acquire remain undetermined. Boeing is offering its B737 AEW&C aircraft, as already selected by Australia.

Indonesia, Thailand and Malaysia will have operated UAVs in a surveillance role by 2015, but it is unlikely that they will have acquired air-to-surface UCAVs.

Vietnam might consider US or Western platform options by 2015, but they will be impeded by the high cost of acquisition, integration difficulties and their low technology base. Their most advanced capability will therefore probably be sourced from Russia, represented by future derivatives of the MiG-29 or Su-27 families. Acquisition of the Su-30MK in small numbers (20–30) is also likely. For strategic reasons, South East Asian nations will probably be uncomfortable about acquiring a new cruise missile capability. Nevertheless, if such a capability were introduced by a regional nation, the domino effect would be rapid.

Implications for Australia

So what does the acquisition of these Russian aircraft mean for Australia's air combat capability, relative to the rest of the Asia–Pacific region?

The most potent threat facing the RAAF and its allies in the region is likely to come from variants of the Russian MiG-29 Fulcrum and Su-27/30 Flanker. These are big, fast, highly manoeuvrable fighters with excellent air-to-air missiles. In a WVR dogfight they are formidable opponents. When the MiG-29 entered service in Malaysia in the mid-1990s it was a much more capable aircraft than had been operated in the region previously, but the capability provided by the MiG-29 at the time did not match its potential. There is a clear possibility that, if the MiG-29 capability had been developed to its full potential, it would have outclassed the F/A-18.

Australia can't afford to be complacent with the total capability advantage we enjoy today.

The Su-27SK is a reasonably capable air-superiority fighter with some ground attack capabilities. The Su-30MK is a more sophisticated two-seat multi-role aircraft with in-flight refuelling capability and a greater range (combat radius of 750 nm given ideal flight profile). It is equipped with a more powerful radar and can carry heavier payloads and the latest Russian air-to-air and air-to-surface guided weapons.

Australia can't afford to be complacent with the total capability advantage we enjoy today, as we have already witnessed that capability can increase in large incremental steps. As a case in point, Singapore had a limited fighter capability in 1995, but today operates fighter aircraft that are qualitatively superior to those of the RAAF. Likewise, Indonesia's acquisition of Sukhoi fighters will represent a big step from its current generation of fighters. However, air combat capability is a much wider issue than simply the fighter platform. Whether this is a real erosion of Australia's capability edge over the Indonesian Air Force will depend on whether Indonesia:

- acquires the intended forty-eight Sukhois
- equips the aircraft with the latest Russian air-to-air and air-to-surface missiles
- develops supporting and enabling capabilities such as AEW&C and AAR
- develops the industry and expertise to support the aircraft in-country
- maintains adequate funding for logistics support and pilot training.

Assuming the age and condition of the airframes, systems and engines lend themselves to such a move, the original relative capability of older F/A-18 variants over their contemporaries can be restored by combat capability improvements such as the introduction of weapons like the ASRAAM and AMRAAM (and the avionics and mission computer changes required to exploit them), helmet-mounted sights, the APG-73 radar (which permits multiple simultaneous BVR engagements), an improved human–machine interface in the cockpit to enhance situational awareness, and the exploitation of data links and robust information networks to confer a force-on-force situational awareness advantage.

Other capability factors such as AAR and AEW&C, larger numbers of fighter aircraft, and superior training and logistic support give Australia the edge over most countries in the immediate neighbourhood. In the future, the acquisition of JSF should also return to Australia a qualitative advantage in the fighter platform.

However, it remains likely that the F/A-18s will have to undergo a further upgrade in structure, avionics and weapons before their retirement in order to remain competitive through to 2015 and perhaps beyond. Upgrades could include:

- addition of stealth features to the airframe
- improved electronic warfare systems
- improvements in air-to-ground weapons capability, as well as the possible addition of follow-on BVR missiles.

Chapter 4

FUTURE OF THE F/A-18 AND F-111

The entry into service of Australia's new air combat capability is based on the planned withdrawal from operational service of the F-111 (around 2010) and the F/A-18 (between 2012 and 2015).

Realising this new capability will depend on two factors. The first factor is whether the F/A-18 and F-111 will be able to reach their planned withdrawal dates, which depends on whether that's technically possible and cost effective. The second factor is whether Australia's intended replacement for these aircraft, the F-35 JSF, will be available to the RAAF in time (this question is dealt with in greater detail in the next section of this report).

Future of the F/A-18

Australia currently operates seventy-one F/A-18 Hornet aircraft: fifty-five single-seat A models and sixteen two-seat B models. Delivery of the original seventy-five aircraft began in 1985 and ran until 1990. Four aircraft have been lost.

In order to ensure that the F/A-18 remains operationally capable until its planned withdrawal date, the government has committed over $1 billion to the Hornet upgrade program, comprising a structural refurbishment program and an avionics and weapons upgrade. Of the seventy-one aircraft, around fifty are usually available for operational use. The other aircraft are either in maintenance or in upgrade cycles. Most of the twenty-one non-operational F/A-18s have been cannibalised to provide spare parts for the operational aircraft. The spare parts for the non-operational aircraft are expected to be replaced progressively over the next five years.

The F/A-18 has a nominal life of 6,000 hours, but has been subject to a fatigue life testing done in collaboration by Australia and Canada. While the F/A-18s are expected to have flown 1,500 more hours than expected by the RAAF because of military operations by fourteen

F/A-18 Over the Olgas. © Defence Department.

aircraft in Iraq in 2003, this is not expected to have a major overall impact on the future of the fighters. While they operated in a harsh environment around and in Iraq, the deployment was for only three months and most of the flying was relatively undemanding in terms of aircraft fatigue.

The earliest production examples of the A/B-model Hornet suffered unexpected rates of airframe fatigue in US Navy and US Marine Corps service, and especially in Australian and Canadian service. Studies have revealed the inability of the Hornet to reach its planned withdrawal date without some form of refurbishment, including the possible need for a centre-fuselage ('centre-barrel') replacement.

The US services are developing a centre-barrel replacement program for some of their Hornets and for other users. Canada has already begun such a program; the RAAF is still considering it. Should it be necessary to extend the service of our F/A-18s beyond 2015, further refurbishment could probably be undertaken to extend to 2017–20. This would likely involve upgrading up to 40–50 of the existing fleet at a cost of some $200–300 million. The Chief of Air Force stated in June 2003 that his preference was to avoid the centre-barrel replacement if at all possible. The RAAF believes that some level of centre-barrel replacement will be needed to achieve the F/A-18's planned 2015 withdrawal date. A final decision is expected to be made in 2005.

Avionics upgrades are also required to the F/A-18 to increase the combat effectiveness of the aircraft. The first phase of the upgrade has seen the F/A-18 fitted with improved communication and navigation systems. Under the second phase, the Hornets received new radars, medium-range air-to-air missiles and upgradeable fight software. The remaining phase will emphasise improved electronic warfare self-protection, improved data links that will add to interoperability with other ADF and coalition assets, and new short-range air-to-air missiles and associated systems. Other projects will add new long-range stand-off weapons to the F/A-18's inventory. In total, these upgrades—coupled with the entry into service of AEW&C aircraft and new AAR aircraft—should assist the RAAF to maintain a competitive level of air combat capability over the coming decade within the South East Asian region.

Future of the F-111

The future of the F-111 is far more problematic. The F-111 fleet currently consists of twenty-eight aircraft: seventeen F-111Cs, four RF-111C reconnaissance aircraft, and seven F-111Gs. An additional five F-111Gs are in long-term storage and an additional two G models have been cannibalised for spares. Originally, twenty-four F-111Cs were ordered in 1963, with delivery delayed until 1973. Fifteen G models were acquired in 1993, and four replacement F-111As were bought and then modified in the 1980s to cover losses from accidents. As of June 2003, the RAAF had a pool of thirteen aircraft available to meet its operational and preparedness requirements.

The F-111s have been dogged by questions about their availability and structural integrity, the cost of operating them, and their overall capability in a modern air and ground threat environment. Past Defence Annual Reports lists problems of wing cracking, fuel tank pressurisation, commercialisation of support functions, general ageing, and capability enhancement and modification projects as causes of restrictions on the F-111s availability for service.

Original government intentions had the F-111 remaining in service until 2020. The Chief of Air Force stated in June 2003 that, until Defence completes a series of studies he was only confident of being able to maintain the F-111 in service until 2010. Then, as part of the DCR, the government announced in November 2003 that the aircraft could be withdrawn from service by 2010, some 5–10 years early. This will save Defence hundreds of millions of dollars annually, but the F-111's retirement will now occur before the arrival of its nominated replacement, the F-35 JSF. This might reflect a view that the JSFs won't arrive by 2012 after all.

F-111 armed with practice bombs. © Defence Department.

And the withdrawal from service of the F-111 is highly dependent on successful upgrades to the F/A-18. The government now expects that further F/A-18 weapons upgrades, in conjunction with the arrival of the AEW&C and new replacement AAR aircraft, mean that Australia will have a strong and effective land and maritime strike capability without the F-111. But this assumes that the F/A-18 fleet has both the numbers to take on the role of the F-111 and that the F/A-18 has received the capability and weapons upgrades to be effective in the F-111 role. Both are critical assumptions.

… there remains uncertainty that the upgrades intended to enhance the F/A-18s' strike capability will be completed before the F-111s retire.

Given that Defence's difficulties with the F-111 upgrade program mean that it has failed to deliver operationally capable aircraft for a modern operational environment, the decision to retire the F-111 early makes some sense. The money being used to maintain the F-111s and upgrade them further can probably be better spent elsewhere but there remains uncertainty that the upgrades intended to enhance the F/A-18s' strike capability will be completed before the F-111s retire.

Even if the upgrades are successful, Australia's strike capability will have fallen well below the levels planned for in the 2000 White Paper. If the F/A-18 upgrades run into trouble, we could face a serious strike capability gap. Therefore, the RAAF also needs to develop contingency plans to keep the F-111s in service until at least 2015 if the planned upgrades to the F/A-18s don't deliver the expected level of capability.

Prior to the government's announcement on the new retirement date of the F-111, an additional $500 million was planned to be spent on capability enhancements to the F-111 fleet. These included improved electronic warfare self-protection, enhanced reconnaissance capabilities for the four RF-111Cs, and improvements to the F-111's precision strike capabilities. The Chief of Air Force stated that 'one or two' of these enhancements 'will be proceeded with'; the rest of the projects are expected to be cancelled. However, no detail was provided on which will stay and which will go, let alone how much this will save. The RAAF have yet to publicly declare how they will replace the reconnaissance capability of the four RF-111C aircraft in 2010.

The interim option

The initial phase of NACC envisages first delivery of the F-35 JSF in 2012, an early date in the JSF production program. If the JSF is late, as is usual for new aircraft development programs, what options are available to cover the loss of capability as the F/A-18A is progressively withdrawn from service over the period 2012–15?

If the government needs to extend the life of the F/A-18, it would need to undertake the centre-barrel replacement on at least 40–50 of the seventy-one aircraft. Another option would be to put some fairly stringent restrictions on how they are flown and for how long. While lengthening the life of the aircraft, this would also have some negative impact on operational effectiveness. In any event, this is also an option worth considering for lengthening the service of the F-111. As a strike aircraft, its flight profiles should be less demanding than for air defence operations. Restrictions on its use would not entail as severe an impact on operational effectiveness.

A second option is to buy an 'interim' NACC platform: the F/A-18E/F is frequently cited as an option. But new 'interim' aircraft do not come cheaply, and it seems most unlikely that the capital cost of an interim buy of some twenty-five aircraft at some billions of dollars could be justified, given the relatively short period of operational service expected before the JSF enters service.

A third option may be to seek the loan or lease of an interim NACC platform, such as late-model F-16Cs. There is a precedent for such an option: when the F-111C delivery to replace the obsolete Canberra bomber was deferred in 1970, a government-to-government lease of twenty-four new F-4E Phantom tactical fighters was arranged to provide a credible interim strike capability.

As well, those who are already writing off the F/A-18A need to bear in mind that the last aircraft was delivered only in 1990, and note the significant government expenditure over recent years spent on the upgrades of both the F/A-18 and the F-111 fleets. It should not be beyond the competence of the Air Force to ensure that the F/A-18A stays the course.

So, while acknowledging that the need for an 'interim' NACC solution will depend on the operational longevity of the F/A-18A, its continuing structural integrity and the anticipated Australian in-service date for the JSF, it seems premature to talk of specific 'interim' NACC solutions in the absence of evidence that such a solution will be needed.

Managing the transition

In any event, the transition between the phasing out of whatever aircraft Australia is operating at the time and the arrival of the F-35 JSF will have to be carefully planned and managed.

When Defence was managing the new Collins Class submarine program, it failed to tie the introduction into service of the Collins with the phasing out of the Oberon submarines they were replacing. This was not least due to two different parts of Defence and Navy being responsible for each duty. As a result, Australia would have had a significant period without an operational submarine capability if the government hadn't extended the service of the last remaining Oberon submarine while at the same time rushing capability enhancements to two Collins boats. While an operational submarine capability gap would have been inopportune, a similar gap in our air combat capability would be unacceptable.

Defence expects that by 2005 it will have a much clearer idea about how to transition from the F/A-18 and F-111 to the F-35 JSF. By then, with the F-35 actually flying, the nature and requirements of the aircraft will be clearer. Detailed technical analysis on the RAAF's ability to maintain the F/A-18 in service will also have been completed.

The first F-35s are—perhaps optimistically—expected to enter into service in 2012, but that's not the same as having an operational level of capability. Operational testing and evaluation of the aircraft, and the training of the people who will pilot and support it, can take at least two to three years. So, while aircraft may be in Australian hands in 2012, it may be 2015 before we have an operational capability suitable for modern warfare.

Once we have defined our air combat capability requirements Defence will therefore need to develop a fighter transition plan that:

- ensures no significant or unacceptable capability gap
- manages the maintaining in service of what may end up being three different types of combat aircraft and their associated support systems at the same time, taking particularly into account the required funding, training, logistics and industry support.

Formation of F-111 and F/A-18. © Defence Department.

Chapter 5

THE F-35 JOINT STRIKE FIGHTER

What is the Joint Strike Fighter?

The US-developed JSF program is designed to develop a reasonably priced, new-generation, multi-role, tri-service (Air Force, Navy and Marines) family of tactical stealth aircraft.

The JSF is designed to replace a number of aircraft currently in service:

- for the US Navy (USN), it will replace the F-14 Tomcat and A-6 Intruder
- for the US Air Force (USAF), it will replace the F-16 Falcon and A-10 Thunderbolt, and perhaps the F-117A
- for the US Marine Corps (USMC), it will replace both the AV-8B Harrier and the F/A-18C/D Hornet
- for the United Kingdom, it would replace the Harrier and possibly the Tornado.

Low cost is the major driver in the JSF program. To date, the principal design aim has been 70% or more commonality between variants to achieve economies of scale and lower fly-away costs. Commonality for avionics, sensors and software is intended to be 100%.

Concept Demonstration Phase contracts were awarded to Lockheed Martin and Boeing in November 1996. Northrop–Grumman and British Aerospace joined the Lockheed Martin team as principal subcontractors. In a competition involving the evaluation of flying demonstrators (Lockheed Martin's X-35 and Boeing's X-32), the Lockheed Martin team was awarded the System Development and Demonstration (SDD) contract for the F-35 Joint Strike Fighter in October 2001.

At a contracted cost of $US19 billion just to cover the SDD phase, the JSF will be one of the largest defence programs undertaken by the US. When delivered, the aircraft will dominate the air combat structure of the USAF with 1,763 aircraft, and a combined USMC and USN

JSF versus F/A-18 and F-111 characteristics

	F-35A	F/A-18A/B	F-111C
Wingspan	10.7 m	11.4 m	19.2 m spread 9.7 m swept
Length	15.4 m	17.1 m	22.4 m
Weight (empty)	26,500 lb	23,800 lb	53,000 lb
Internal fuel weight	18,000 lb	10,800 lb	32,500 lb
External weapons load	6,500 lb	6,500 lb	12,500 lb
Max speed	mach 1.6	mach 1.8	mach 2.2
Combat radius	590 nm	290 nm	1,000 nm
Crew	1	1–2	2

purchase of 680. The JSF is also expected to be widely exported to US allies, and later to wider US defence markets, although only the UK and, to a lesser degree, Australia have so far committed to buying the aircraft. The UK expects to purchase some 150 JSFs, bringing the total number of confirmed orders to 2,593. Against this backdrop, Australia's involvement is relatively minor; the JSF's SDD phase alone is 2.5 times the total estimated cost of the Australian NACC project.

The SDD phase will continue until about 2012, producing twenty-two aircraft for testing and development. Concurrently, about 450 aircraft will be produced within the Low Rate Initial Production program across the three variants. Initial operational capability is expected for the USMC's short take-off, vertical landing (STOVL) version in 2010, for the USAF's conventional take-off and landing (CTOL) version in 2011, and for the USN's carrier version in 2012. To achieve these aggressive program timelines, the Preliminary Design Review (PDR) was completed in 2003 and the Critical Design Review (CDR) must be completed during 2004. These design reviews are important indicators of the health of the program.

The F-35 PDR, including the review of both on-board and off-board systems, was held in the US from 24–27 March 2003. Tom Burbage, the general manager of the Lockheed Martin F-35 JSF program, declared that the PDR showed that the preliminary design meets the

USAF F/A-18 flying behind the X-35. © Lockheed Martin.

F-35 key performance parameters and that the program remains on schedule for CDR in 2004. However, while the program remains on schedule and budget, there are a number of issues that remain open after the PDR and that have already consumed much of the schedule margin:

- The primary difficulty is the higher than expected preliminary weight estimates of the F-35. In particular, the STOVL version is 600 pounds overweight.
- There remain weapons clearance and integration issues. The USAF JSF program manager, Major General Hudson, advised that they will largely integrate only the latest guided weapons, such as the Joint Direct Attack Munition, rather than the unguided weapons that dominate current Australian weapon stocks or some of the guided weapons the RAAF uses, such as the Harpoon anti-ship missile.
- With a total of nearly 15 million lines of code in the aircraft, simulator and associated systems, software remains a key challenge.

The US Government Accounting Office has reported that such problems have historically resulted in 'increased program costs, longer development schedules or a reduction in system capabilities'. JSF cost price is already under pressure. Citing continued problems with weight margins, the Pentagon has cut 70 fighters from the early acquisition runs and transferred US $5.1 billion to the SDD program from production. In total, it is assessed that the initial program cost estimates were optimistic.

Important milestones for the F-35 JSF

The SDD Phase of the JSF project will run for approximately eleven years, until 2012. A number of key milestones will have to be reached before the aircraft enters service with the RAAF.

Finalisation of aircraft design (Critical Design Review)	2004
First engine test	2004
First flight of CTOL F-35	2005
Australian project approval by Cabinet	2006/7
Low Rate Initial Production starts	2006
Full-scale production starts	2008
First aircraft delivered to USAF	2008
Australian contract signature	2008
Initial operational capability with USAF	2011
Intended initial delivery for RAAF	2012

JSF combat performance

In effect, the JSF is still a 'paper plane'. The aircraft that have flown to date have been concept demonstrators. The first production aircraft won't fly until at least 2006 and full production is expected to be reached only in 2008.

Because the JSF is still under development and much of the system detail is classified, any assessment of its combat performance is necessarily at a general level and subject to considerable change during the aircraft's development. Over the next two years in particular, the nature of the JSF's performance and operational capabilities—its radar signature, speed, range, payload and manoeuvrability—may be subject to significant change, as the US is determined to keep costs down.

Nevertheless, some qualitative assessment can establish the key advantages and disadvantages that the JSF is likely to exhibit in future air warfare. Once Defence has more complete data on the JSF, a far more rigorous analysis program of simulation and modelling will be needed to assess the aircraft against requirements and threats. Such an assessment should determine key issues, such as how many JSF aircraft Australia needs, weapons requirements, critical supporting capabilities and potential complementary capabilities.

The analysis provided here is based on what is known about the USAF version of the JSF. While it remains in US interests to maintain commonality between its own aircraft and those of the other partner countries, there is no doubt Australia will receive an export version of the F-35. What remains unknown is how the capability and performance of the export version will differ from those of its US counterpart. A study is currently being undertaken in the US on the expected commonality between US and partner JSF aircraft, with a view to developing a partner JSF aircraft specification that is as close to the US aircraft as is possible under US national disclosure policy. That report was supposed to have been finalised in August 2003. Its results remain unknown.

In effect, the JSF is still a 'paper plane'. The first production aircraft won't fly until at least 2006 and full production is expected to be reached only in 2008.

JSF air-to-air combat assessment

While it has some significant air combat capabilities, the JSF isn't primarily designed to be an air superiority fighter: it is a multi-role fighter, capable of both air defence and strike operations. For most countries intending to buy the F-35, the aircraft will complement others dedicated to air defence and air combat. For the USAF, the F-35 will complement the F/A-22; for the USN, it will complement the F/A-18E/F. The UK will use the Eurofighter Typhoon as its air superiority fighter, as will Italy. The latter concept may be challenged if the JSF ends up having a superior air-to-air capability than the Typhoon. If they eventually buy the aircraft, the remaining countries partnered in the F-35's SDD phase are expected to rely on it as their primary combat aircraft, much like Australia.

The typical JSF air-to-air load is six AIM-120 AMRAAMs carried internally, with a further six external hard points for external fuel or other weapon types. However, the penalty for carrying external weapons is a degradation of the stealth of the aircraft. The baseline JSF will also carry internally the AIM-132 ASRAAM that is soon to be in service with the RAAF's F/A-18s. The typical combat radius for JSF is cited by Lockheed Martin as about 590 nm, although current assessments place that radius at about 640 nm. JSF therefore has a superior combat radius to the F/A-18A's 300 nm). This would allow the JSF greater flexibility in both defensive and offensive counter air roles.

JSF air-to-air combat performance can be broken down into two components: BVR and WVR engagements.

BVR capability: fighting when you can't 'see' the enemy

Detection is the starting point of the air-to-air engagement cycle, and is a function of sensor performance and the signature of the intended target. Like previous generations of fighters, the JSF will rely on its air intercept (AI) radar as the primary sensor. The JSF Active Electronically Scanned Array (AESA) radar has borrowed heavily from the radar on the F/A-22 Raptor (APG-77) and the F-16 Block 60 (APG-80) and should remain state-of-the-art into the next decade, when the JSF is in production. In fact, the JSF radar is a development beyond the F/A-22 and there is a plan to transfer JSF radar capability to the F/A-22. Based on the number of active elements, it would have about 40% less power and nearly 20% less range than the F/A-22 radar, but still be capable of detecting relatively high-signature targets (such as the Eurofighter aircraft) at an estimated range of 70 nm. To complement AI radar capability, JSF will have an integrated electronic support and electro-optic suite, providing passive detection capabilities.

The JSF is designed to be a very low observable (VLO) aircraft or stealth aircraft. While the detection performance of radars on many of the fourth generation aircraft could be similar to the JSF AESA, the fact that the JSF will be harder to detect on other radars is a fundamental advantage. The fighter will also have significantly lower infra-red and electromagnetic emissions, the latter primarily through its low probability-of-intercept radar. Assuming the threat had an equivalent radar, it might only detect the JSF at a range as close as 20 nm. This range would be well inside the envelope of many modern, active, radar-homing air-to-air missiles, including the AIM-120 AMRAAM currently in service with the RAAF (estimated range about 40 nm). In all probability, the JSF would therefore achieve 'first shot' against existing fourth generation fighters.

However, AI radar is not the only means of detecting opposing fighters. AI radar has limitations in terms of search volume and its capacity to detect low observable targets, and it may be exploited by adversary electronic support listening systems. Comprehensive situational awareness is therefore based on the fusion of intelligence, surveillance, reconnaissance and electronic support systems in addition to on-board fighter systems—which the JSF is supposed to have at its disposal.

In summary, and assuming similar levels of supporting capabilities and weapon systems, it is likely that the JSF will be superior in BVR air combat to fourth generation fighters such as the Eurofighter, Rafale and Su-27/30.

Within visual range: the high-technology knife fight

Ideally, future air warfare involving the JSF will be conducted BVR, where the aircraft has a substantial advantage. Nevertheless, some factors will continue to drive pilots to WVR engagements.

Within visual range, JSF survivability will be driven by situational awareness, the performance of defensive and offensive weapon systems, and the manoeuvrability characteristics of the JSF itself. The combination of advanced electro-optic (EO) and electronic support systems should provide the JSF with robust all-round situational awareness against existing threats.

All-round awareness is critical because, in modern combat, targets may be placed outside the AESA radar antenna's coverage (about 60 degrees). The JSF defensive avionics suite, which should include a radar jamming (electronic attack) system and a countermeasures dispensing system, will be responsive to inputs from the JSF sensors or the pilot. Less certain is the performance of those countermeasures against weapons with improving counter-counter measures.

In WVR combat, high off-boresight targeting is critical to achieving first shot. The combination of helmet-mounted sight and high off-boresight weapon system (such as ASRAAM) will provide the JSF with a highly lethal off-boresight capability. However, this combination is already a standard fit to most fourth generation fighters and is being fitted to our existing F/A-18s. The employment of radar missiles will also become increasingly important in the WVR environment and the small relative radar signature of the JSF may provide an advantage.

Manoeuvrability and energy will remain important considerations WVR, but probably less important than situational awareness and off-boresight weapons performance. With a thrust ratio of about 1:1, the JSF will probably be at a disadvantage, relative to fourth generation fighters of the 2015 era, in specific excess power (the ability to accelerate or gain energy) and turning performance: the JSF is not optimised for manoeuvrability or acceleration.

In summary, the JSF is not optimised for the WVR environment. If the fighter is forced WVR, its main advantages are its integrated sensors, small signature (possibly infra-red as well) and its defensive avionics system (depending on actual system characteristics). Therefore, highly capable fourth generation fighters may threaten the JSF.

Performance against new and emerging threats

In the threat environment of 2015, Australia's JSFs will also have to deal with a range of very low observable threats and targets, including other JSFs, cruise missiles and UAVs/UCAVs. The ability of the JSF radar to prosecute these targets autonomously will probably be limited; based on radar cross-section signatures below 0.01 m^2, it may be limited to less than 20 nm. Even if the US were to release sensitive, counter-stealth, radar algorithms to Australia, the JSF will still have to rely on cueing from external sensors such as AEW&C and intelligence, surveillance, reconnaissance and electronic warfare (ISREW) capabilities, particularly against cruise missiles that do not emit.

X-35. © Lockheed Martin.

JSF air-to-ground combat assessment

Survivability

Strike aircraft must contend with threats both from air and from ground environments, often making the strike mission the more dangerous. Against this backdrop, the penetration ability and survivability of the strike aircraft is an important planning issue, particularly in a political system that expects minimal casualties. Survivability is a function of the adversary's ability to detect and engage the platform.

The low signature of the JSF reduces sensor detection range, perhaps by a factor of three to four over conventional fourth generation aircraft. In the threat environment of 2015, this attribute will become more important as highly capable air defences, such as advanced Russian surface-to-air missile systems become available and widespread. The JSF's signature advantage also allows it to operate at high level, outside the range of many ground-based threats, including anti-aircraft artillery and infra-red missiles, and reduces exposure to air-based threats.

In total, JSF survivability is expected to be markedly superior to that of current strike aircraft such as the F-111.

By substantially limiting the probability of being detected, the JSF acts as a force multiplier by reducing the requirement to generate large support packages for the strikers. The JSF's full capability to penetrate threat systems will only be realised by the inclusion of supporting AEW&C and ISREW capabilities (before and during the mission) and by the on-board JSF defensive suite. Australia might also consider a dedicated force-level electronic attack (jamming) capability to support the JSF, as the US has demonstrated that off-board electronic attack substantially reduces the detection of low-signature aircraft by threat systems. The JSF is expected to have the ability to provide electronic attack both for self-protection and for escort of other JSFs. Even on a strike mission, the JSF will carry at least two air-to-air missiles internally to provide self-escort.

Despite the low signature of the JSF, some roles such as suppression of enemy air defences or deep strike might still prove too risky. NACC will need to evaluate UCAVs and stand-off weapons to determine if some roles could be more effectively performed by capabilities supplementary to the JSF.

Once the JSF is detected by an adversary, survivability is based on reducing the probability of the aircraft being destroyed. This requires identifying a threat, locating it in range and bearing, and managing the trajectory and tracking profile of the weapon through a combination of speed and geometry. The JSF's AESA radar, 360° EO situation awareness and electronic support systems will be state-of-the-art. The aircraft should therefore be more able to provide accurate information to the pilot, allowing him to effectively prioritise and respond to threats. However, due to its relatively low thrust-to-weight ratio, the JSF will be limited in its ability to shrink the geographic area within which weapons are engaged by increasing speed.

Because of a lack of data, it is impossible to assess how effective the JSF defensive avionics suite will be against threats from 2015 onwards. The JSF will be the primary strike platform for the US, and the US will probably invest heavily in a robust electronic attack capability, but full capability may be denied to export customers. In addition, the low signature of the JSF greatly improves the effectiveness of electronic attack, relative to fourth generation fighters, because the jamming-to-signal ratio is proportional to radar cross-section.

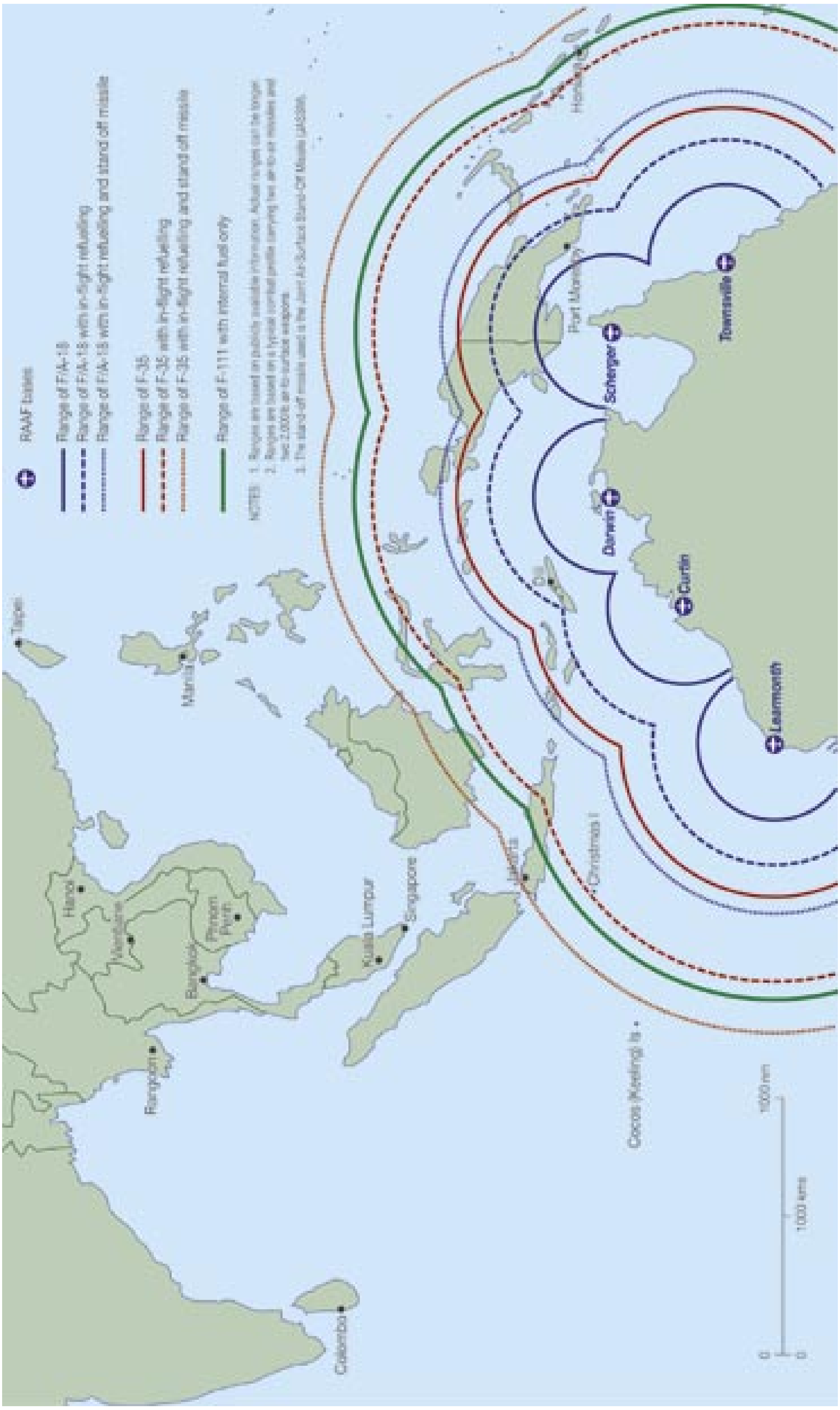
The ability of the JSF to directly target threat systems will be substantially enhanced by the combination of synthetic aperture radar, electro-optical and electronic support cueing. Data fusion between these systems will remove some of the workload from the pilot in interpreting the information.

In total, JSF survivability is expected to be markedly superior to that of current strike aircraft such as the F-111. The JSF's ability to provide self-escort (protection) is also a substantial advantage over a dedicated strike aircraft. The fighter also enjoys advantages in terms of passive (stealth) and active (hard and soft kill) countermeasures.

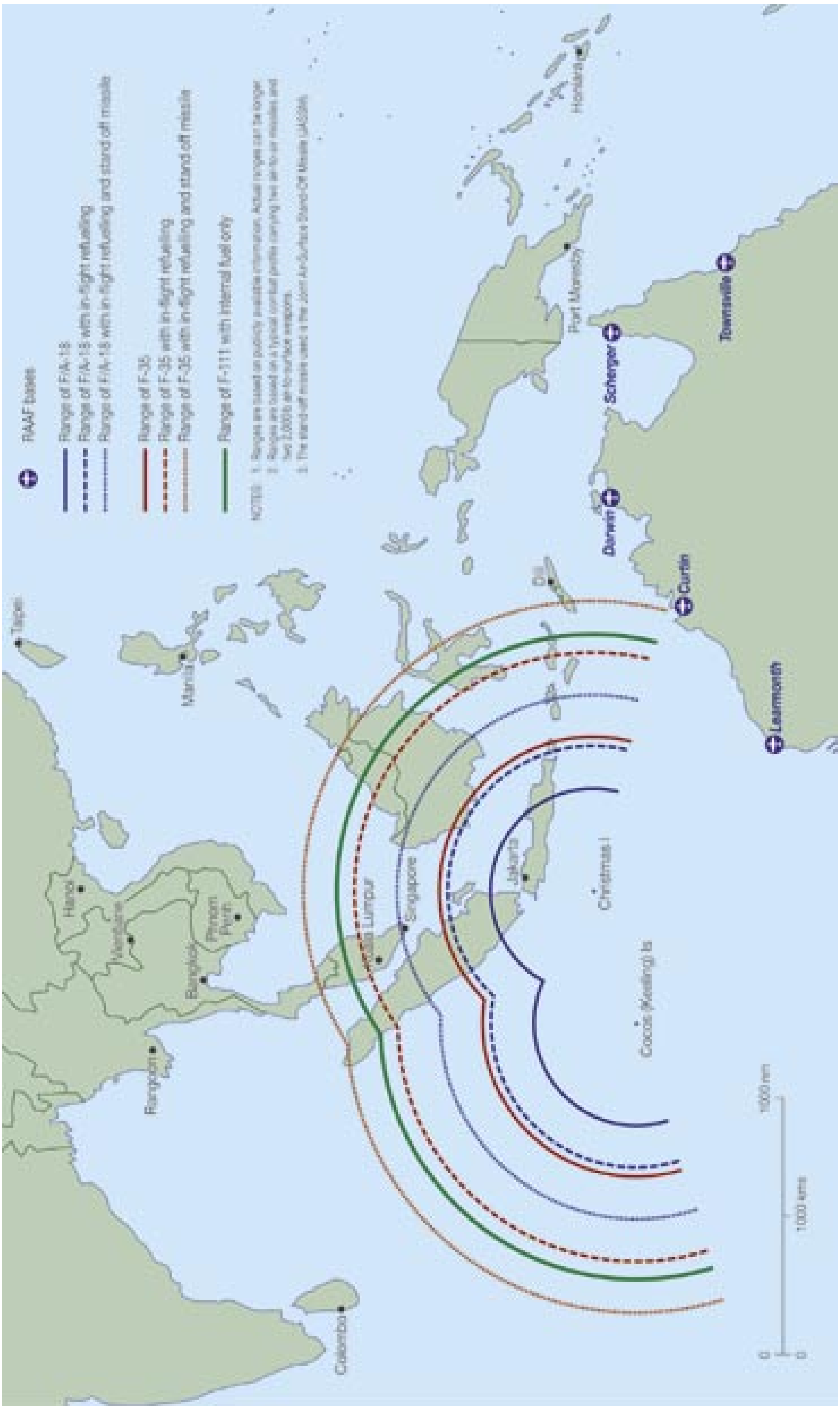
Weapons effectiveness

The need to produce large numbers of bomber and strike aircraft has diminished with improvements to the accuracy of aircraft sensors and weapons. However, this generational improvement in weapon systems is not unique to the JSF. To explore the benefit that the JSF is likely to bring to ADF strike capability, this section will provide a synopsis of JSF capability compared to the F-111 from the perspective of weapons effectiveness. The F-111 has been selected as the reference because, even in relation to the fourth generation multi-role fighters, the F-111 is regarded by many as the superior strike platform.

- **Sortie generation.** Lockheed Martin expects the JSF to have an availability rate of 90%, substantially better than the ageing F-111, but achieving this figure may require significant logistic stockholdings. The improved availability rate of the JSF has the same effect as purchasing more aircraft and multiplying force size, as does the fighter's ability to accurately re-task in flight.
- **Sensor accuracy and fusion.** The greatest difference in targeting capability between the JSF and the F-111 is created by the synthetic aperture radar, real-time off-board targeting support and on-board data fusion from many sources. The synthetic aperture targeting mode of the JSF's AESA radar will provide high accuracy (1–3 metres) in all weather at very long range. On-board data fusion will also present the pilot with the most current targeting data possible from off-board intelligence, surveillance and reconnaissance and from the fighter's on-board systems. This, coupled with GPS, gives targeting precision and weapon delivery accuracy of less than five metres for weapons such as the GPS-guided Joint Direct Attack Munition (JDAM).
- **Payload/range.** One of the most important measures of effectiveness of a strike fighter is the product of the maximum (unrefuelled) range and payload. The F-111 has excellent range–payload characteristics, exceeded only by heavy bombers. By contrast, the JSF will have a range payload product of around 50–70% of the F-111's. However, while Australia may need a long-range strike capability, much of the mission profile would probably be in 'ferry mode', typically over water, and potentially devoid of air defences. The range of penetration into 'harm's way' may be relatively short. While the new fighter cannot match the range of the F 111, the $2 billion Air-to-Air Refuelling Project will deliver more capable refuelling aircraft to support JSF operations (see range maps on pages 49 and 50). These tankers could well provide mid-range refuelling, both inbound and outbound, without risk from anything but very long range interceptors.



Map 1: Respective Aircraft Ranges from Australian Bases



Map 2: Respective Aircraft Ranges from Offshore Islands

- **Integration and interoperability.** The JSF has been designed as a network centric capability and will integrate within the broader US command and control, communications and electronic warfare architectures. The fighter will therefore be more able to draw from and contribute to national and force-level ISREW capabilities. Operation of the JSF will also allow Australia to more readily participate in a US-led coalition, where interoperability of systems is a critical requirement.

Supporting and complementary capabilities

The analysis of JSF performance has highlighted a number of supporting or complementary capabilities that might add to a greater force effect. Detailed analysis of these capabilities needs to be undertaken to determine the optimal 'balanced force' to meet capability requirements. Because the JSF may be purchased by many regional nations, Australia's relative capability could be determined by the integration and quality of supporting capabilities, rather than simply by the JSF platform alone.

- **AEW&C.** Against current regional threats, the JSF will be less dependent than the F/A-18 on AEW&C because of its superior sensor suite. However, the growth in low/very low signature threats, particularly cruise missiles, will require detailed analysis of the AEW&C/JSF capability mix and the vulnerability of AEW&C to low observable threats. The JSF may not be the only, or optimal, way to engage cruise missiles; a combination of AEW&C with surface-based air defence systems might prove a more effective method. And if the JSF was to fully utilise its stealth advantage by going into operations 'nose-cold' (that is, with its own sensors switched off and relying on external sensors), then it would rely on systems such as AEW&C aircraft more than the F/A-18. Therefore, if the government wants to realise the JSF's full potential, it should exercise the option of purchasing a further two AEW&C aircraft.
- **AAR.** The JSF has a greater combat radius than the F/A-18, but a smaller radius than the F-111. Arguably, the JSF has less need of AAR for air-to-air combat but a greater need when performing those roles carried out by the F-111. The ADF will need to decide the battlespace effects required from precision strike, the strike package sizes, the combat ranges needed to strike targets, and sortie generation factors to determine the JSF force size and its requirement for AAR. AAR is currently being addressed under Project Air 5402 and its force size will depend on requirements from the NACC JSF analysis. So the optimal number of AARs to support the JSF fleet should be assessed as a priority. Based on recent

X-35 being refuelled. © Lockheed Martin.

operations in Iraq in which AAR capability was the dominant limiting factor on mounting air operations, it is not unreasonable to advocate for at least 6–7 AARs for Australia, and it would not be surprising if detailed analysis suggests a requirement for more.

- **Force-level electronic warfare.** Force-level electronic warfare comprises electronic support and electronic attack. Electronic warfare self-protection cannot be traded off against force-level electronic warfare capability because of potential vulnerabilities in force-level electronic warfare availability, coverage and communication links. Nevertheless, a dedicated force-level electronic attack capability will improve the effectiveness of the JSF's low signature. The fighter will be able to share information via data links and broadcast services, and should be an integrated component of the future force-level electronic support architecture.
- **Strategic ISREW.** Improvements to the accuracy, availability and timeliness of ISREW information will have a large impact on JSF effectiveness. NACC will need to understand the impact of future ISREW architecture on air warfare. The ADF will need to understand and acquire the intelligence, surveillance and reconnaissance collection, analysis and distribution capability required for near real-time targeting that JSF will be able to exploit.
- **UCAVs.** In a heavily defended environment, the JSF will be more survivable than any aircraft Australia has operated. However, as the sophistication and density of enemy air defences rises, JSF (and hence pilot) survivability diminishes, perhaps to a point that is unacceptable to the government and the public. NACC will need to identify and quantify areas in which a UCAV might be a more cost effective or desirable option. Such analysis would also include the overheads associated with UCAV operations, particularly command, control and communications. The costs of having two systems rather than one would also have to be identified.
- **Stand-off weapons.** Consideration of stand-off weapons, potentially launched from platforms other than the JSF, would also be an option where JSF survivability is an issue. Stand-off weapons may prove to be cheaper and more practical than UCAVs, particularly during the first phase of the NACC project. As the JSF Project Office continues discussions on the total suite of weapons that will ultimately equip the JSF, Australia needs to ensure that ADF requirements are factored in, and not simply accept US force requirements that may be quite different from ours. At this stage, stand-off weapons issues are expected to be addressed in the JSF Block Upgrade approach. It is understood that Defence intends to purchase the Lockheed Martin's Joint Air–Surface Stand-off Missile for JSF Block 4, to be delivered in 2012–13.

The preceding list is not exhaustive. Other capabilities, such as tactical data links, missiles, air-to-ground munitions and mission planning systems, will need to be considered.

Furthermore, if the ADF is to remain true to its declaration on the importance of network-centric warfare, the total ADF air defence picture needs to be factored into NACC planning.

In addition to NACC and projects such as AAR and AEW&C, two other projects will add directly to the ADF's air defence capabilities. Joint Project 117 seeks to acquire a new ground-based air defence system, and Sea 4000 will lead to the procurement of three or four new air warfare destroyers for the RAN. Together, these two projects will cost $4–5 billion. Beginning at a strategic level, analysis is needed to determine the best balance between Joint Project 117 (Ground-Based Air Defence), Sea 4000 (Maritime Air Warfare Capability) and NACC, and what, if any, trade-offs might be made between these projects.

Chapter 6

THE OTHER 'CONTENDERS'

This section overviews the aerospace platforms that were candidates in the original Project Air 6000. The aim is not to conduct a detailed analysis of each type, but to identify some of the aspects of each and to try to understand why the government has nominated the JSF as the preferred solution.

During the June 2002 press conference announcing decision to participate in the JSF SDD phase, the Chief of Air Force suggested that a comparative analysis of all the candidate aircraft had been made and had led to the JSF being selected as the best aircraft to meet Australia's needs. Despite an offer made to journalists to 'go right through the characteristics of all the candidates', that comparison has yet to be released publicly.

Boeing F-15E Eagle

F-15E Eagle. © US Defense Dept.

The F-15E is a large twin-engine strike fighter midway in size between the F/A-18A and the F-111. It spans 42.8 ft, weighs 32,000 lb empty and has a maximum take-off weight of 81,000 lb.

The F-15E evolved from the F-15C air superiority fighter. The F-15 design heritage stems from the Vietnam War, where both USAF and USN fighters had difficulty coping with the air combat threat posed by the small, fast and agile MiG-21.

The F-15 design criteria stressed high thrust-to-weight, speed, both short and long range air-to-air weapons, good visibility from the cockpit, and agility. Above all, the requirement stressed the need for a powerful radar, and the size of the F-15 is a direct consequence of the need to carry a large-diameter radar antenna. Boeing has produced more than 1,500 F-15s; they have been exported to Japan, Israel, Saudi Arabia and purchased by South Korea.

With the addition of conformal fuel tanks, multi-mode radar, infra-red and laser targeting sensors, and mission system technology from the F/A-18A, the F-15C evolved into the F-15E strike fighter. When the USAF retired its F-111 aircraft the strike role was assumed by the F-15E, although the shorter range F-15E was more reliant on USAF in-flight refuelling support than the F-111.

> … the purchase of an expensive, non-stealth aircraft of dated design, with high maintenance costs, against a requirement projecting to 2040, would not be a forward-looking decision.

The F-15E carries 13,123 lb of internal fuel plus 9,402 lb of fuel in two conformal tanks. Being a large aircraft, it can carry a wide range of weapons and external fuel tanks while still maintaining an operationally useful combat radius. Its demonstrated range under tactical conditions is substantially greater than the F/A-18A's but less than the F-111's. One hallmark of the F-15 series is its demonstrated long-range radar performance. In the strike role, its modern radar and sensors have benefited from continued updates and are superior to those in the F-111.

The first F-15E entered operational service with the USAF in April 1988. The aircraft is still in production for the USAF, and in April 2002, Korea selected the F-15K as its new strike fighter. Korea has ordered forty aircraft, scheduled for delivery from 2005. Singapore has short listed the aircraft together with the Rafale and Typhoon. Derivatives of the F-15E will stay in production until at least 2011.

The Korean deal includes forty F-15K aircraft, electronic warfare equipment, a suite of air-to-air missiles with helmet sight cueing, a range of precision and stand-off strike weapons, and newly integrated General Electric engines. The reported US$4.6 billion project price covers not only the platform but an air combat system with a full range of sensors, electronic warfare equipment, integrated air and ground weapons, and an industry package.

Despite lacking the range of the F-111, the F-15E has a demonstrated track record in both air superiority and precision strike operations. Some regard it as the benchmark for current in-service strike fighters. It comes with already integrated weapons and is planned to receive precision small bomb JDAM weaponry in 2006 and two squadrons of F-15E have already been upgraded with Active Electronically Scanned Array radars.

Congressional critics of the F/A-22 Raptor often cite the robust all-round performance of the F-15E against existing threats as a good reason not to proceed with the F/A-22, although the USAF has not accepted that view.

The F-15E would not be cheap. But it would carry less procurement, schedule, cost and performance risk than development designs. It is a proven interoperable system. The F-15E has been subject to some low observable treatments but is not a stealth aircraft.

Its support costs per aircraft would likely be more than those of the F/A-18A but less than the F-111's, although the new engine package may offer benefits in this regard. A question mark also hangs over the quality of the Australian industry package likely to be offered as part of an acquisition.

Notwithstanding the F-15E Eagle's demonstrated capability, the bottom line appears to be that the purchase of an expensive, non-stealth aircraft of dated design, with high maintenance costs, against a requirement projecting to 2040, would not be a forward-looking decision.

Boeing F/A-18E/F Super Hornet


F/A-18E Super Hornet. © US Navy.

With a wingspan of 44.4 ft, an empty weight of 30,564 lb and a gross take-off weight of 66,000 lb, the F-18E/F multi-role strike fighter is slightly smaller than the F-15E. It is essentially a 25% scaled-up F/A-18A/B with similar aerodynamic features. The single-seat version is designated as the F/A-18E and the two-seat version as the F/A-18F.

The F-18E/F Super Hornet had its genesis in the cancellation of the A-12 stealth strike aircraft, which left the USN with no follow-on strike aircraft to replace the aging A-6 Intruder. The F-18E/F was quickly developed to fill the emerging gap in the USN air order of battle. Subsequently, the USN decided to replace its F-14 Tomcat air superiority fighter with the F/A-18E/F.

The F-18E/F is a purpose-designed, multi-role fighter utilising much of the technology developed from its smaller predecessor. Like the F/A-18A it is agile, has a slow landing approach speed, and has a reputation for being able to tolerate high levels of battle damage.

The F/A-18E/F carries 14,190 lb of internal fuel and in its normal operational configuration would carry three 480 US gallon external tanks with 9,468 lb of fuel, plus weapons. Although of longer range than its predecessor, it still falls well short of the range demonstrated by the F-111. Many of its systems and sensors are derived from its predecessor and its radar reflects the aircraft's need to be a 'jack of all trades' rather than to excel in the air-to-air arena. The F/A-18E/F has benefited from low observable technology, notably in the design of its engine intakes, but it is not a stealth (very low observable) aircraft.

The F/A-18E can reasonably lay claim to being a credible strike fighter system with a range of integrated weapons. As a naval strike fighter, it makes several compromises between approach speed, weight and structure. In the Australian environment, which stresses long sensor detection range, the proposed active array radar under development for the Super Hornet would be an important capability enhancement.

As it has secured no orders beyond the USN, the future upgrade path for F/A-18E/F will depend on how the USN apportions its aviation development priorities between the F/A-18E/F and the JSF.

The USN currently plans to buy 548 Super Hornets through to 2010, although budgetary pressures suggest this could be reduced to 460 aircraft. On the other hand, the USN hopes to secure funding for an electronic warfare version of the aircraft labelled the EA-18 Growler, which is proposed to replace the USN's 125 EA-6B Prowler electronic warfare aircraft.

The F/A-18E/F has benefited from 'affordable manufacturing' technology and would be cheaper than an F-15E. It is claimed to have 40% less parts than the F/A-18A, and should have low schedule and cost risk. The Super Hornet is a fairly predictable entity because of its development heritage and Australian familiarity with its F/A-18A predecessor. The manufacturer's previous F/A-18A experience may also assist the development of an industry package.

But the bottom line appears to be that the Super Hornet is not sufficiently advanced from its F/A-18A heritage. It is still encumbered by some weight and design features stemming from its need to be aircraft-carrier compatible, and it is not a stealth aircraft. In the Australian context, its range, electronic warfare systems and radar performance would come under close scrutiny. It would be too dependent on in-flight refuelling and its dated F/A-18A design heritage is inappropriate for operational requirements to 2040.

Dassault Rafale

Rafale fighter at Seoul Air Show 2001.
© SKOREA-AVIATION.

The Rafale is being developed as a multi-role fighter for the French Air Force (Rafale C) and the French Navy (Rafale M). It is a twin-engine, delta-wing aircraft with foreplane. Rafale C has a wingspan of 35.5 ft, an empty weight of 21,700 lb and a maximum all-up weight of 43,000 lb, increasing with further development to 54,000 lb.

The Rafale was initially proposed as a multi-role aircraft to replace French Air Force Jaguars, with a naval variant to replace French Navy Crusaders and Super Etendards. It is almost identical in size to the Eurofighter Typhoon (the French withdrew from the Eurofighter consortium in 1985).

The prototype flew in 1986 and the Rafale is now envisaged as a replacement for up to six types of French combat aircraft. Its manufacturer, Dassault, has a long history of developing and exporting robust multi-role fighter aircraft, although the Rafale has yet to achieve an export sale. Dassault has now been joined in a development consortium by the two French companies Thales (electronics) and Snecma (engines).

The Rafale comes in both single-seat and two-seat versions with multi-mode radar, an electronic warfare suite, an electro-optical warfare capability and a data link package. Progressive integration of air and ground weapons will be complete in 2009. Further phases of weapons integration are proposed, including a helmet-mounted sight capability in 2006. Development priority has been given to the naval Rafale M. The naval version is about 80% structurally similar to the Rafale C, but comes with a 1,345 lb weight penalty as a consequence of its navalisation.

The Rafale C carries 9,920 lb of internal fuel, about the same as the F/A-18A. The internal fuel can be supplemented by five large external fuel tanks containing an additional 16,700 lb of fuel (note that the F/A-18A carries only 6,630 lb in three external tanks). To reduce the reliance on the Rafale's large external tankage and to augment the relative small internal capacity, Dassault flew a prototype with two conformal fuel tanks in April 2001. The two conformal tanks fitted along the spine of the aircraft contain a total of 4,040 lb.

The Rafale is marketed as a long-range aircraft, although it seems to place undue reliance on external tankage. The conformal tank option is attractive, but its future development path and funding are unclear and it may impose flight envelope limitations.

The Rafale features some fuselage wing blending, which contributes to a reduced radar signature, but it is not a stealth (very low observable) aircraft. The small size of the nose radome of the aircraft also suggests that its radar may have difficulty meeting the Australian performance requirement.

The first French naval Rafale squadron has been formed. The French Air Force is accepting some interim standard Rafale aircraft, with its first squadron scheduled for operational status in 2006. To date, the French Government has contracted for sixty-one aircraft out of a total envisaged buy of 294, with the last aircraft due for delivery in 2019.

By withdrawing from the Eurofighter consortium, the French have chosen to be masters of their own program rather than be involved in the complexities of a European consortium. They have maintained their development aim of a multi-role combat aircraft, but with a production base of only 294 aircraft and both land and naval variants, the pace of development has been limited by the constraints of the French national budget.

The Rafale development consortium has proposed an export version that includes conformal tanks, active array radar, upgraded electro-optics and improved Snecma M88-3B engines. This version was offered to South Korea with a planned delivery of 2006. However, after making the short list of two, the Rafale was beaten by the F-15K, although some reports indicated that the Rafale was technically superior. In October 2003, Singapore shortlisted Rafale against its requirement for 20 fighters.

Lack of stealth capabilities, integration with US-sourced weapons and other interoperability issues could be likely problems.

The Rafale appears not to have any compelling price advantage, as Australia would be expected to contribute significantly to the development of the project. However, Dassault has done previous business in Australia and would be expected to offer an attractive package for Australian industry.

The bottom line is that the Rafale is seen as lacking the range and sensor performance that are fundamental to capability. It also involves substantial development and capability risk, especially given its slow pace of development. Lack of stealth capabilities, integration with US-sourced weapons and other interoperability issues could be likely problems. And the projected development of some capabilities is expected to go beyond 2012, which is the planned introduction date for JSF. In essence, the Rafale is today's technology for tomorrow's environment.

Eurofighter Typhoon

Eurofighter Typhoon. © 2003 BAE SYSTEMS.

Initially called Eurofighter, the Typhoon is being developed by the Eurofighter consortium as a multi-role fighter. Production workshare is determined in accordance with the number of aircraft required for each nation: UK 37%, Germany 30%, Italy 20% and Spain 13%. The Typhoon is a delta-wing aircraft with foreplane and two Eurojet turbofan engines. It spans 35.9 ft, weighs 24,240 lb empty and has an all-up weight of 46,300 lb, with a projected overload weight of 50,700 lb.

The genesis of the Eurofighter program was the need to develop an air superiority fighter to replace British, French, German, Spanish and Italian fighters. After the French withdrew in 1985, the 1987 European Staff Requirement specified an agile, high thrust-to-weight aircraft armed with AMRAAMs and ASRAAMs to counter the threat of high-performance Soviet fighters in a European conflict scenario.

The Typhoon is similarly sized to the Rafale, with the most obvious external difference being the Typhoon's large under-fuselage air intake. Budgetary pressures and the end of the Cold War resulted in a reduction in the proposed production run from 765 to 620 aircraft. The first of seven development aircraft flew in 1994.

The Typhoon features multi-mode radar, an electronic warfare suite including towed decoys, an infra-red sensor, a helmet-mounted sight and a high degree of cockpit automation, including voice activation. Progressive integration of these capabilities will be complete in 2006. Air-to-air weapons integration is proceeding, but there are doubts over the development path and funding for the integration of the systems and weapons necessary for the air-to-ground role.

The 'Tranche 1' contract is for 148 aircraft. First deliveries of aircraft slipped into 2004, with the first squadron planned to be operational in 2006. Tranche 1 will be delivered with three levels of progressive improvements in capability, with the first deliveries of aircraft being capable of air defence training (2003), the second group fully air defence capable (2004), and the third group multi-role capable (2010).

Contract signature for 236 Tranche 2 aircraft was planned for 2003 for delivery in 2006. These aircraft are envisaged to be of enhanced operational capability, with improvements in the air-to-ground weapons package and with the Storm Shadow stand-off cruise missile to be integrated in 2010. Tranche 2 contract signature has been delayed over concerns about the cost Tranche 3, for 236 aircraft, will be delivered out to 2015.

The Typhoon carries 9,920 lb of internal fuel, about the same as the F/A-18A. The internal fuel can be supplemented by three external fuel tanks containing an additional 5,900 lb of fuel, slightly less than that carried by the F/A-18A. As a consequence of this moderate fuel capacity and the need to achieve an improved combat radius in the strike role, Eurofighter is proposing the development of two upper-fuselage conformal fuel tanks containing a total of 8,800 lb.

The Typhoon includes radar cross-section reduction, but it is not a stealth (very low observable) aircraft. The small size of the nose radome of the aircraft also suggests some limitations in radar performance. As well, the air-to-air heritage of its radar suggests that its robustness in the air-to-ground role would need to be critically examined.

Despite the longevity of the Eurofighter program, the Typhoon is still very much a development program, with consequent risks in development, performance, schedule and budget. As with the Rafale, ongoing and progressive development of the aircraft is envisaged in parallel with production deliveries. On top of this is the management/political risk associated with the four-nation ownership structure of the Eurofighter consortium and based on prices reportedly being paid by the European partners, a Typhoon purchase would not be cheap.

The bottom line is that Typhoon is not a stealth aircraft and, in Australian operations, its range, systems and radar performance would come under close scrutiny. More critically, given its air superiority design heritage and slow pace of development, the Typhoon is not generally seen as able to meet the demanding operational requirements of the Australian multi-role capability. There are potential interoperability problems, but given the close nature of the US–UK military relationship these aren't likely to be insurmountable. Similar to Rafale, many would perceive that Typhoon is not a significantly large improvement in capability over the F/A-18 to justify the billions of dollars of investment.

Finally, the fact that Italy and the UK have committed to the JSF (the UK committed US$2 billion to join the JSF project as an industry partner, while Italy committed some US$1 billion) raises questions about the ongoing level of funding commitment by the European partners to the development of a multi-role Typhoon.

Lockheed Martin F-16 Block 60

F-16 Fighting Falcon. © Lockheed Martin.

The F-16C/D is a single-engine, multi-role fighter slightly smaller than the F/A-18. It has a wingspan of 31 ft, an empty weight of 18,600 lb and a gross take-off weight of 42,300 lb. The maximum weight of the F-16C/D Block 60 is reported to be 50,000 lb.

The YF-16 demonstrator first flew in 1974, winning the USAF Lightweight Fighter competition. The F-16 was envisaged as a lightweight day fighter operating as the low end of a mixed force, with the F-15 providing the high end. The initial requirement emphasised close-in air combat, good visibility from the cockpit, and agility: hence the blended wing design, relaxed flight control stability and a powerful high-bypass ratio single engine.

Subsequently the F-16 gained a long-range air-to-air combat capability with AMRAAMs and an all-weather strike capability to evolve into a multi-role fighter. The F-16 has been exported to nineteen nations and more than 4,000 aircraft of various configurations have been built. The F-16 is still in low-rate production for the USAF and is expected to remain in production until at least 2010.

The current build of F-16C/D aircraft is Block 50/52. This model includes upgraded multi-mode radar, improved infra-red navigation and targeting sensors, improved electronic warfare, the addition of Link 16 data links, helmet-mounted sight weapons cuing, and air-to-air and air-to-ground sensors. Much of the ground attack capability was introduced into the earlier F-16C Block 40/42 to enable the USAF to redress the loss of all-weather strike capability when the F-111 was retired from USAF service.

The F-16C carries 6,800 lb of internal fuel (the two-seat F-16D model carrying only 5,900 lb) plus 6,700 lb of fuel in three external tanks. Although only a small aircraft, its high thrust-to-weight ratio enables it to carry a wide range of weapons and external fuel tanks. Its demonstrated range under tactical conditions is better than that of the F/A-18A. The F-16 has benefited from continual development and upgrading, with the current emphasis being on the integration of the latest range of US precision weapons, such as JDAM.

The F-16's introduction into service was marred by a high accident rate and concerns that the aircraft's day fighter design heritage would limit its operational utility. The accident rate was attributed to an immature engine and an insufficiently developed flight control system. The USAF response was to 'compete' the engine by developing a General Electric alternative to the original Pratt & Whitney engine. All models since Block 30 can accept either engine, as requested by the customer.

Engine enhancements flowing from the competition between its two engine suppliers have been an important stimulus to the F-16's achievement of improved reliability, better performance and reductions in the cost of logistic support.

The F-16C Block 60 is under development for the United Arab Emirates and Israel. An active array radar will be fitted, with an internal infra-red system replacing the current 'podded' system. In addition, an up-rated engine and spine-mounted conformal fuel tanks holding 3,350 lb are proposed. The USAF is expected to continue to buy F-16 aircraft pending the full development of the JSF.

The F-16 is a far cry from the aircraft that initially entered USAF service in 1985. It is a known quantity that works well, and for a small aircraft it carries out its roles with competence and all-round reliability. It is, however, not known for long range and its small radar is an obvious limitation. It has benefited from some signature reduction but is not a stealth aircraft.

The Block 60 update, with the addition of active array radar, the internalisation of its infra-red system and more internal fuel, is the most significant update since Block 40/42. However, with both the USAF and Lockheed Martin fully focused on the development of the JSF, it is likely that further upgrades of the F-16 will receive a lower priority as the JSF comes on line in about 2010.

The bottom line is that, in 1981, Australia declined the purchase of the F-16A in favour of the F/A-18A. In these circumstances, and notwithstanding the capability of the F-16C Block 60 aircraft, the purchase of an F-16 as a Project Air 6000 solution would have been a contentious decision.

Lockheed Martin F/A-22 Raptor

F-22 Raptor. © US Airforce.

The F/A-22 is the USAF replacement twin-engine air superiority fighter for the F-15C. It is a similar size to the F-15, with a wingspan of 44.5 ft, an empty weight of 31,670 lb and a gross take-off weight in excess of 60,000 lb.

The construction of the Lockheed Martin YF-22 and Northrop/McDonnell Douglas YF-23 prototypes were authorised in 1986 under the auspices of the USAF Advanced Tactical Fighter project. Two aircraft of each type were ordered, each type being fitted with Pratt & Whitney YF119 and General Electric YF120 engines. In 1991, the F/A-22 with F119 engines was announced as the winner. Two key design criteria were stealth and supercruise.

As a stealth aircraft, the F/A-22 cannot carry external fuel tanks without jeopardising its stealth characteristics. A high internal fuel capacity was therefore a design requirement. The internal fuel capacity of the F/A-22 is classified but is estimated to be about 19,000 lb. An additional 15,215 lb in four external fuel tanks can be carried when stealth is not required.

To preserve its stealth signature, the F/A-22 carries its weapons in three internal bays. One infra-red missile is carried in each of two side bays and six AMRAAM long-range air-to-air weapons are carried in the under-fuselage bay. All electronic antennae are conformally mounted and all electronic emissions from the aircraft are controlled to ensure a low probability of detection.

Supercruise is the ability to sustain supersonic speed without the use of afterburners. Tactically, a speed of the order of mach 1.4 precludes a successful attack by missiles launched from either the beam or rear sectors. Effectively, an aircraft in supercruise can only be engaged from the front, and only then if the engaging weapons system has the detection and reaction capability to respond.

a range of questions, such as technology transfer, development and schedule risk, would need to be addressed … But the dominant concern is simply one of affordability.

Stealth plus supercruise provides the F/A-22 with a substantial combat advantage. As well, the ability of two F/A-22 aircraft to continually exchange and share sensor data without voice communication (also a key feature of the JSF and any aircraft equipped with Link 16 or comparable data links) overcomes a key vulnerability of fighter operations and significantly enhances combat effectiveness.

The F/A-22 program is under development following the construction of nine prototype aircraft. The project features a heavy emphasis on the development of software, mission systems integration and weapons integration. The F/A-22 is planned to move to high-rate production in 2003, with the first squadron being declared operational in 2006.

Following a 1993 review, an air-to-ground capability was authorised. The initial concept was for the F/A-22 to contribute to strike operations by delivering two internally carried JDAM precision weapons following a stealth penetration into the target area. More recently, the F/A-22 strike capacity is to be increased by enabling the delivery of eight precision-guided, small-diameter bombs, all carried internally.

The F/A-22 has not been without its development problems and the project has been extraordinarily expensive, but it is an extraordinary combat aircraft that will go unchallenged until new breakthroughs in technology. Critics have argued that it is a 'silver bullet' project whose capability is not required, but it has survived repeated funding challenges in the US Congress, largely on the basis that the F-15C will start to lose its combat effectiveness against future threats and a replacement will be needed.

The USAF remains completely behind the project and, barring termination by Congress, the F/A-22 will supersede the F-15C in the air superiority role. It will also augment the USAF capability in stealth precision strike, which is currently carried out by the F-117 and the B-2.

There is little doubt that the F/A-22 would perform exceptionally in Australian air-control scenarios, but a range of questions, such as technology transfer, development and schedule risk, would need to be addressed. As well, the development path from air superiority fighter to strike fighter is still unclear and possibly unfunded, and there would be very little scope for any Australian industry involvement.

But the dominant concern is simply one of affordability. A commonly quoted cost is US$62 billion for 339 USAF production aircraft. To this needs to be added development and weapons costs. There is now little scope for a quality/quantity trade-offs, because aerospace combat forces are already quite small in numbers. A credible number of 'silver bullets' is still required to maintain a critical and sustainable combat mass. The bottom line for Australia is that the F/A-22 has insufficient multi-role capability at too high a price.

SAAB JAS 39 Gripen

JAS39 Gripen.
© 2003 BAE Systems.

The SAAB JAS 39 Gripen is a single-engine, multi-role fighter with delta wing and foreplane. It has a wingspan of 27.5 ft, an empty weight of 14,600 lb and a maximum all-up weight of 30,864 lb.

SAAB has been designing and building jet fighters since the end of World War II. Situated between the Western powers and the Soviet Union, Sweden fostered a strong national aerospace capability that was an integral part of its policy of armed neutrality. Unfortunately, this policy did not assist the export of SAAB aircraft, which otherwise had a good reputation as capable fighters.

The requirement for Gripen stemmed from the Cold War period, and it was intended to replace the Swedish Air Force fleet of Viggen and Draken fighters. Since the break-up of the Soviet Union and the consequent downsizing of the Swedish defence forces, SAAB has further developed the Gripen as an export aircraft.

The Gripen was designed as a multi-role aircraft, sized to operate with minimal manpower and logistic support from short sections of motorway dispersed around Sweden. It is a compact aircraft carrying 5,000 lb of internal fuel. Since its first flight in 1988 it has been progressively developed, with the last of the Lot 3 aircraft scheduled for delivery in 2007. This will complete the SAAB contracted commitment to deliver 204 aircraft to the Swedish Air Force.

The Swedish Lot 3 aircraft include improved cockpit displays, helmet-mounted sight, improved multi-mode radar processing, enhanced electronic warfare systems, in-flight refuelling capability and an electro-optics package. Gripen features an advanced data link capability and its integrated armament packages include heat-seeker missiles and AMRAAMs, and a range of air-to-ground missiles including German Taurus stand-off weapons.

An export version of the Gripen has been developed by SAAB–BAE Systems Gripen AB—a joint venture between SAAB and BAE Systems. Sales to date have been to South Africa (28 aircraft by 2012) and the Czech Republic (24 aircraft). While the Gripen lacks the size and radar performance of some other fighters, it has emerged as a strong contender in the lower end of the world market. It has also benefited from the BAE Systems linkage, although from the Australian perspective the Gripen would have difficulty meeting some operational requirements. An active array radar is proposed for integration by 2010.

The bottom line is that, although Gripen would come at a significant cost advantage, its lack of stealth and small size would be a disadvantage in the demanding Australian operational scenario, which stresses range, sensor performance and weapons payload.

Sukhoi Su-30M

Indian Air Force's Sukhoi-30k aircraft.
AP via AAP/Suddharth Kumar

The Russian Su-30M is a large, two-seat, twin-engine, multi-role fighter with foreplanes and thrust-vectoring engines. It has a wingspan of 48.2 ft, an empty weight of 39,022 lb, a normal take-off weight of 57,518 lb and a maximum weight of 83,775 lb.

Even to the avid military enthusiast, the Sukhoi series of fighters with its history of inconsistent model designations and 'one-off' fighter demonstrator aircraft can be most confusing. The Su-27 prototype first flew in 1977, a large aircraft with unique fuselage/wing blending and two widely mounted engines in separate tunnels. Known initially by the NATO designation Flanker A, the Su-27 was the high part of a high–low fighter force mix, with the MiG-29 as the lower capability fighter.

The role of the Su-27 was to engage NATO fighters at long range, especially the F-15. It was also designed to engage aircraft carrying cruise missiles, before they could launch their stand-off weapons. Other roles included escort of Soviet strike aircraft and the interception of NATO airborne warning and in-flight refuelling aircraft. These roles demanded long range, a powerful radar and infra-red sensor, and long-range air-to-air missiles.

The Su-27 represented a unique aerodynamic solution featuring internal fuel capacity unprecedented in a fighter. Its size enabled the mounting of a large radar and infra-red sensor, plus the ability to carry up to ten air-to-air missiles. Subsequent model designations included a side-by-side two-seat attack aircraft generally known as Su-32, and the Su-30. The prototype Su-30, a tandem-seat long range interceptor, first flew in 1989. In 1997, the prototype Su-30M multi-role fighter was demonstrated, featuring the addition of foreplanes and thrust vectoring.

The current model is best represented by the specifications of the Su-30MK as sold to India. The Su-30MK has benefited by the addition of Western technology, particularly avionics, multifunction displays, navigation equipment and GPS. The aircraft is armed with up to twelve long and short range air-to-air missiles, and a wide variety of guided bombs and stand-off missiles, including long range anti-ship missiles.

The Su-30MK fuel capacity is 20,724 lb, all contained internally in main and auxiliary tanks without the need to carry external fuel tanks, with their high drag penalty. The Su-30MK's strengths are relatively long range, powerful radar, good optical sensors, heavy weapons load and high agility. In capable hands it is a formidable air superiority fighter and it should make the transition into a most capable strike fighter.

More than 600 Su-27 aircraft have been built and exported. The attractively priced Su-30MK will add significantly to these totals. But the Su-30MK still poses difficult development, logistic, support, interoperability and industry problems. In particular, it lacks sophistication in systems integration, and although the aircraft is regarded as robust, Russian industry has yet to establish a reputation for responsive support.

From the Australian perspective, the bottom line is that the Su-30MK would have been an enormously controversial decision, inviting strong criticism from all quarters. Indeed, many wonder why it was ever on the list.

Uninhabited combat aerial vehicles

Artist concept of a Naval Unmanned Combat Air Vehicle (UCAV-N). © US Navy.

The limited number of ground-attack 'UCAVs' available in the market today have evolved from UAV airframes designed for ISR missions. One example is Predator A, which is a piston-engined UCAV that can fly 400 nm, loiter for 24 hours, and return 400 nm to base. It is equipped with electro-optic and infra-red sensors and synthetic aperture radar, cruises at 118 knots, and operates at around 10,000 feet altitude. The Predator A can launch a Hellfire air-to-ground missile guided by a laser illuminator carried in the UCAV.

Predator B is a turboprop-powered development with greater speed, altitude and payload capability, and is planned to carry some eight Hellfire missiles.

Predator streams real-time video back to its operating base via a line-of-sight radio link. This link is limited to about 150 nm; a satellite link must be used over greater ranges.

UCAVs are a further development of unarmed UAVs and can be simply described as combat aircraft without pilots. The Boeing X-45 and Northrop Grumman X-47A Pegasus are development UCAVs for the USAF and USN respectively. Both services are directing the development effort towards achieving a stealth/strike capability against targets that are protected by strong air defences. The X-45 and X-47 may be being brought together in a joint project.

Neither service expects the UCAV to replace the manned strike aircraft in the immediate future. It is seen as a supplement to the more flexible manned aircraft strike option and may be developed to fill the role of a long-endurance electronic warfare platform—a role that is well suited to the preprogrammed characteristics of the electronic warfare jamming mission.

While UAVs and UCAVs can be expected to undergo further significant development, their roles will be supplemental to manned aircraft.

It is important not to credit UAV and UCAV technology with too much capability until the technology has first been demonstrated in realistic operational scenarios. In this regard it is worth recalling that in 1957 the then British Minister for Defence, Duncan Sandys, announced that Britain would cease development of manned fighter aircraft as they were redundant in the missile age.

Sandys was right in that technology had delivered the guided missile, but he failed to comprehend the limitations of the guided weapon in operational situations, complete with the 'fog of war', as distinct to the more clinical environment of scientific testing. As a result, both the Royal Air Force and the British aerospace industry suffered an enormous setback in the further development of manned aircraft.

Certainly, large high-altitude UAVs with long range and theatre persistence will increasingly undertake surveillance, reconnaissance and intelligence missions. These UAVs will carry highly capable sensors and will depend on wideband satellite communications for control and reporting. They will be sophisticated systems with significant support requirements. They are not cheap.

A developing but less clear role likely to be filled by UCAVs will be higher risk stealth penetration missions. These missions, which would include attacks on surface-based air defence sites, will not require the flexibility of manned aircraft. Such UCAVs will be of substantial size to gain the range and penetration speed required for long-range operations. Again, they will be dependent on wideband satellite communications.

Smaller UAVs and UCAVs of limited range and speed, and tied by line-of-sight communications to a controller, are operational now. These vehicles are light, cheap, unsophisticated and tactical in nature. Their sensors are narrowly focused and have been likened to 'looking down a drinking straw'. They will be procured more on the basis of specialist tactical needs than of any NACC requirement, for which they lack speed and range.

While UAVs and UCAVs can be expected to undergo further significant development, their roles will be supplemental to manned aircraft, which will still form the core capability of the air combat force.

The bottom line is that by May 2012, when the strike capability phase of NACC is planned for decision, a more comprehensive understanding of the role UAVs will play will have been gained. This may see UAVs, or a mix of UAVs and manned aircraft, as a possible option.

Chapter 7

RISKS AND ISSUES

If the F-35 JSF delivers everything that has been promised by Lockheed Martin and the Australian and US governments, the fighter will arguably prove to be the best available replacement aircraft for Australia's F/A-18 and F-111 aircraft. The question that remains, however, is how much of what has been promised by the JSF—in terms of its stealth, sensors, cost, general capability, reliability, supportability and so on—might be lost in the delivery and to what degree this will erode the basis of the original effective decision to acquire the aircraft.

The government needs to recognise that there are substantial risks and issues associated with the choice, which should be acknowledged, accepted and ultimately addressed. We also need to accept that our ability to manage some of these risks will be quite limited. While entry in the SDD phase of the JSF project will allow Australia access to some data and information, we will have a very limited ability to:

- alter the US (and UK) user requirements, which in turn means that Australia cannot influence the final JSF capability
- control costs, schedule or quality performance in any way
- enter the production schedule at the point we would prefer
- secure any guarantees of substantial Australian industry participation.

Having program risks does not make the JSF unique: every new military development program has risks, whether the development is of aircraft, ships or tanks. As the JSF aircraft evolves from being a 'paper' design aircraft to a 'real' production and in-service aircraft, it's only natural that problems will surface.

Risk management is one of the many critical tasks that Defence undertakes within the NACC project. The risk management process involves identifying risks, determining their probability and impact, and defining mitigation strategies where necessary. The department seems committed to a program of rigorous analysis to confirm that the JSF will meet Australia's requirements. This effort is backed up by the presence of some twenty Defence Science and Technology Organisation scientists working on the project for that purpose. However, Defence's risk mitigation strategies do not have any public visibility and, until they do, doubts will continue to arise about the department's ability to manage the project appropriately.

If the F-35 JSF delivers everything that has been promised … the fighter will arguably prove to be the best available replacement aircraft for Australia's F/A-18 and F-111 aircraft.

Given the size and complexity of the JSF project it can be expected that the government would receive at least six-monthly updates on its progress from Defence. The government should then make an annual report to the Australian Parliament updating progress on the JSF project. The report would cover how Australia is responding to the various elements of risk and opportunity outlined in this study.

Changing capability

The major issue currently facing the government is that, when it made the effective decision to acquire the JSF, the development of the ADF's specific and detailed capability requirements for the NACC project had only just begun. Defence argues that the JSF is the best aircraft to meet the ADF's capability requirements. Within the high level of the White Paper guidance, this statement is probably true. However the detailed measures of effectiveness and performance of the air combat system are what JSF must be assessed against, and it is believed that these have still not been fully developed.

Minister for Defence Robert Hill checks the full-scale mock-up of the F-35 JSF at the Lockheed Martin plant. © Lockheed Martin.

The decision to commit to the SDD phase seems to have been motivated more by the US-imposed deadline than by a proper and thorough analysis of the aircraft against the ADF's requirements. In fact, the NACC JSF decision is unique in Australia's defence procurement history, as the government has effectively made a sole-source selection of the aircraft even before it has given formal approval to the NACC project and its top-level requirements.

Keeping costs down is the major driver of the aircraft's development in the US. As the JSF develops further and problems arise, it is likely that some elements of the aircraft's capability will be sacrificed to keep overall costs down. As the capability of the JSF changes, there is also a parallel risk that the ADF requirements for NACC will continue to evolve. It therefore remains uncertain at what point Defence might decide that the JSF no longer meets our requirements.

Australia has a very limited ability to influence most, if not all, of the risks associated with the JSF. Admittedly, there is a very real question as to whether Australia really wants the ability to influence the final JSF capability. Defence's general aim should always be to balance its desire to acquire and retain a 'standard' aircraft, and thereby reduce costs and risk, against any perceived gap in ADF requirements.

But we're not talking here about developing a uniquely Australian solution: rather it's about influencing the general JSF design to ensure that it meets our specific requirements. And our only real element of control is our actual involvement in the JSF program. The danger remains that, having taken the effective decision to commit to purchase the aircraft, Defence will prove incapable of walking away from that commitment if Australian requirements are not met.

Naturally, some capabilities and requirements will remain classified, and requirements are subject to ongoing refinement as analysis continues. However, Defence needs to publicly specify, in detail, the capabilities of the JSF that make it the preferred solution for Australia's new air combat capability. Some sort of baseline definition is needed now: as the development of the aircraft continues and perhaps as its final performance specifications change, this will allow continuing assessment of the appropriateness of the decision to acquire it.

Contingency plans

Should it be decided that the JSF does not meet our requirements, the next risk is that Defence does not seem to have any contingency plan to cater for this, other than restarting the capability selection process halted by the JSF decision.

Defence began the formal selection process in 2001, and after extensive modelling and analysis this was expected to result in a recommendation to government in 2006. Should the department restart this process in 2006, this could mean that a decision goes to government in 2011, when the new aircraft are due to replace the F/A-18 in 2012. Obviously the process could be shortened, but this highlights the risks associated with the absence of a back-up plan. Defence believes that, if the JSF proves unacceptable for ADF requirements at the 2006 decision time or earlier, the department could reassess the remaining Project Air 6000/NACC contenders against the later, better refined requirements. Defence further states that the 2012 in-service date could most likely still be met in those circumstances, given that all alternative aircraft would already be in production and in service.

Normal Defence procurement practice when it selects a winning tender is to have a second-place tenderer on hold, on whom it can call should the original tenderer falter in negotiations or not meet ADF requirements for whatever reason. This principle should also apply to the JSF purchase. At the same time as Defence is analysing the JSF, it could undertake a parallel process to decide which of the other contenders would best meet Australia's capability requirement. It would also have the advantage of placing some pressure on Lockheed Martin and the Pentagon to ensure that Australia's requirements are ultimately satisfied. Singapore is currently taking this approach. While it is a Security Cooperation partner in the JSF, it has also initiated another competition running to replace its ageing A-4 Skyhawk fleet. The competition, between Dassault Rafale, Eurofighter Typhoon and Boeing F-15, gives Singapore an alternative plan if it decides not to purchase the JSF.

Industry would be under no illusion that the JSF is not the preferred aircraft, and could be supplemented for the cost of assisting this new tendering process. This would be consistent with the initiative recently announced by the government as part of the Kinnaird Review of Defence Procurement, which called for greater expenditure of funds in the early development of capability proposals. Just as a contingency strategy is needed to manage the retirement of the F-111 should the upgraded F/A-18 not deliver the expected level of replacement capability, so do similar strategies need to be developed in case the JSF doesn't meet the required level of replacement capability for the F/A-18.

Weapons fit

In order to keep JSF costs down and the program on schedule, the US has been progressively narrowing the types of weapons the aircraft will be able to carry when it enters service in 2012. Under current Pentagon plans, the first operational JSFs will only be able to carry a mix of GPS- and laser-guided bombs, and air-to-air missiles such as ASRAAMs and AMRAAMs. While the Block 3 JSF aircraft available to Australia in 2012 will have a useful range of air-to-air and air-to-surface weapons, they will lack a stand-off weapon and a dedicated anti-ship weapon.

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These plans do not include existing ADF weapons, such as the Harpoon anti-ship missile. Norway is considering the development of a new naval strike missile that can be carried internally by the JSF, should Norway ultimately buy the aircraft. The US Navy doesn't need Harpoons to equip the JSF, because it can carry these weapons on its F/A-18E/Fs. Australia could fund the integration of Harpoon on the JSF but we would have to bear the substantial costs and technical risks of doing so alone. This course is highly unlikely, as the Harpoon is probably too old to justify integration.

So, based on current plans, compared to the F/A-18 and F-111, the JSF will not have a dedicated stand-off maritime strike weapon, although it will be able to carry a range of weapons that might offer similar effects. There will be Harpoon-equipped F/A-18 and AP-3C aircraft in the RAAF until at least 2015 so Defence has until then to introduce an anti-ship capability for the JSF if that's still deemed necessary.

Furthermore, two projects that are currently proposed in the Defence Capability Plan to enhance the ADF's precision guided weapons capability—the Bomb Improvement Program and the Follow-on Stand-Off Weapon Capability—are likely to be decided before the formal decision to acquire the JSF is made. These projects total some $500 million. Defence should ensure that both these projects are compatible with the JSF purchase.

Cost, schedule and performance: the trade-off triangle

JSF project risks can affect cost, schedule or aircraft performance, either in isolation or in combination. Technical, engineering and manufacturing risks may affect all three, while program management risks can affect schedule and cost.

The contract unit price 'spiral'

Cost is the most significant risk to Australia, but we will have very limited control over it. According to recent reports, the JSF's development cost has risen by around US$7.5 billion (an increase of some 22%) and resulted in a 12-month delay in production for the conventional JSF variant. The above cost increases have mostly arisen from the increased weight issue and problems with software development.

Most Lockheed Martin program-level risks can affect unit cost. In particular, the total production run of all three JSF models was projected to be as high as 5,000–6,000. Recent estimates are now below 4,000 units and falling; the 'firm' total production run could fall to

F-35 manufacture. © Lockheed Martin.

3,000. As the JSF SDD phase progresses, the unit fly-away price for the conventional unit (the recurring cost to produce an aircraft) appearing in the media has risen from US$30 million to US$38 million. The fewer aircraft made, the higher the per-unit cost.

The primary focus of USAF procurement efforts is on the F/A-22 Raptor fighter, and to meet future air combat requirements it wants to buy 381 of them. However, Congress has limited the USAF to a US$43 billion production cap that will probably only purchase 276 aircraft. Media reporting suggests that F/A-22 numbers may fall even further, to about 180. Against this background, and with 1,793 JSFs planned for USAF service, the USAF might consider trading off some JSFs for F/A-22s, as they regard the Raptor as the key factor for twenty-first century air combat. The prospect of a ground attack variant of the F/A-22 has further solidified USAF support behind that platform.

If the JSF schedule does not map to the NACC schedule, Defence will need to have a detailed contingency plan for maintaining Australia's air control and precision strike capabilities.

In 1996, the US confirmed planned JSF numbers (US and UK) at 3,038 aircraft. At the time of Australia's signing of the SDD agreement, this number had decreased to 3,002. After the USN and USMC reviewed their requirements, they committed to 2,593 JSFs (2,443 aircraft for the US and 150 for the UK). The USN/USMC reduction of some 400 JSFs was due to a plan to integrate their respective squadrons. The USAF is known to be studying a similar plan to integrate its active and reserve squadrons in a bid to reduce overall aircraft numbers. Given that the first JSF won't enter service until at least 2010, further large decreases in orders cannot be ruled out at this early stage. The size of the US JSF order (almost 2,500 aircraft) also makes it far easier to contemplate cuts numbering in the hundreds. And as a result of its recent defence white paper, the UK is also reportedly considering cuts to its JSF orders, from 150 to 80 aircraft. That said, likely final JSF production numbers will still be considerably larger than for any of the aircraft's competitors.

The total contract value for an Australian JSF deal will be a function of the number of aircraft purchased, the stage in the production run when they are bought (historically, the price declines as the production run matures), and how many 'extras' Australia wants. To achieve the best price for the JSF, Australia should aim to enter a production run with the factory operating at full capacity, which is planned at some 200 CTOL aircraft per year. It is also important that we understand clearly what the baseline conventional variant delivers and what the non-aircraft 'extras' will cost, including training, simulators, spares and logistics, special test equipment, and manuals. A big cost will be continuing software support, including an in-country support capability.

Schedule

Schedule is nearly as important as cost, because Australia needs to replace its aging F-111 and F/A-18 fleets at specific times. JSF production planning has not progressed sufficiently to identify the production lots that will be available for foreign partners. The US and the UK have priority on the Low Rate Initial Production block of aircraft, planned for 2006; the first full rate production multi-year block starts in mid-2011 and extends to mid-2013. The JSF Joint Project Office should be working with all the JSF partner countries, including Australia, to determine production rates to suit particular delivery requirements. Australian requirements for delivery were supposedly identified as an essential part of the negotiations to join the JSF SDD, and Defence has apparently received formal advice from US officials of the aircraft's availability to suit our delivery requirements (to enter into service in 2012).

But history has demonstrated that, in programs as complex as JSF, production schedules planned early in the design phase are rarely achieved. USAF Secretary James Roche, who has substantial industry experience, commented in April 2003 that 'I may, as a guy from industry, believe that the F-35 estimates today are optimistic'. Virtually all of the program-level risks affect the schedule and dovetail into a critical path for the completion of SDD milestones and the start of production. In recognition of the possibility of project delays, Defence is apparently allowing for a potential 12-month delay in JSF delivery. And there are indications that the April Critical Design Review may be delayed some months.

If the JSF schedule does not map to the NACC schedule, Defence will need to have a detailed contingency plan for maintaining Australia's air control and precision strike capabilities at a level commensurate with government guidance. A thorough cost–benefit analysis will be necessary to determine whether an interim capability, such as the F/A-18E/F, F-16 Block 60 or F-15K, is preferable to maintaining and upgrading the existing F/A-18A/B and F-111 fleets. If such an interim purchase (as opposed to lease) is necessary, consideration should also be given to making the interim purchase more permanent and then delaying the eventual purchase of the JSF or another follow-on aircraft until at least 2035.

Performance

Australia has no ability to influence the ultimate performance of the JSF, but we must be aware of any warning signs. Lockheed Martin's identified program-level risks include 'requirements control under performance based specification', more commonly referred to as 'requirements creep'. The JSF program has, from the beginning, been driven by costs and not by requirements. As JSF matures, user interest will gain momentum and the desire for greater capability will grow in parallel. Greater weight, and hence greater power, will inevitably result from increased capability—an outcome Lockheed Martin recognises with its 'air vehicle weight control' risk.

Irrespective of requirements creep, JSF weight will almost certainly grow as the detailed design progresses towards Critical Design Review in 2004. In particular, the STOVL version is 600 pounds overweight. Any increase in weight without a commensurate increase in thrust will erode JSF air combat performance. In order to meet overall JSF weight targets, it is also possible that some capabilities of the aircraft will have to be removed or degraded.

Most modern aircraft have experienced seemingly uncontrolled weight growth during the detailed design phase between Preliminary Design Review and Critical Design Review. The inevitable JSF weight reduction initiative may well be driven by weight concerns in the carrier and short take-off versions, but it will also impact on the performance of the conventional version. Weight growth was a key element in the failure of the A-12 aircraft program (the JSF predecessor for the USN). An ongoing assessment of the adequacy of

STOVL version of the X-35. © Lockheed Martin.

the F-135 and the F-136 engines to meet power demands for take-off and basic thrust will be necessary, as growth in these engines may be limited. Performance growth will be technically challenging but there are some possibilities, such as variable cycle technology, that offer some scope for minor thrust increases.

Release of classified data and technology

The risk associated with the export of stealth technology and advanced avionics (including electronic warfare technology) can be inferred when Lockheed Martin raises 'multi-level of classification' and 'technical assistance agreement (TAA) process maturity' as risks. 'Multi-level of classification' refers to the dichotomy in which the JSF is on the one hand an unclassified and multinational program, and on the other is highly classified (and presumably non-exportable). The salient issues for Australia are the stealth features and performance of the CTOL variant, and the counter-stealth capability of its radar. Historically, the US Government has seen stealth as a US 'crown jewel', acquired at great cost and to be protected at all costs. Export of the true stealth aircraft (the F-117, B-2 and F/A-22) has never been considered.

There is no doubt that the JSF will be exported, but this will be done through the development of an 'export version'. This version would not include some of the (often quite significant) capabilities of the US military model. The most cost-effective way to produce and market an export version would be to introduce it now. If an export variant is required later, its design would have to progress behind the development schedule of the basic CTOL JSF. This could add significant cost to the SDD effort and may cause up to several years delay in production of the export aircraft. If agreement on the export system performance features has not already been obtained, the agreement process could also significantly delay the schedule. Whether the US or the partner countries are responsible for the cost of export variant design is undetermined. Perhaps the most intriguing program-level risk that Lockheed Martin identifies is 'anti-tamper'; that is, designing the aircraft so that neither the export partner nor 'the enemy' can reverse-engineer the US-classified technologies built into the airframe and avionics.

Defence has stated that eighty-one Australian companies are named in the Global Project Arrangement set up in the US to facilitate the release of technology. The arrangement is an umbrella export authorisation issued by the US Department of State that allows Lockheed Martin and other US suppliers on the JSF program to enter into agreements with partner suppliers to transfer certain unclassified technical data. The arrangement does not cover the transfer of any classified information, or of certain unclassified, export-controlled information in sensitive technology areas such as stealth, radar and propulsion.

The US Government Accounting Office (GAO) recently stated that 'the extent of technology transfers necessary to achieve program goals related to aircraft commonality will push the boundaries of US disclosure policy for some of the most sensitive US military technology'. A US Congressional committee is expected to hold hearings this year to determine whether the JSF is too reliant on foreign software. Even as close an ally as the UK—also a formal partner in the JSF's development—has highlighted 'serious problems' in accessing the necessary US technologies that will ultimately support the JSF.

As mentioned previously one of the more significant lessons from Australia's experience with the F/A-18 program arose from the unsatisfactory handling of technology transfer from the US, and of intellectual property issues. Defence needs to determine the level and type of technology transfer necessary to operate and support the JSF, and government needs to ensure that we get it.

Even as close an ally as the UK … has highlighted 'serious problems' in accessing the necessary US technologies that will ultimately support the JSF.

Technical risk

Australia will have a very limited opportunity to influence technical and program risks. In 'managing' technical risks, the focus is therefore on determining the impact those risks will have on cost, schedule and capability. Prima facie, the technical risks appear to have received Lockheed Martin management attention and are under control.

In a recent briefing, the company identified what it believed were the program-level risks, some of which are explained above. The purely technical risks noted were typical of like programs at this point, including software executability, mission system fusion algorithms, electro-hydraulic actuator development, canopy bird strike compatibility, and STOVL military velocity.

However, it is surprising that so *few* technical risks identified prior to Preliminary Design Review. Defence states that this is because most of the technology in the JSF is relatively mature and was demonstrated in the Concept Demonstrator Program. However, the US GAO maintains that a number of JSF technologies remain immature and need further development. With the exception of the STOVL risk, the B-2, F/A-22 and F-18 E/F programs would all have foreseen very similar risks. The absence of publicly revealed risks associated with technically challenging areas, such as the low-observable features of the aircraft, propulsion integration or uniquely new avionics capability, including situational awareness derived from electro-optics, should be questioned.

During the JSF Concept Demonstration Phase, two different variants of Lockheed Martin's designs were built and flown. Unfortunately, for cost reasons, the aircraft designs were frozen several years before all the research and development had been completed; this work was necessary to provide a design configuration for an operational aircraft. The Concept Demonstration Phase could therefore address only the most fundamental, and perhaps the most important, risk of 'design commonality'. Although there were some avionics risk reduction efforts during this phase, the JSF has relied to an extent on earlier programs, most notably the F/A-22 program, to address and solve its avionics technical risks.

The Preliminary Design Review highlighted the ongoing risk in a tremendously large and complex software development program. Another substantial area of risk is the fusion and integration of the aircraft's onboard sensors. Both of these risk areas were identified by Pentagon and Lockheed Martin officials during their Australian briefings on the JSF mid 2002. To give some perspective on the issue, both software code and sensor integration are primary issues behind problems in Defence procurement, including in the cases of the Collins Class submarines, the Jindalee Operational Radar Network and the Super Seasprite naval helicopter. These also form a significant part of the technical risk associated with the Australian AEW&C program, although the latter remains on schedule.

Industry issues

The US has established a partnership program that allows foreign countries access to data, information and potential industry participation. A number of countries have already joined the SDD phase, ranging from Level 1 Partners to Security Cooperation Partners.

Australia's decision to participate in the JSF SDD phase as a Level 3 partner is motivated both by the prospect of JSF being a large component of the NACC solution, and by the opportunity to develop Australia's aerospace industry. Defence Minister Robert Hill said that SDD participation would put Australia at the forefront of developing the world's largest and most advanced combat aircraft program over the next thirty years. Further, the Minister for Industry has suggested that, because Australia currently has a 1% share of the global aerospace industry market, it is reasonable to expect participation in the JSF SDD to realise at least $4 billion in related revenue. Both propositions are open to question.

SDD involvement will cost Australia $288 million over ten years. Amongst other tasks, the recently established Australian New Air Combat Capability Integrated Project Team, comprising staff from Defence and the Department of Industry, Tourism and Resources, will provide the Minister with a robust assessment of Australian industry's capacity to participate. The overall aim is to maximise participation across the SDD and the production, manufacture, and through-life support aspects of the program. To that end, Lockheed

Australian JSF Industry mission scouting for work in a recent trip to the US. © Lockheed Martin.

Martin, its partners and the Integrated Project Team have together taken considerable steps to engage industry and develop a strategy for industry involvement.

Participation in the SDD phase does not guarantee participation in future phases, especially full-scale production. Nor does the US guarantee that partners will recoup their investment in the program through contracts with their respective industries.

At an early stage, the Department of Defence identified some 350 Australian companies which could participate in the JSF program. Defence has stated that eighty-one Australian companies are named in the Global Project Arrangement set up in the US to facilitate the release of technology. Twenty-six requests for quotations have been issued to Australian companies, as well as twenty technical assistance agreements. To date, twelve Australian firms have received work on the SDD phase. The total value of these contracts is unknown. Nor is it known how many Australian companies have so far lost bids for work; however, when GKN won the first JSF contract for an Australian company, at least five other bids at around the same time were unsuccessful.

In the past, international armament programs such as the JSF have traditionally been conducted using work share arrangements rather than competitive tendering. These programs give out predetermined levels of work based on contributions to the program. In the case of the JSF program, the US has used a competitive 'best value' tendering process in order to keep costs down.

However, Lockheed Martin has told the GAO that, because of limited aerospace capabilities in some partner countries, 'traditional industrial arrangements' might be used in the JSF production phase. Lockheed Martin is understood to have developed a plan to use 'strategic best value sourcing' to supplement its original competitive approach. According to the US Department of Defense, this plan will allow for a limited number of work packages to be directly awarded to industry in partner countries where contract awards to date have not met expectations.

Other JSF partner members are already expressing their dissatisfaction with the level of industrial cooperation arising from the program. A number of media reports indicate that Norway in particular has been pushing for a greater involvement, and the governments of Norway, Denmark and the Netherlands have discussed joining forces to put pressure on Lockheed Martin to improve the level of industry participation.

Possibly as a result of this dissatisfaction, the Norwegian Government signed an industrial participation agreement on the Eurofighter aircraft earlier this year, thereby keeping its options open on any future purchase. So far, Eurofighter is reported to have forwarded or developed contracts, worth some US$22 million to Norway, in areas such as radar technology, flight control, weapons integration and imaging sensor enhancements. Earlier in 2004 media reports stated that Danish companies involved in the JSF program were considering leaving the project because they have yet to receive any work from Lockheed Martin. Canada, Denmark and Norway are also reported to be on the verge of signing a government-to-government agreement to cooperate in capturing contracts for their respective industries during the JSF's SDD phase. Greater Australian cooperation with other international JSF partners needs to be developed in dealing with Lockheed Martin and the Pentagon.

Participation in the SDD phase does not guarantee participation in future phases, especially full-scale production.

It remains uncertain whether the government has determined the minimum return on investment to industry that Australia expects from its contribution and involvement in the SDD phase of the JSF program. A simple dollar-for-dollar return on the $300 million invested should not be considered adequate. The US GAO recently reported that a Pentagon study revealed that JSF partners could potentially earn between $5 and $40 of revenue in return for each dollar contributed to the program. This would mean a return to Australia of between $1.4 billion and $11.5 billion for our SDD investment. In cooperation with industry, Defence should specify the size and nature of work that we expect. Only then can we determine whether our participation in the SDD phase is worth the investment made, let alone decide whether a greater return on investment needs to be pushed with Lockheed Martin.

Another issue is the quality of the industry work Australia might receive and should push for. The focus needs to be on:

- developing the infrastructure expertise needed to support the aircraft once they enter into ADF service
- 'smart' work to build Australian capabilities
- 'bulk' work to help the Australian economy and redress the cost of buying the aircraft.

Logistic support

One of the stated intentions behind the JSF program is to lower operational costs through increased reliability, delivered in part through an aircraft prognostics and health management system that monitors key systems. Lockheed Martin projects the cost of maintaining the JSF at 50% less than the cost of maintaining the legacy aircraft the JSF will be replacing. This is an extremely ambitious goal, which has never before been achieved with replacement aircraft. In fact, the norm is for operations and maintenance costs to increase rather than decrease with new platforms, not least because of increasing software support requirements. Defence expects that overall operating costs—including fuel, personnel, spares, maintenance and so on—may be more likely to be about 15% less than for legacy aircraft such as the F-16 and F/A-18.

Nonetheless, the degree of logistics support for the JSF that needs to be performed in Australia will be a critical issue for Defence to monitor. Defence should not rely on estimates that the JSF will require less in-country logistics support as a rationale for not developing the ability to sustain the aircraft within Australia.

The government-to-government SDD agreement only provides a framework for SDD work, although the exchange of letters signed at the time of joining the SDD apparently addressed Australia's aspirations for the expected thirty-year life of the aircraft. In any event, the government may find it necessary to use its influence with the US Administration to improve Lockheed Martin's offerings, if these are found to be of little value for whole-of-life support.

A JSF support concept understood to be under development will set out the in-service support requirements for the aircraft, which should allow partner countries to develop plans for support infrastructure. According to the GAO, one partner country has already expressed concern about the pace of information sharing and decision making related to the JSF support concept. A strategy is currently being developed by the JSF Program Office and Lockheed Martin to identify the best approach for maintaining the aircraft. This includes the setting up of logistics centres in partner countries. A major issue will be how the US determines its global support requirements and whether US aircraft would, in fact, be serviced overseas.

The Australian Government announced in August 2003 that BAE Systems Australia would spearhead a joint industry–government bid to establish Australia as the regional service hub for the F-35 JSF, an issue reportedly emphasised by the Prime Minister during the recent Australian visit of President Bush. Media reports indicate that the Dutch Government is actively trying to secure the establishment of a European regional support centre for the JSF. According to those reports, this centre would perform third-level maintenance and overhaul of the aircraft, aircraft components and engines. It could also provide storage and distribution of spare parts, software management for sensitive maintenance systems, and training.

Given that we are the only Asia Pacific partner in the SDD phase (Singapore remains a only security cooperation participant) there should be no competition for that role within our region. But Australia is geographically remote and it could make more economic sense for any JSF aircraft sold to or stationed in Korea or Japan to return to the continental US rather than make a longer 15-hour flight to Australia.

Even if Singapore buys the JSF, its aircraft might not be serviced in an Australian facility some 12 hours flying time from Singapore or they could be stationed in the US. With an advanced defence industry, Singapore is also likely to press for maintenance to be done within its own territory. At a bare minimum, Australia needs to be able to support the JSF in Australia, not in Singapore or the US. Complete self-sufficiency over the life of the aircraft is neither feasible nor desirable, but a balance will need to be struck between cost and strategic support requirements.

Australia's logistic support arrangements for the JSF will ultimately be a balance between requirements and affordability.

Two other issues of concern about logistic support stand out for specific attention. The first is software support. The number of lines of code for the JSF dwarfs those of the space shuttle and the B-2, and the figure is said to be 6.5 times higher than for the F/A-22.

The second issue of concern relates to the measures required to maintain the stealth capabilities of the JSF. Given the expected lack of involvement of Australian companies in the development of stealth technology for the JSF, questions arise about our ability to maintain the aircraft's stealth capabilities once it enters service.

Australia's logistic support arrangements for the JSF will ultimately be a balance between requirements and affordability. Defence needs to make a realistic assessment of the type of logistic support we truly require in Australia to maintain and upgrade the JSF, how much it is likely to cost, and the ability of Australian industry to supply it.

Glossary

AAM	Air-Air Missile
AAR	Air-Air refuelling
ADF	Australian Defence Force
AESA	Active Electronically Scanned Array (radar)
AEW&C	Airborne Early Warning and Control
AI	Air Intercept
AMRAAM	Advanced Medium-Range Air-Air Missile
ARM	Anti-Radiation Missile
AR	Active Radar
ASM	Air-Surface Missile/Anti-Ship Missile
ASRAAM	Advanced Short-Range Air-Air Missile
AWACS	Airborne Warning and Control System
BVR	Beyond Visual Range
BVR AAM	Beyond Visual Range Air-Air Missile
C2	Command and Control
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CDP	Concept Demonstration Phase
CDR	Critical Design Review
CTOL	Conventional Take Off and Landing version
CV	Carrier Version
DSTO	Defence Science and Technology Organisation
EA	Electronic Attack
ECM	Electronic Counter-Measures
EO	Electro-Optic
ES	Electronic Support
EW	Electronic Warfare

EWSP	EW Self-Protection
HMS	Helmet Mounted Sight
IOC	Initial Operational Capability
IPT	Integrated Project Team
IR	Infra red
IRS&T	Infra Red Search & Track
ISD	In service date
ISREW	Intelligence, Surveillance, Reconnaissance and Electronic Warfare
JASSM	Joint Air-Surface Stand-off Missile
JDAM	Joint Direct Attack Munition
JHMCS	Joint Helmet-Mounted Cueing System
JSF	Joint Strike Fighter
LO	Low Observability
LOT	Life of Type
LRIP	Low Rate Initial Production
MOU	Memorandum of Understanding
NACC	New Air Combat Capability
PDR	Preliminary Design Review
PGM	Precision-Guided Munition
PWD	Planned Withdrawal Date
RAAF	Royal Australian Air Force
RCS	Radar Cross Section
SAR	Semi-Active Radar or Synthetic Aperture Radar
SDD	Systems Design and Development (phase of JSF program)
SEAD	Suppression of Enemy Air Defences
STOVL	Short Take-Off, Vertical Landing
UAV	Uninhabited or Unmanned Air Vehicle
UCAV	Uninhabited Combat Air Vehicle
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy
VLO	Very Low Observable
WVR	Within Visual Range
WVR AAM	Within Visual Range Air-Air Missile

Contributors

Booz Allen Hamilton is one of the world's largest consulting firms, with over 13,000 staff worldwide. In 2000, Booz Allen established a Defence and National Security Team in Canberra, building on the substantial Defense and National Security Businesses operated in the US. Mark Jansen, Greg Hewson and Christiaan Durrant were former Air Force Officers and are recognised experts in fighter and strike operations, air combat requirements analysis and aerospace intelligence assessments. Dr John Cashen was a former Vice President and Chief Defence Scientist of Northrop Grumman, a Research Leader in Australia's Defence Science and Technology Organisation and was the lead designer of the B-2 aircraft.

Air Vice Marshal Brian Weston (Rtd) AM has extensive air force and fighter experience, having instructed on fighter aircraft, developed fighter tactics, commanded a fighter squadron, commanded an air force base and commanded the RAAF tactical fighter force. Since leaving the Air Force, Air Vice Marshal Weston has remained active in military matters and works in the defence industry.

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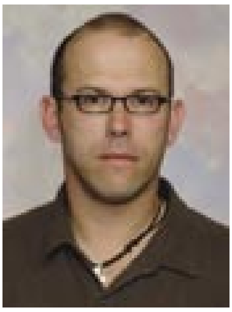

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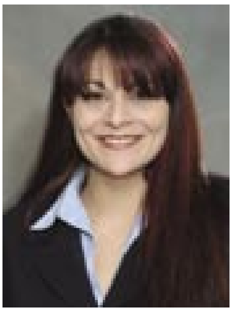

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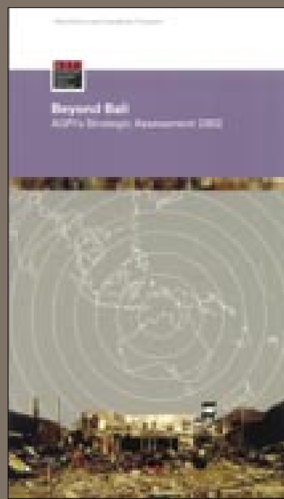

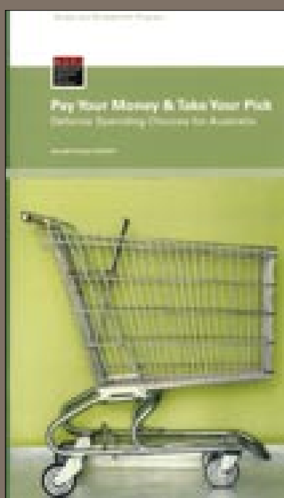

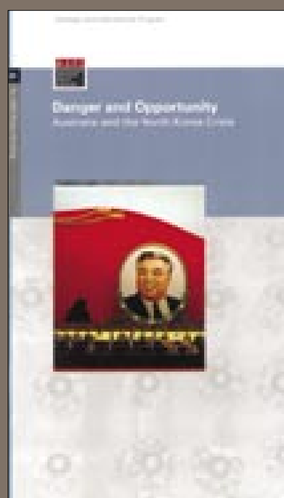

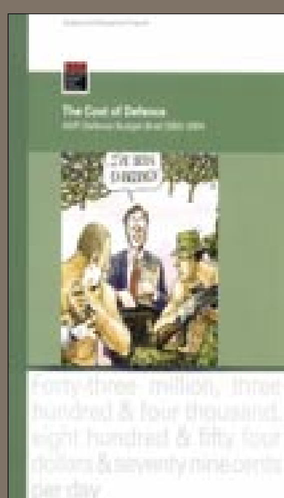

A Big Deal: Australia's future air combat capability

Over the past two decades, the RAAF's F/A-18 and F-111 aircraft have provided Australia with potent air combat capabilities. However, the cost of keeping both fleets operating has risen substantially while their effectiveness in the twenty-first century regional threat environment has diminished.

To maintain Australian Defence Force capability consistent with government requirements, the New Aircraft Combat Capability project is scheduled to deliver up to 100 new aircraft at a total cost of $16 billion. The project's scope and timing are driven by the need for the new aircraft to enter operational service progressively as Australia's seventy-one F/A-18 and thirty-three F-111 aircraft are withdrawn from service, in 2010 and 2012–15 respectively.

On 27 June 2002, Defence Minister Robert Hill announced Australia's intention to participate in the United States F-35 Joint Strike Fighter (JSF) System Development and Demonstration at an initial cost of some $300 million. He went on to declare that the JSF 'is the aircraft for us in the future'.

Whether the JSF might achieve the government's air combat requirements is determined by complex interrelationships between key factors, such as the future threat environment, JSF weapon system characteristics, supporting and enabling Australian Defence Force combat capabilities, F/A-18 and F-111 obsolescence, economic considerations, and time.

In effect, the JSF is still a 'paper plane'. The first production aircraft won't fly until at least 2006 and full production is expected to be reached only in 2008. Arguably, if the JSF delivers everything that has been promised by Lockheed Martin and the Australian and US governments, it will prove to be the best available replacement aircraft for our purposes.It remains to be seen, however, how much of what has been promised by the JSF in terms of its stealth, sensors, cost, general capability, reliability and supportability might be lost in the delivery, and to what degree this will undermine the original decision to buy it.

This ASPI policy report aims to help Australians understand the choices we have to make, the issues we need to consider, the options open to us, and the risks we might face.

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