



Is the JSF good enough?

Can Australia's air combat requirements be met by the JSF, or do we need the F/A-22?

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by Air Marshal Angus Houston

Australia's air combat capability is on the threshold of a new era as the F-111 and F/A-18 approach the end of their service lives. In the Defence White Paper in 2000 the government announced that it planned to replace both types of aircraft with a single new platform. Defence Minister Robert Hill later announced that Australia would become a partner in the System Design and Development phase of the Joint Strike Fighter (F-35) project. He indicated that the government intended to acquire the JSF as Australia's new front-line combat aircraft—though a government decision to actually acquire the JSF is still some time off—at least 2006.

The JSF will be a true fifth generation, stealthy, multi-role, single-seat, single-engine, fighter aircraft. The strength of our future air combat capability—and our largest defence project ever—is a matter of strategic importance. Are we sure the JSF is going to be good enough? Should we not be looking at going 'top shelf'—the F/A-22?

The strength of our future air combat capability—and our largest defence project ever—is a matter of strategic importance

Of course the F/A-22 is not the only option for our new combat aircraft. There are a number of advanced fourth generation aircraft on the market today, and these were examined in the earlier stages of our thinking about Australia's next fighters. Our advice to government to move to a more modern fifth generation aircraft reflected our view that the fourth generation aircraft would not meet our needs, nor be good value for money. Many countries in our region are introducing advanced fourth generation aircraft. For Australia to sustain a decisive combat edge in the air over coming decades, we need to



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

move to the more advanced capabilities of a fifth generation aircraft over the next decade.

In future unmanned combat aircraft may offer important options for Australia, but none are yet at a sufficiently advanced stage of development to provide an alternative to our current need for a new manned platform. Other options, such as the further upgrading of our current platforms for service well beyond

2020, present high risks and high costs for capabilities which would not be superior to those we can get from the JSF. We have plenty of recent experience with aged airframes and with the high technical risk of Australian-unique systems integrations on complex aircraft. And we know the logistics costs of operating multiple aircraft types. We are sure this is not a viable path.

But why do we think the JSF will do the job?

The job to be done

The job to be done by the RAAF's air combat forces was set out in the 2000 Defence White Paper, and this remains an excellent basis for our strategic planning for the unpredictable strategic environment of the next few decades.

In terms of air superiority:

- Air combat is the most important single capability for the defence of Australia because control of the air over our territory and maritime approaches is critical to all other operations.

Qualitatively:

- The government's aim is to maintain the air combat capability at a level at least comparable qualitatively to any in the region, and with a margin of superiority to provide an acceptable likelihood of success in combat.
- These air combat forces should also be capable enough to provide options for deployment in support of a regional coalition.

Quantitatively:

- These forces should be large enough to provide a high level of confidence that we could defeat any credible air attack on Australia or in our approaches.
- They should have the capacity to provide air defence and support for deployed ground and maritime forces in our immediate region.

In terms of our air strike capability

Qualitatively:

- The government's aim is to 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 crews.
- We also want the capacity to strike targets with sufficient accuracy to minimise risk of collateral damage.
- Such a level of capability should also provide options to contribute to regional operations against more capable adversaries at acceptable levels of risk.

Quantitatively:

- We do not seek a strike capability large enough to conduct a sustained attack on an adversary's wider civil infrastructure.
- We want the capacity to mount sustained strike campaigns against a significant number of military targets that might be used to mount or support an attack on Australia.

From time to time, a government also may want options to deploy an air combat capability further afield than the immediate region, as recent history has shown. However, such contingencies have not to date been force structure determinants. In general, the force structures developed to meet guidance have been able to provide options for contributions further afield appropriate to a nation of our size and status.

Winning in the air

Air superiority is at the heart of Australia's military strategy. We need to be able to ensure that the full range of ADF operations—land and maritime—can be conducted without threat from adversary air operations. But the traditional image of dogfight battles in the air between opposing air forces is usually a most inefficient way of achieving air superiority. Precision targeting and weaponry allow us to take a new and more efficient approach. For example the wars against Iraq in 1991 and 2003 featured, as their initial priority operation, a carefully orchestrated and methodical neutralisation of communications systems, command and control nodes, surveillance and warning systems, defensive missile systems, and aircraft and their logistical support on the ground. The results were, in each case, a quick and comprehensive denial of an adversary's ability to mount most, if not all, air operations. There were few aircraft-on-aircraft engagements in the 1991 Gulf War, and none in the war of 2003.

This is the way our future air force would want to operate to achieve air superiority, in preference to fighting air battles of attrition—glamorous and gladiatorial though air battles may be. An adversary's air capabilities are better destroyed on the ground than in the air. Thus the fundamental keys to air superiority in coming decades will be reach and precision, exercised by a determined leadership that is prepared to seize the initiative.

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Of course the ability to give battle in the air still needs to be retained. Any air campaign will still call on an ability to fight and win air to air engagements, and we cannot assume that our initial strike operations will succeed fully. So there is an immense dividend to be gained by an air force that can, through the use of a single aircraft type, conduct decisive air-to-ground campaigns but then swing roles

to fight air battles where necessary. That means precious resources are not tied up in a second specialised aircraft type dedicated to what should be, in doctrinal terms, a subsidiary (but still necessary) purpose.

Networks—the way of the future

The information technology revolution is changing the way war is conducted in the air. As the ability to move information increases, we can start to think of all elements of our air capability functioning in real time as a single system. And we need to start thinking of our aircraft not as stand-alone platforms, but as elements in that system. In future it will be the system, not just the pilot and his aircraft, that defeats the adversary.

In Australia we need to meet this challenge in a dynamic regional capability environment. In our region, the trend towards more effective air combat, ground-based air defence and information capabilities seems likely to continue. Many nations in our region have acquired, or plan to acquire, advanced air combat aircraft with advanced capabilities. These include 'Beyond Visual Range' (BVR) systems, that can detect and destroy adversary forces at long range, and 'Look-down Shoot-down' capabilities, which can find and destroy hostile aircraft from above, even against the clutter of the ground. Ground-based sensors and command and control capabilities are also being enhanced.

Acquisition of new platforms, alone, is unlikely to provide us with the qualitative edge that we need in this emerging environment. A qualitative edge will only be achieved through enhancing individual platform capabilities by integrating them as part of a system within which the platform will operate. We will maintain our capability edge by developing a network-centric air combat system that exploits information and communications systems to create the desired effects.

We will maintain our capability edge by developing a network-centric air combat system...

The performance of an effectively networked system will exceed the sum of its individual parts. This is achieved by exploiting data link information technology to display a common picture of an engagement that is shared in real time between all participating sensors, shooters and command and control nodes within the system. Everybody should be working from a common view of adversary and friendly activities. A capable and well-designed networked system—operated by good people—should always prevail over an adversary that is not supported by a similar system, even though that adversary might possess highly capable platforms.

In a fully networked system, data will be brought together—‘fused’—at many levels:

- In the aircraft itself, where sensor information is integrated within the avionics system, rather than by the pilot, freeing the pilot to concentrate more fully on the tactical situation.
- Between fighters in flight over a high capacity data link, so they can share their picture of the engagement.
- Between the fighters and remote sensors such as AEW&C, Over the Horizon Radar and other ground or sea based radars—and the command and control system.
- With intelligence information using satellite links from systems in space capable of providing real time tactical information as part of the network.

It is this total network—including sensors and shooters—that defines the capability.

Of course fighters remain the essential core of the network, and it is important to examine the capabilities of the individual platform options and their ability to contribute to the system.

The F-35 Joint Strike Fighter (JSF)

The JSF is intended to set new benchmarks in affordability, availability and supportability, for a high-performance stealth aircraft. Apart from its stealth design, it does not break a lot of new ground in its aerodynamic design, though it is clearly from the same stable as the F/A-22. But

its designers have squeezed in an extraordinary amount of fuel for a single-engine fighter of this size.

The JSF ... is clearly from the same stable as the F/A-22.

The JSF’s advanced sensors and communications systems are key to its ability to integrate into a networked air combat capability. At the heart of the JSF’s sensor suite is its Active Electronically Scanned Array (AESA) radar. It is state-of-the-art, capable of both air-to-air and air-to-ground target detection, identification and weapon allocation. The radar also acts as a passive, highly precise long-range sensor for emissions from threat systems, and can actively jam other air and ground emitters. Importantly, it can conduct most of these activities simultaneously or near simultaneously. A radar warning receiver (RWR) provides information on threat emissions for those areas outside the scan area or frequency coverage of the radar.

The JSF will be fitted with an advanced Electro-Optical Targeting System (EOTS) that provides long range infra-red search and track of air targets, long range detection of ground targets, a laser range finder and a laser target designator.

Unique to the JSF is a Distributed Aperture System (DAS) comprising six infra-red sensors positioned around the aircraft to provide a spherical display in the pilot’s helmet visor of the position of other flight members, targeting for air-to-air missiles, locating ground targets and detection of threat aircraft and missiles. It provides the ability to look through the aircraft structure, eliminating blind spots.

The JSF has an extensive communications and data link suite. The high capacity inter/intra flight data link allows a flight of JSFs to act as a fully fused team. Link 16 allows sharing of data with other air and surface players. Satellite communications provide for beyond line-of-sight communications (JSF is the first fighter aircraft to have satellite transmit and receive capability). There is a software driven



JSF © Lockheed Martin

Joint Tactical Radio System, primarily for communications with ground forces, and there is a Prognostics and Health Management data link that provides for integration with the JSF's logistics system while still airborne.

As important as the individual sensors and systems are, the real leap in capability comes from fusion of data. This includes:

- spherical RWR coverage to detect radar threats
- passive electronic support from the radar array
- long range detection of targets using the DAS or EOTS
- active radar detection of targets—air, land and maritime
- close range warning of threats using the DAS
- connectivity to the rest of the formation and the wider network through the data and communications links.

A fundamental feature of the JSF project is to achieve affordability by containing costs throughout its life. This is being done by

avoiding high-risk untried technology, and leveraging off earlier programs, such as F-22. There has been a tight discipline placed over the operational requirements to control requirements creep. Senior decision-makers can over-ride demands for 'nice-to-have' capability enhancements that could drive up the cost.

That is not to say that the project is without risk. The software development task is truly challenging. There have already been weight growth problems, typical of most fighter aircraft programs at this stage of development but of sufficient gravity to cause some delays. There may even be crashes—there usually are with new fighter aircraft with relatively new engines.

Doubtless there will be further problems as the development program progresses. While not denying these risks, and realising that some of them are likely to have cost and schedule impacts, the US has a great deal riding on making the JSF a success. And it's not just the US that needs aircraft. All JSF partners and a number of potential future customers need to replace their aging fleets. With that demand will come a large production base, probably well



F/A-22 © Lockheed Martin

in excess of 3000 aircraft worldwide, which is particularly important to us in terms of growth potential. The ability to share the cost and risk of growth developments across such a large customer and production base greatly lowers the potential cost to us of keeping our fleet up to contemporary standards of capability throughout its service life.

The F/A-22

The F/A-22 will be the most outstanding fighter aircraft ever built. It may even represent the end of the line in manned fighters. Every fighter pilot in the Air Force would dearly love to fly it.

The twin engine F/A-22 will have an extraordinary thrust to weight ratio in virtually any operational configuration. Its internal fuel load is about the same or slightly more than the JSF. Unlike previous stealth designs, the F/A-22 sets new levels in stealth without having to compromise its aerodynamic performance. The agility of the F/A-22 promises to be unmatched. Of great importance too is its ability to sustain supersonic speeds without the use of afterburner, termed supercruise.

The F/A-22 is breaking new ground also in the degree of integration of its avionics systems. It will seamlessly fuse information coming from the aircraft's:

- powerful AESA air-to-air radar
- high sensitivity all-round RWR
- spherical missile warning system
- inter/intra flight data link
- link 16 data link for off-board networking.

The F/A-22 program has had an extended gestation period. The 13 year development and test program has experienced problems with the performance and reliability of software and avionics. However, Initial Operational Test and Evaluation has now begun, and the USAF expects to have full rate production authorised, and its first operational wing formed, by early next year.

The F/A-22 is breaking new ground also in the degree of integration of its avionics systems.

The relatively recent plan to develop a comprehensive air-to-ground capability in the F/A-22 will require major new technology modifications. There is limited growth potential in the current avionics and processors, and some components are already obsolescent. To reach its full air-to-ground capability, the F/A-22 will have to be fitted with a development of the JSF radar and JSF-era avionics processors and computer architecture. This is planned to occur between 2013 and 2015.

Originally conceived as a 750 aircraft program at the height of the Cold War, program numbers have been progressively cut. Congress has placed a cost cap on the production funding for the program. The US General Accounting Office (GAO) estimates that 218 aircraft can be bought under this cap. USAF future budgets state a requirement for 277 aircraft.

Comparing the JSF and F/A-22

Strike

It would be nice to be able to specify a new air combat aircraft that has the same radius of action on internal fuel as the F-111 in the strike

role. But no one is making such an aeroplane. For the future, therefore, we are going to have to adapt to a lesser range platform supported by air-to-air refuelling and in some cases stand-off weaponry to provide range extension. DSTO analysis to date indicates that the scenarios and target sets of interest to us can still be effectively prosecuted with a combination of the JSF and air-to-air refuelling.

The CTOL JSF, retaining stealth by not carrying external stores or fuel tanks, is specified to have an unrefuelled radius of action in the strike role of at least 590nm. There are no public domain figures for radius of action of the F/A-22 in the strike role. Its radius, though, is likely to be similar to the JSF because, whilst the F/A-22 has only about the same internal fuel as the JSF for a slightly heavier aircraft with two engines, it is likely to be an extraordinarily aerodynamically efficient aircraft. Both aircraft should have similar reach when air-to-air refuelling is added to the equation.

At present the F/A-22 has no air-to-ground radar capability but a major systems upgrade has been proposed. When the F/A-22 has had its radar, computer architecture and avionics processors updated, it would be expected to



F/A-22 © Lockheed Martin

have a significant air to ground capability, but one that will be more reliant on off-board data because it will not have the equivalent of the JSF's EOTS system.

JSF will have the advantage in weapon carriage because its internal weapons bay can carry 2000lb class weapons including the variants of the BLU-109 hard target weapon. The largest weapons that the F/A-22 weapons bay can accommodate are the 1000lb class. Recently there has been increased interest in small weapons. A combination of greater precision and more effective explosives mean smaller weapons can do the same job as previous generation large weapons. That means more weapons can be carried on a single sortie. Both aircraft will be able to carry these new generation small diameter weapons internally, though with a larger weapons bay it is likely that the JSF will be developed to carry more of them.

...the JSF strike capability will be more versatile and comprehensive for our requirements within our region.

On the other hand, stealth combined with supercruise and its very high operating altitude would make the F/A-22 less vulnerable to surface-to-air missiles.

On balance, while both aircraft offer a strike capability of quite some significance, the JSF strike capability will be more versatile and comprehensive for our requirements within our region.

Air Superiority

As already stated, there is no question that the F/A-22 will be the world's best aircraft for the air superiority task. It is not surprising then, when comparing the F/A-22 with the JSF, nearly all discriminators favour the F/A-22.

...the F/A-22 will be the world's best aircraft for the air superiority task.

The larger F/A-22 will have a more powerful radar and more powerful electronic warfare systems. Interestingly, literature suggests that the F/A-22 will not be fielded with an infra red search and track system or a helmet mounted sighting system due to funding constraints in development, but we might expect these capabilities to be developed eventually.

Chiefly, though, the F/A-22's air combat advantages relate to its ability to supercruise and its manoeuvrability. Supercruise is tactically important for two reasons. Firstly, it makes the F/A-22 difficult to attack from the rear or beam sectors. Secondly, launching one's missiles supersonically extends their range in comparison with equivalent missiles launched from a slower opponent. The ability to fire the first shots in a beyond-visual-range (BVR) engagement is extremely important. In the air combat arena of the future, we can expect the F/A-22 to be supersonic a larger part of the time than 4th generation aircraft and the JSF due to the need for the latter to conserve fuel.

Fortunately we only expect to do battle against F/A-22s in training exercises. Against 4th generation adversaries, the JSF has the decisive advantages of stealth and comprehensive situation awareness, both from its onboard sensors and through the network. It also has some additional advantages. The JSF has a very large internal fuel load and will not suffer the drag penalties imposed by external stores and weapons. It will be able to operate supersonically more often than most opponents. The JSF—with its combination of fused data from onboard and offboard sensors—will be able to detect and identify threats before it itself can be detected and should have a comfortable margin in its ability to achieve first launch in the BVR arena against 4th generation opponents. Coupled with the ability to simultaneously engage multiple targets, the JSF, like the F/A-22, offers the potential for real advantages in exchange ratios in BVR combat against 4th generation opponents.

Platform agility is not an unimportant consideration even in the BVR arena (or the strike role for that matter). There is a threshold level of agility needed to defeat adversary

missiles. There are specific manoeuvres, combined with countermeasure employment, that need to be conducted when airborne or ground-based missile launches are detected. Our analysis supports the view that the JSF has adequate agility for this purpose.

Platform agility becomes a very important consideration when we consider air combat capabilities in the within-visual-range (WVR) arena. We do not need to pore over complex performance graphs to determine that the F/A-22 has a clear margin in agility over the JSF. It is sufficient to note that the F/A-22 has a higher thrust to weight ratio and has vectored thrust engines. The margin is obvious. The F/A-22 was designed from the outset to be a generational advance in manoeuvrability.

The JSF on the other hand aspires largely to replicate the agility of the previous generation in order to contain cost. The performance predictions for JSF show a blending of F-16 and F/A-18 characteristics—the 9g capability of the F-16 and the high angle of attack slow speed capability of the F/A-18. These predictions are soundly based on experience with concept demonstrators and a great deal of wind tunnel testing and computer modelling. Whether or not this performance is achieved in practice depends on weight growth during development, installed performance of engines and performance of the flight control system. Weight growth has already been an issue (primarily with the STOVL version) but extra design effort is being put in early to get the weight down. The Pratt & Whitney F135 engine is performing well and meeting performance targets.

The next question to answer is ‘does agility matter in the highly networked air combat arena of the future that we aspire to?’ The answer is ‘yes, but not as much as it used to matter in the past’. Let me explain.

When we were last buying a fighter, over 20 years ago, agility was a central consideration, particularly in the within-visual-range (WVR) air combat arena. Since that time, however, there have been two quite radical technological developments affecting WVR combat. The first is the advent of highly agile, countermeasures-resistant ‘dogfight’ missiles. The second is

the perfecting of helmet-mounted sighting systems that allow pilots to acquire and launch ‘dogfight’ missiles at targets far from the aircraft’s line of flight—even behind the launch fighter’s own wing line. Previously, the attacking aircraft had to be manoeuvred so that the target was in or near one’s head-up display for the missile to acquire the target, and launch zones were more restricted due to the lower manoeuvrability of the missiles themselves. Now the missile does most of the manoeuvring.

It is important to note that infra-red homing ‘dogfight’ missiles are ‘launch and leave’ weapons with very high kill probabilities. That is, after launch they need no further support from the launching aircraft. Thus there is no advantage to achieving the first shot if, during the time of flight of the missile, the target aircraft manages to fire back. His missile will still hit you, even if yours hits him first. So both aircraft likely will be lost.

Though it might be hyperbole to suggest that entering the WVR air combat arena in future will result in mutually assured destruction (for there is always the ‘fog of war’ to contend with) it is no exaggeration to observe that the WVR arena of the future is going to be a very lethal place. Exchange ratios of close to parity are likely to be the fate of those who choose to fight there. And parity of exchange ratios means a battle of attrition—not a smart way to fight, particularly for a small force.

If decisive and superior exchange ratios are to be achieved in the air combat arena of the future, it will have to be done in the BVR arena. Looked at another way, an air force that wishes to leverage its BVR capability advantages needs first to ensure that its adversary is unable to gain advantage through orchestrating WVR engagements. This is an important consideration for countries like Australia that are not superpowers. A superpower can more easily dictate BVR rules-of-engagement. Australia has to recognise that it might, at times, have to operate in a more ambiguous rules-of-engagement environment facing adversaries intent on forcing WVR engagements.



JSF © Lockheed Martin

There are a number of prerequisites to being effective in the WVR arena:

- dominant situational awareness
- helmet mounted sighting systems
- highly agile 'dogfight' missiles
- superior countermeasures
- a threshold (*but not necessarily superior*) level of platform agility.

This threshold of agility is needed, as we have seen, to ensure we have been able to fire well before an adversary can destroy us. On current indications, the JSF has this capability with a margin to spare, though it goes without saying that our analysts and technology experts are watching this area very closely as the project progresses through its development phase. The JSF will not aim to fight in the WVR arena, but will be capable of fighting there if needs be.

It is within this frame of reference that we make our judgements about the capability needed to do the job required of us by government. While there is little doubt that the F/A-22 would do the air combat job outstandingly well, everything we are seeing to

date indicates that the JSF will do the job very well too, and it is a more versatile strike aircraft.

Releasibility and the 'export version'

Some discussion is needed to address the occasional commentary that the version of JSF released to Australia will be degraded in some way that casts doubt on its ability to fulfil the purpose that we intend for it. It is difficult to discuss this issue in public, because the precise capabilities of our aircraft are carefully guarded secrets. What can be said though, is that Australia was given information on the level of JSF capability it would receive prior to entering the project and that commitment has been reinforced by more detailed technical briefings since joining the project.

The US does not provide information on any *relative* differences in capability released to different countries, nor will it be specific about any margin of capability it may have reserved purely for itself. Australia, as a close ally of the US, has fared well in the release of leading edge capability in the past and there is every indication that this situation will continue with JSF.

We have a great deal of *absolute* information about the JSF capability that the US intends to release to us. About 30 DSTO scientists are now working independently on analysing JSF capability to ensure it will deliver what we need. This will allow the government to be fully informed when the time comes to make an acquisition decision.

As a partner in the project our pilots and scientists have had the opportunity to participate in the structured systems analysis and evaluation being conducted in a dedicated simulation facility in the US. This facility uses a combination of computer modelling and man-in-the-loop simulations of operational scenarios and is loaded with the latest JSF performance data as the system development phase proceeds. The simulations are also loaded with the threat systems of greatest interest to us. Our participation means that we are able to monitor how the project is developing in considerable detail, access a great deal of technical information, and refine our independent assessments of the JSF's operational suitability to our concepts for operations.

Numbers matter and costs matter

There has been no government decision yet on the number of aircraft to be acquired under the new air combat capability project. The 2000 Defence White Paper and subsequent reviews propose the acquisition of 'up to 100 aircraft', and the Defence Capability Plan 2004—2014 identifies a notional budget for the project of \$11.5bn to \$15.5bn. But much intensive operational analysis and force balance studies remain to be done before a final decision on numbers will be made.

Key issues to be taken into account in determining the number of aircraft to be acquired include:

- the balance between numbers of JSF, AEW&C and air-to-air refuelling (AAR) aircraft the aim being to achieve the most cost effective force structure overall (noting that AEW&C and AAR aircraft make significant contributions even when not supporting combat aircraft)
- the contribution from other force elements such as the new Air Warfare Destroyers
- the number of geographic areas that may need to be supported simultaneously
- potential for concurrent air superiority, strike (maritime and land) and ground support operations—noting that as a true multirole aircraft the JSF can perform all tasks, even on the same mission
- rotation of forces, which recent operational experience has shown is a major issue
- aircraft required in a maintenance pool, expected to be low given the JSF's expected reliability and minimal deeper maintenance requirements
- attrition aircraft to cover losses throughout the service life of the aircraft.

Like armies, air forces organise, deploy and operate in formed units. The basic operational unit is the squadron. Fighter aircraft as a minimum operate as a pair but the basic fighting unit is typically four aircraft, to provide mutual support and concentration of firepower. Squadrons are sized to allow a unit to deploy and conduct a specific task, for example air control, over a specific area. The JSF will require the RAAF to rethink the basis of squadron sizing, taking into account the increased endurance of the JSF and the expected increased availability of aircraft. Overseas operators are looking at squadron sizes ranging from 12 through to 24 aircraft. Current thinking in the RAAF is that a larger number of smaller squadrons might be preferable, providing greater flexibility for a relatively small force. Options of 12 or 16 Fully Mission Capable aircraft are currently being examined, which would require either about 14 or 18 aircraft total in the squadron, allowing for maintenance requirements.

The recent decisions to acquire five air-to-air refuelling tankers and the additional two AEW&C aircraft (giving a total of six) are an acknowledgment of the need for the Air Force to have the capability to conduct air control operations in two separate areas simultaneously. This is consistent with White Paper 2000 guidance that identified the need

for land forces to conduct two concurrent but geographically separated operations. Each area could need at least one squadron of fighters deployed to cover air control tasking, possibly more if intensive 24/7 operations were in prospect. It is quite possible that at the same time direct support of land operations may be required. And concurrent strike operations may also be required—either land or maritime. Four squadrons looks like being the minimum prudent operational force to meet potential concurrency requirements.

With four deployed squadrons of even 14 aircraft, backed up by a squadron-sized rotation capability, the total number is already up to 70 aircraft. To this must be added aircraft for training—possibly 10 to 18—plus a pool of aircraft undergoing deeper maintenance or regular upgrades, and additional aircraft to allow for expected attrition over the life of the fleet. The number quickly gets up to 100. So the number mentioned in the White Paper, and accepted by government to date, is pretty close to the mark. A much greater number obviously would be much more expensive and possibly difficult to sustain, and a much smaller number could be leaving us seriously exposed.

The latest unit cost forecast for the CTOL JSF is about US\$45m, though this is for aircraft well down the production run. Earlier aircraft will be more expensive and there will be additional costs for any additional equipment or Australian unique modifications—although the latter are being strongly resisted. The JSF nonetheless remains cheaper than most of the original contenders for the Air 6000 project. Admittedly, the project is at an early stage, and despite the heavy management focus on cost control, costs may well rise before the aircraft goes into full rate production. Indeed, we are budgeting on this to a certain extent.

Current project office estimates are that 100 CTOL JSF—along with necessary integration/support/training requirements—can be accommodated within the original Air 6000 funding provisions.

A force of 30 aircraft is clearly inadequate...

A recent GAO report quotes the unit cost estimate for the F/A-22 at US\$153m. While the F/A-22 program is more mature than JSF, there is still the potential for cost increases because the F/A-22 has to be fitted with new avionics processors and architecture in order to achieve its full air-to-ground capability. Allowing that the unit cost forecasts for both aircraft are a bit 'rubbery', it is reasonable to estimate that the budget currently earmarked for a 100 aircraft JSF program probably would support an F/A-22 acquisition of only about 30 aircraft. A force of 30 aircraft is clearly inadequate to provide the capability for concurrent air control and strike operational tasking and to support an organic training organisation.

A substantially larger F/A-22 fleet could be funded two ways—by supplementing the Defence budget (at a considerable opportunity cost to the Australian public) or from within the Defence budget (which would cause a serious unbalancing of the entire ADF). The industry program with an F/A-22 purchase would also be of considerably lower quality and value because that program was not established with international industry participation in mind, is more mature (ie, virtually all work has already been allocated), and the total numbers to be built are so much less than JSF.

Conclusion

The conclusion is clear. The JSF is the more cost effective option for us, even though the F/A-22 might do important parts of that job better. Of course, the final performance of the JSF is far from being proven and there are a number of key risks still to be managed in the project. But the track record of the US military and the US aerospace industry in delivering on projects like this is very good. On all the indications of the moment (and we now have a ring-side seat) the JSF will be able to do the job set for us by government:



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- It promises the margin of capability we require for the tasks we intend for it.
- It will be the most 'network-enabled' capability on offer.
- It will be truly multi-role, giving us great operational flexibility and cost effectiveness.
- It can be acquired in operationally meaningful numbers within the available budget.
- It will be able to be supported in service at lower cost than any alternative.
- It will have the best growth potential, at lowest on-going cost to us, of anything on offer because of its large production base.
- And finally it offers the potential for a significant and long-term industry program that should exceed in value and benefits the conventional offset arrangements of any alternative.

The conclusion is clear

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Air Marshal Angus Houston joined the Royal Australian Air Force (RAAF) as a cadet pilot in 1970. He was admitted as a Member of the Order of Australia (AM) in 1990 for his work in the transfer of responsibility for Blackhawk operations. Air Marshal Houston was posted to the Joint Operations staff at Headquarters Australian Defence Force and was involved in strategic planning during the Gulf crisis of 1990/91. He was Chief of Staff, Headquarters Australian Theatre in 1997-99, Commander of the Integrated Air Defence System in Malaysia/Singapore from 1999-2000 and Head Strategic Command from 17 August 2000. Air Marshal Houston was appointed as Chief of Air Force on 20 June 2001, and in the 2003 Australia Day Honours, promoted to Officer of the Order of Australia (AO).

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