

What's Plan B?—Australia's air combat capability in the balance

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Executive summary

The F-35 *Lightning II* (Joint Strike Fighter) is Australia's choice of air combat aircraft for the period out to 2030 and beyond. But, having signed up in 2002 to what was then an embryonic developmental program, we opened ourselves up to uncertainties in both cost and schedule.

Problems that became obvious early in the program made it necessary in 2006 to commit several billion dollars to acquire twenty-four *Super Hornets* to supplement the RAAF's *Hornet* fleet and to avoid a capability gap as the F-111 reached the end of its useful life. The revised plan saw the F-35 being introduced to Australian service in 2018, with the ageing *Hornets* being phased out over the following few years.

The F-35 program was restructured in 2007 but the resulting estimates of costs and schedule were again found wanting. Between 2009 and today considerable work has gone into still further restructuring and the production of a new set of cost and schedule estimates.

The result is a schedule and cost estimate that is probably still workable for Australia—but with margins for error that are much reduced. The biggest risks are:

The approved funding for the initial buy of fourteen F-35s for the RAAF beginning in 2014 is becoming very marginal. Additional cost increases could see those aircraft become more expensive than budgeted. Planned later buys probably remain affordable within the existing budget.

On current plans the full warfighting capability of the F-35 won't be delivered until 2016 and the US Air Force have moved their in-service date to some time after that—perhaps 2017. Australia may find itself moving to initial operating capability only slightly later than the USAF. Additional slippages could further compress the timeframe.

The fall-back options for the RAAF to manage these contingencies are:

Costs: slip at least some of the fourteen initial aircraft to later years—with the downside risk of slowing the working up of capability.

Schedule: for modest further schedule slippage, keep the *Hornet* in service a year or two longer than is currently planned—albeit at a higher cost and reduced comparative capability. ('Plan B'). For slippages of more than two years the most credible option is a purchase of more *Super Hornets*. ('Plan C').

Neither of those options needs to be implemented now. But a close eye has to be kept on the F-35 program over the next two years. The two most important indicators are:

- the price of the fourth and fifth production batches of F-35 compared to respective contracted and estimated prices
- the delivery of software increments according to schedule and with the planned functionality.

Introduction

The Australian Government signed up to the F-35 Joint Strike Fighter program back in 2002. The reasoning was clear enough; the F-35 was marketed around the promises of 'fifth generation' stealth and sensors and a multi-role capability for strike and air-to-air missions, all at a comparatively low cost. Together with the *Wedgetail* and multi-role tanker aircraft planned for delivery towards the end of the 2000s, the F-35's attributes would cement Australia's regional airpower lead.

As well as the capability argument, there was an economic incentive to rationalise the fast jet component of the air combat capability into a single type by replacing both the F-111 and the 'classic' F/A-18 *Hornet*. Not only was the projected acquisition cost of the F-35 less than potential rivals, the through-life support costs were projected to be similar to the much less capable F/A-18 *Hornet* it would replace. In 2003, the decision was made to retire the F-111 in 2010 on cost and risk grounds, with the *Hornets* to receive an upgrade to their sensors and weapons that would carry the RAAF's capability over until the F-35 entered service beginning in 2012.

At least that was the plan. In 2006 there were already signs that the F-35 was going to run behind schedule. (It was also clear that costs were growing, although government officials consistently denied that.) At that point the Howard government decided to acquire twenty-four F/A-18F *Super Hornets* as a 'bridging capability' that would alleviate the capability gap that would appear when the F-111 retired. After some serious slippages from the initial 2002 plan, the F-35 program underwent a re-plan in 2007. The resulting schedule moved the initial operating capability dates out several years.

But with delivery of the *Super Hornets*, the schedule for the delivery to Australia and introduction to RAAF service of the F-35 could be revised without a major impact on capability. It had always been the case that the Australian budget contained significant contingency funds for cost overruns, and the schedule now had several years of breathing room that could accommodate the sort of problems to be expected from what was increasingly clearly an ambitious development project. After this revision everything seemed on track for a smooth transition later this decade.

Unfortunately, ongoing development troubles with the F-35 are casting doubt on that plan as well. This paper examines the current status of the F-35 program and analyses the implications for Australia's plans. As will become clear, margins are getting uncomfortably tight in some respects and there may be—and certainly *should* be—planning going on within the Defence Department to have a fall-back plan in place should the situation further worsen. The government will need to take a hardheaded look at the situation. And it shouldn't rely on Defence for

dispassionate advice—their answer will remain 'F-35', pretty much independent of the question.

A troubled history

The program was extensively re-planned in 2007 but it soon became clear that even that re-plan underestimated the remaining challenges. In late 2009 the US Secretary of Defense Robert Gates appointed a Joint Estimating Team, which reported that additional schedule delays were to be expected and that the System Development and Demonstration (SDD) phase was underfunded. This resulted in further substantial changes in early 2010. Gates added \$2.8 billion to SDD, appointed a new Program Manager, extended the SDD schedule by about thirteen months, added an additional test aircraft, added a software development line and committed to budgeting to the results of yet another round of cost estimates.

This was followed up in late 2010 with a Technical Baseline Review (self-initiated by the new Program Manager) which led to a decision in late 2010/early 2011 to seek further funding for SDD of \$4.6 billion (additional funds have come from Pentagon resources rather than partner nations) and to further delay the schedule by about twelve months for the Air Force conventional take off and landing (CTOL) and Navy carrier variant (CV) and about two years for the Marines short take off vertical landing (STOVL) version.

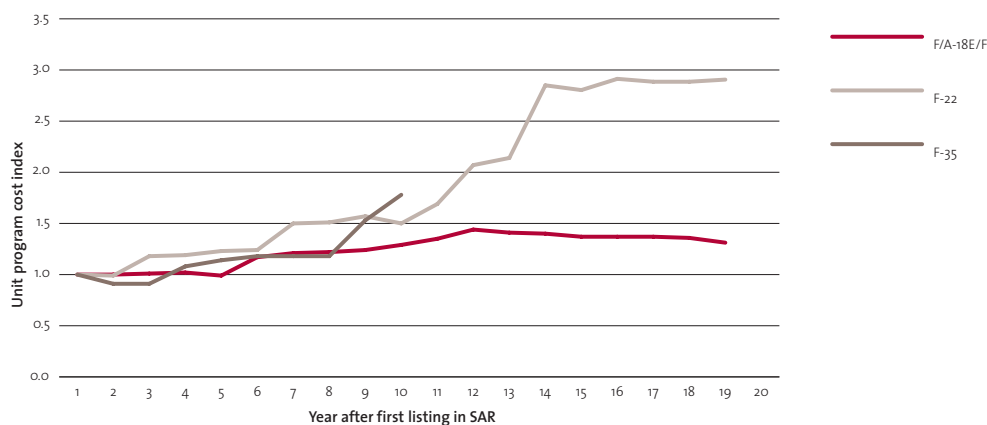
These changes to schedule and funding in 2010 should result in a more realistic schedule and reduced risk. So far indicators are positive; the test flight schedule for the JSF is ahead of plan over the last six months and aircraft production has been on track for the past seven months. This is the first time that F-35 production has not slipped since the start of low rate initial production (LRIP). It's worth noting that there are no concerns about the capability of the aircraft.

The most recent public reporting of the F-35 program is from the US Government Accountability Office (GAO). The program gets a mixed scorecard, as evidenced by the title of the report 'Joint Strike Fighter: restructuring places program on firmer footing, but progress still lags'. The GAO acknowledges the progress that has been made in the last few months as test aircraft have been delivered and flying testing has ramped up. In tabling their report the GAO told Congress that 'if effectively implemented and sustained, the Department's restructuring should place the JSF program on firmer footing and lead to more achievable and predictable outcomes'.

But they also point out a raft of remaining challenges, not least of which being the development of the complex software required to make the F-35 an effective warfighting machine. (And, unusually, they also include an annex that lays out their previous decade's worth of critical observations and the Pentagon's often blithe responses, adding up to a pretty robust 'we told you so' riposte to critics who accused them of being unnecessarily pessimistic in years gone by.) There is now a 2011 re-re-plan, with further delays to delivery schedules and a reduction in the number of aircraft to be delivered in the next five years.

Costs

There are now ten years worth of GAO and Pentagon reports on the cost of the F-35, allowing for both trend analysis and for comparison with other programs, good and bad. The resulting picture is not reassuring. Figure 1 shows the indexed unit cost growth for the F-35 and, for comparison, the F-22 *Raptor* and F/A-18E/F *Super Hornet* programs. This chart shows the change in the average unit program cost, which includes the amortised R&D cost as well as the aircraft costs. The *Raptor* program is generally regarded as an exemplar of runaway costs, while the *Super Hornet* is regarded as a highly successful program.

Figure 1: Comparison of three aircraft program costs.

Sources: US DoD Selected Acquisition Reports 1990-2010; ASPI analysis.

At the end of year six, all three programs showed similar unit cost growth projections against their baseline projection. After that point the evolution of *Raptor* and *Super Hornet* unit program prices were dramatically different—cost growth continued to plague the *Raptor* while *Super Hornet* costs rose only slowly and then tapered off (and are still falling today). Writing in 2006, this author noted that the future direction of the F-35 trend line was unclear and depended critically on whether the advertised proactive treatment of risk in the F-35 program proved successful. Clearly that has not been the case.

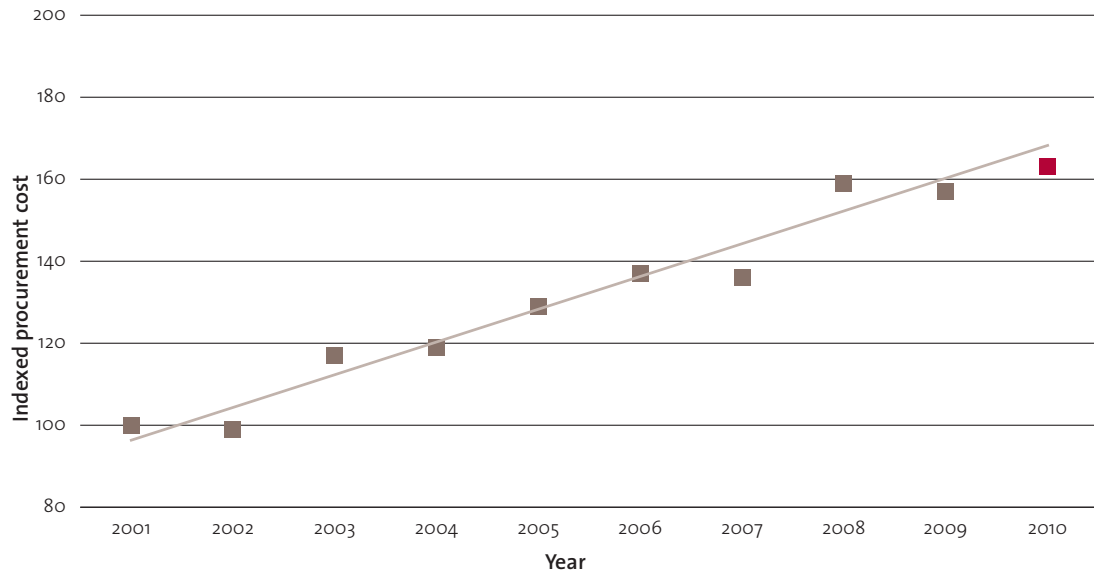
The data from the last few years shows that the F-35 program costs have escalated dramatically. At the end of year ten, the projected average unit program cost has grown by 78% above the original estimate. Some care is needed here: the rapid increase in JSF cost at the nine and ten year marks is partly due to new US legislation (the Weapon System Acquisition Reform Act of 2009) that required an independent (and more conservative) cost estimate to be used rather than the previous project office estimates. On an 'apples with apples' comparison basis the F-35 program is faring about the same as the troubled F-22 *Raptor* program at the same stage, which was showing a 50% increase. However, half of total planned production of the F-22 had been cut by that stage. Things got even worse for the F-22 later on, with the final number produced being less than a third of the planned total, at a unit cost just short of 200% above baseline.

This pattern of rising unit costs followed by number cuts, which in turn drive the unit costs still higher and so on is called a 'death spiral' in Pentagon circles. So far the F-35 has avoided significant cuts to numbers, with only 15% of the planned production run for US purchases being cut (from 2,866 to 2,457). The danger is that further cuts will follow if costs continue to rise—a risk that can only be exacerbated by the current US government fiscal situation. Nonetheless, F-35 numbers are very high and even a savage cut of half will still result in over 1,000 aircraft being produced—enough to ensure that production efficiency is attained. (For example, *Super Hornet* prices levelled out around the 500 mark.)

So overall number cuts don't present too big a threat. More of a concern for early buyers is the prospect of production numbers being deferred to later years due to a combination of fiscal pressures and uncertainty remaining in the development program. The US has already reduced early aircraft numbers by a couple of hundred, which will have the effect of making earlier aircraft to other customers more expensive—a point that will be relevant to Australia (and to which this paper will return later).

Australian Defence planners might reasonably argue that the program cost is irrelevant to Australian plans because we won't pay the R&D component as a paid-up member of the international JSF consortium. For us the *procurement cost*, which includes all of the ancillaries required to operate the aircraft but not the R&D component, is a more relevant measure. Helpfully, the GAO break out the procurement cost separately in their annual reporting, providing a figure more directly relevant to an Australian purchase. Figure 2 shows the result. The latest data point for the F-35 shows a 58% increase in unit procurement cost—a number essentially identical to the cost growth exhibited by the F-22 at the same stage of development and fully double the cost growth at year ten in the *Super Hornet* program.

Figure 2: Indexed F-35 unit procurement cost as estimated by GAO 2001–2009. The red point at the top right is the F-22 at the corresponding stage of development.



Source: GAO major weapons systems annual reports

Yet another round of reviews in the Pentagon will produce some new numbers later this year. ASPI's estimates of four years ago—dismissed by Defence officials at the time as too pessimistic—are set to be surpassed.

That's the bad news. The good news is that reality appears to be less stark than the worst-case estimates. Manufacturer Lockheed Martin has signed a fixed price contract for the fourth LRIP batch at around \$130 million per aircraft. While a long way from the initial promised sticker price of \$55 million—those days are a distant memory now—it's well under the recent headline figures.

One of the things to watch for as an indication of stability in the program will be whether the batch four aircraft are actually delivered to the contracted price. There's certainly an incentive for them to be—unlike previous deliveries, Lockheed Martin will be out of pocket if they aren't. And the next indicator will be the negotiated price for LRIP batch five. Those negotiations should occur late this year. If things are tracking well, the price should be below the batch four price. It's worth noting that the F-22 procurement cost showed little growth after year eleven. If the F-35 follows suit, there may not be any bad surprises to come.

Schedule

The financial tightening is of concern. But perhaps even more seriously, schedule pressures mean that the ability of the RAAF to maintain its fleet of around one

hundred combat aircraft—the publicly-stated necessary number to maintain capability—in the last few years of this decade is now coming under question.

The inevitable teething problems that come with new technologies are manifesting themselves in the F-35 program. According to the GAO, the aircraft are not displaying the predicted levels of reliability, with the CTOL version managing 1.8 flying hours between failures, 60% of the planned figure of 2.9 (the mature target is 6.0).

For the first time, the latest GAO report discusses stealth issues, describing problems with the manufacturing tolerances of the aircraft's specially shaped outer skin. The current aircraft may be less stealthy than possible, in part because parts sourced from different manufacturers are not mating as smoothly as planned. Again, this is nothing new—Airbus and the *Eurofighter* consortium both had great difficulty making the distributed manufacturing business model work too. The problem will likely be solved, but GAO note that this won't happen before mid-2015, which may result in aircraft manufactured before then requiring substantial reworking. However, actual testing of the F-35 is indicating that the aircraft is meeting its stealth design targets. Program head Admiral Venlet, in his brief to US media on 21 April, when questioned about the GAO's reference to these issues, said 'in regard to aircraft signature... we have delivered aircraft off the production line and have flown them over ranges and we have very, very good results. We don't have any worries currently that we have detected'.

More of a concern is the software—a bugbear of many modern defence projects. Development is behind schedule and the latest re-plan has slipped each successive delivery further out. The initial warfighting capability is scheduled for late 2013 and the full warfighting capability is now out to April 2016. There are software engineering approaches that could deliver interim stages of capability earlier (a 'spiral development' approach) but each interim delivery will require extensive testing and the overall effect would be to lengthen the process and increase costs. It will be important to watch whether future software deliveries are on schedule—and contain the planned functionality. There has been a tendency to defer functionality to later software blocks in order to keep to schedule (or, more accurately, to reduce the lateness of delivery).

The USAF, which had until recently planned to achieve initial operating capability (IOC) in 2016, has advised Congress that they expect a further delay of perhaps two additional years. It would clearly be preferable for Australia to wait until after the USAF had achieved IOC before introducing the aircraft into local service. In that case the RAAF's IOC date must be starting to look more like 2019/20. A fall-back position might be to 'piggy-back' on USAF initial operational testing and evaluation (IOT&E). In that case the USAF achieving IOC in late 2017 (or perhaps early 2018) would still allow an Australian IOC at the end of 2018.

That should ring some warning bells. When Australia signed on to the F-35 program back in 2002, it was planned that first deliveries of the aircraft to RAAF would occur in 2012, a year after the USAF achieved IOC in 2011. Four years were to elapse between USAF and RAAF IOC, with the RAAF achieving that mark in 2015. Under this plan, the F-35 would replace the F-111 as it reached life of type. But today the F-35 is still at least seven years away from operational status with Australia and the F-111 is gone. The time between IOC for the USAF and the RAAF has telescoped from four years to one or two. Even if nothing else goes wrong, the F-35 will arrive as the 'classic' F/A-18 *Hornets*—which numerically form the bulk of the RAAF's fast jet fleet—reach the end of their service lives.

So where does this leave Australia?

So where does all this leave Australia's plans? Government has approved the purchase of fourteen aircraft to be delivered from 2014 at a cost of \$3.2 billion. Because of cost increases and reductions in early production numbers, they will cost more than planned. It's hard to be precise because we don't yet know what the LRIP six (from which the first Australian aircraft will come) and later prices will be, and we don't know exactly how much of the \$3.2 billion is for aircraft as opposed to other project overheads (facilities, simulators etc).

But making some reasonable assumptions based on experience with other aircraft purchases suggests that margins for that batch must be getting very tight indeed. It's not clear what will happen if the approved allocation is insufficient. Going back to government in the next couple of years for extra money isn't likely to be a winning strategy. The only real option would be to defer the purchase of at least some of the fourteen to a later batch, but that has the potential to further erode the margin for error in reaching IOC as planned.

Beyond the initial fourteen the financial situation probably isn't desperate. Australian plans have long had quite a bit of 'fat' in the form of contingency funds that should cover likely costs for follow-on acquisitions. (Quite why the project has more money than seems required is a separate question.)

Overall, schedule is more of a concern than cost. Any further slippage in the F-35 program risks eroding Australia's margin for error dangerously. To evaluate the potential impact, of further F-35 delays, it's worth looking back at the F-111 transition plan to see what could have happened in the absence of the *Super Hornet* purchase.

Towards the end of its life, the F-111 required enormous effort and investment. According to the Defence Annual Report, in 2007–08, a force of 21 F-111Cs achieved 2,933 flying hours at a cost of \$147 million, compared with 3,600 hours that were programmed (81% achieved); some 71 *Hornets* achieved 11,301 hours, or 98% of planned flight time, at a cost of \$112 million—or \$50,000 per flying hour for the F-111, compared with around \$10,000 for the *Hornets*. (There are some caveats to be applied here—the reporting mechanisms for both fleets do not accurately capture all of the costs due to the difference in the ways uniformed and civilian support is reported. The overall per hour costs of the *Hornets* is likely closer to \$30,000. But the F-111 was undeniably getting more expensive with time, not least because Australia was now a 'parent' Air Force after the USAF retired its F-111 fleet.)

The huge maintenance burden was bad enough; the increasing risk of groundings due to unforeseen technical problems meant that availability was becoming hard to guarantee, and the F-111's survivability had been compromised by a new generation of air defence weapons and sensors. This combination of rising costs and reduced capability compared to the external environment are likely to become issues for the *Hornets* as they age. All aircraft cost more to maintain as they near life of type. The 'on again off again' saga of the *Hornet* structural refurbishment program (centre barrel replacements) and uncertainty about wing fatigue issues in the F-111 in their last decade of service shows that managing the airframe life of ageing aircraft is an uncertain business. That is not a criticism—these are difficult issues to manage and surprises become increasingly likely with age. As far as capability goes, the *Hornets* do not have modern AESA radar systems such as those in the *Super Hornet*, which will make them increasingly uncompetitive in modern air combat.

The purchase of the *Super Hornets* was contrary to advice from the RAAF that an interim aircraft was not necessary. The decision was much criticised at the time (including, it must be said, by this author) but it was a sound one. By ordering a front line aircraft off an established production line, the government provided the RAAF with both a credible capability for at least the rest of this decade and saved it from either having to keep the F-111 limping along at great expense and reducing capability, or from seeing the air combat fleet reduced in both size and capability. Of course, this was not without a cost—the need for an interim aircraft effectively added several billion dollars to the cost of transition of the air combat capability.

Given the current state of the F-35 program, the question that must be going through the minds of government and Defence planners is whether there is another looming capability gap later this decade. The *Hornets* are currently performing acceptably, thanks to the work that went into them in the upgrade program, but plans are to phase them out towards the end of this decade (with a decreasing number of aircraft continuing into the early 2020s).

What is Plan B (and C)?

There are only two reasonable alternatives. We could throw more money at the *Hornets* but, as discussed above, the likely outcome would be a modest extension of an already dated type at great expense—and significant downtime as the aircraft were being worked on. Or we could let the size of the RAAF fleet decrease as the *Hornets* age out. But even if the capability implications of that could be accepted, that's unattractive for continuity reasons. It's easier and more effective to maintain a capability than to let it dwindle and then try to reconstitute it—as the submarine arm of the Navy would readily attest.

Nonetheless, if an additional gap of a year or two was to transpire, the *Hornet* life extension is probably the least bad option. This would constitute 'Plan B'. But a longer gap would probably require another tranche of additional aircraft to plug the gap—'Plan C'. The only credible Plan C answer is more *Super Hornets*. We've already incurred the fixed costs of acquiring the type and have an established training program. The aircraft is in frontline service with the USN and has acquitted itself well—the USN is planning to keep them in service to at least 2030. Boeing has a roadmap for the *Super Hornet* that may see future aircraft with more powerful engines, longer range and a smaller radar cross section due to 'podded' weapons carriage. Luckily the *Super Hornet* production line will be open for a few years to come—which reflects the uncertainty in delivery dates of the F-35 for the USN, who added another forty-one *Super Hornets* to the planned production run last year on top of an earlier addition of over 100 aircraft.

We'd probably have to buy additional *Super Hornets*, but there's one other possibility worth at least entertaining—leasing. The capability gap problem was faced at both ends of the F-111's life in Australian service. In many ways the F-111 was the F-35 of its day—an aircraft developed in a multi-service program (though the USN later withdrew) and which offered a leap in performance above the types it was to replace, but which required more development time (and money) than originally thought. The original delivery date of 1968 proved unrealistic due to mechanical failures in early aircraft and the need for re-engineering, testing and re-certification pushed the date out to 1973. The RAAF's ageing *Canberra* fleet no longer offered state-of-the-art capability. The answer was to lease twenty-four F-4E *Phantom* aircraft from the US. The *Phantoms* served with the RAAF between 1970 and 1973, providing a capability that neatly bridged the gap between the *Canberra* and F-111.

That sort of solution is less likely today. The US Government would have to agree to take aircraft back when their own future plans are looking uncertain. But it might be worth at least asking the question—providing a loyal customer and a close ally with

a fall-back position isn't an unreasonable ask. And it might keep Australia tied to the F-35 program when it might be tempting to buy more *Super Hornets* and be done with it.

Conclusion

Things are manageable for now and some recent indicators are more positive for the F-35 than they have been for several years. But further development problems have the potential to negatively impact on Australia's air combat capability and/or cost billions of dollars extra.

If things go awry, Plan B is another *Hornet* life extension program. Plan C would be more *Super Hornets*. If capability planning is all it should be, these plans are being developed now. It's to be hoped that there are discussions underway now with the relevant players in the US to put in place solid contingency plans.

So the options are there, should more bad news emerge from Fort Worth in the next few years. But Australia must keep a close eye on the indicators of F-35 progress and be prepared to act accordingly.

Notes and further reading

The April 2011 GAO report 'Joint Strike Fighter: restructuring places program on firmer footing, but progress still lags', is available at <http://www.gao.gov/new.items/d11325.pdf>

Earlier versions of the figures analysed here appeared in 'What price the JSF?' *Australian Defence Magazine*, September 2006. (Available at http://rumourcontrol.com.au/analysis/JSF_cost_analysis.pdf) The analysis here uses a slightly different methodology, using then-year dollars, expressing all estimates in program baseline dollars rather than current year dollars. This explains some differences between the graphs. The conclusions are the same.

ASPI's 2004 paper *A big deal: Australia's future air combat capability* explains the thinking in the first few years of Australia's involvement in the F-35 program. It is available at http://www.aspi.org.au/publications/publication_details.aspx?ContentID=42

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