Submission to Foreign Affairs, Defence and Trade Committee Inquiry into the planned acquisition of the F-35 Lightning II (Joint Strike Fighter)

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February 19, 2016

Executive summary

We do not see any need to change the program of record at the moment. The F-35 remains the RAAF's best choice for its future air combat capability, notwithstanding some disappointing program performance to date and the remaining uncertainty regarding unresolved technical issues.

The hedging strategy of the purchase of 24 Super Hornets and the upgrade and life extension of the classic Hornets still provides a few years' grace, but further delays to F-35 delivery could drastically limit the range of possible responses in the early 2020s, and a capability gap could become a possibility.

Although it might not prove necessary, as a prudent hedging measure we recommend that Defence gather data regarding the window of opportunity for future orders of an additional tranche of Super Hornets, with a view of having a viable 'second hedge' strategy.

Introduction

For more than a decade, ASPI has followed the development of the F-35, and has provided commentary on the status of the program and its implications for Australia's air combat capability. In many ways it has been—and remains—a vexing exercise. There is no doubt that the F-35, like many projects, has been a victim of a conspiracy of optimism as far as initial estimates of costs, schedule and (perhaps) capability are concerned. It is now almost a decade late—and will be later still by the time a mature capability is delivered. It is substantially more expensive than early costings suggested, and there are still many program issues at various stages of resolution, even after fourteen years of development. Yet those close to the program, both here and in the United States, are resolute in their view that the aircraft remains a potential game changer in air warfare.

The public discussion is an exaggerated version of the same dichotomy and there is a small but vocal cadre of F-35 opponents who seize upon any bad news as a sure sign that the program is a colossal error. Based on the program underperformance issues mentioned above, some of the criticisms that have been levelled are fair, and the overall performance suggests

that it is unlikely that we will see anything as ambitious again. But there are also elements of the discussion that are poorly informed, selective in the data used and ultimately unhelpful.

To some extent, we understand why the public discussion has been difficult and fractious. ASPI does not draw on classified information for its public discussion papers, and we have found it difficult to draw confident conclusions one way or the other from publicly available official information. We note that a recent article from the Jane's Defence Group, reporting on the Pentagon's 2015 Directorate of Operational Testing and Evaluation report, made a similar observation:

> The issuance of a critical report followed by a robust defence has now become a familiar theme for the F-35 programme. For those outside looking in, it can almost seem as if there are two separate realities when it comes to the programme; one where everything is behind schedule and over budget, and in which the F-35 is single-handedly bleeding the defence-industrial complex dry, and another where all the former issues have been resolved and the effort is forging ahead to budget and schedule, and in which the F-35 will be the answer to the West's combat aviation prayers for the next 30-or-so years.
>
> This toing-and-froing between the [Office of the Secretary of Defense] and [F-35 Joint Program Office] over the 2015 DOT&E report is but the latest in a long list of such exchanges between those that see only negatives when it comes to the F-35, and those that appear only to see the positive. Regardless as to which side is right, it is a pattern that is sure to be repeated often before the truth is finally known.

The net result for us is that our publications and commentary have therefore focussed on presenting the data as best we can, and suitably qualifying the judgements we have drawn. The main points from our substantial body of work on the subject can be summarised as follows:

- The F-35 program was poorly managed in the US from 2002 (when the Australian Government first committed to the aircraft) until 2010. The program performance resulted in significant cost overruns and schedule slippage. Early program estimates for both were unrealistic. [See attached 2014 F-35 costs re-re-revisited for a discussion of F-35 cost growth.]

- A significant overhaul of the program in 2011 and much closer management by the Pentagon has resulted in a more stable outlook for costs and schedules, albeit still with risks of further problems remaining. [See attached ASPI's 2015 F-35A Budget Update for our most recent analysis of USAF budget projections.]

- The poor performance of the F-35 program has had significant implications for the management of Australia's air combat capability, as well as the total cost of

capability. The ‘interim air combat capability’ acquisition and subsequent support of 24 F/A-18F Super Hornets exceeded $6 billion, and the upgrade of the classic Hornets cost over $3 billion. Given the developmental nature of the program in 2002, contingency plans should have been in place much earlier. [See attached 2011 ASPI publication What's Plan B? for a commentary on planning at that stage.] Some good work on the 'classic' F/A-18A/B Hornet fleet has pushed the deadline into the 2020s, but the same issues will resurface if there are further significant slippages in the F-35 delivery schedule—see our comments below.

- That said, there are few realistic alternatives to the F-35 at the moment—other potential choices are less stealthy, have poorer electronic warfare capability and are likely to be well overmatched by the F-35. That will be less the case as time passes, which again reflects the penalty of delayed delivery schedules. Our most recent summary is the pre-2014 government announcement analysis Taking wing: time to decide on the F-35 Joint Strike Fighter (attached).

- The lure of high-tech work for Australian industry has distorted government decision making. The contingent nature of that work, requiring ongoing participation in the F-35 program, has been used to constrain Australia's options. [Discussed in the attached ASPI blog piece US – Australia military interoperability II, which points out that American industry policy settings have disadvantaged Australia in other defence-related areas as well.]

It is not the aim of this submission to re-analyse F-35 programatics, or to provide a capability assessment. ASPI will do that as a matter of course if circumstances change and reliable information becomes available. Instead, we will focus on the Australian Government’s realistic options for managing the nation’s air combat capability.

The Australian Government’s current options

Broadly speaking, the two options available to the government as of early 2016 are:

1) do nothing other than the program of record: i.e. continue to plan on the successful delivery of the F-35 in time to replace the F/A-18A/B ‘classic’ Hornet in the first half of the 2020s. (The most recent public data is an initial operating capability (IOC) of 14 F-35s by the end of 2020, with the remaining 58 aircraft due for delivery to the RAAF in 2023.)

2) develop a hedging strategy that provides for a second ‘interim’ purchase of aircraft in case the F-35 program is further delayed, beyond the expected lifetime of the classic Hornets.

Option 1 requires less effort, but it also carries a higher risk of a capability gap in the event of a failure of the F-35 to be delivered in a suitable timeframe. At the time of writing the

'Taking Wing' paper referenced above, there did not seem to be a high priority for a hedging strategy, as the program performance appeared to have stabilised. However, given successive DOT&E reports since, the evaluation of the F-35 program in that paper may have erred on the side of optimism—noting the caveat that it is actually hard to assess the current state of known problems from the available conflicting views.

It seems to us that it would be prudent to at least devote some staff work to developing an alternative. The RAAF can be expected to resist that notion, as was the case back in 2007 before the Howard government took the decision to acquire 24 Super Hornets. The then Chief of Air Force told Parliament that Air Force's view was that purchase of a bridging fighter would only be a last resort. Time has shown that assessment to be wrong, and the Super Hornets now represent a successful hedge against the realised delays in delivery of the F-35.

For a number of reasons, the most sensible hedge would be another tranche of Super Hornets. We base that assessment on the following basis:

- no other fifth generation aircraft is available on the world market. (In that respect, we observe that there is essentially no chance of the F-22 Raptor being reinstated to production, especially for export.)
- most (all?) of the fixed costs of acquiring the Super Hornet have already been borne
- any other type would necessarily bring with it new supply chains and flight and ground crew training requirements, putting strain on the RAAF's capacity to absorb the several other new types in the pipeline.

No decision to implement another interim purchase has to be made for a few years yet. As the ANAO notes, life extension work on the classic Hornet fleet has pushed its retirement date from 2015 to 2022 and beyond. But by 2023 the classic Hornets will be well into their fourth decade of service (see the table below) and there must be some uncertainty in the actual end of life (the ANAO analysis shows that costs definitely increase towards the end). Given the increasing challenge of keeping a 1980s platform at contemporary standards of capability, scope for further extension would be limited.

Table: Current and projected ages of Australia's F/A-18A/B fleet. (See note at end.)

Year	Number (2016)	Age (2016)	Age (2023)
1985	6 (1xA; 5xB)	31	38
1986	12 (12xA)	30	37
1987	14 (7xA; 7xB)	29	36
1988	24 (20xA; 4xB)	28	35
1989	11 (11xA)	27	34
1990	4 (4xA)	26	33

Given a three-plus year lead time for the delivery of a new-build Super Hornet, that suggests a decision would be needed around 2019 at the latest. A possible complicating factor to

consider is the status of the production line, though it seems that there is some margin there as well. The US Navy is Boeing's primary customer for the Super Hornet and the Growler, and while production for the US Navy has been low in recent years, delays in the F-35 program—and the F-35C carrier variant in particular—have resulted in additional purchases of new-build Super Hornets and Growlers. Boeing's informal advice is that it plans to keep production open until 2019 at least, and possible future international sales would extend that date (customers may include Kuwait, India and perhaps even Canada). However, low rate production might result in an upwards variation in price, and there is also the need to take into account the time required for long-lead items to be ordered.

Notes

The ANAO report *Management of Australia's Air Combat Capability* includes detailed data on Hornet flight hours between 1992 and 2012. The 'classic' Hornet fleet flew an average of 11,900 hours per year, distributed between the 71 operating aircraft, which averages to around 168 hours per aircraft per year.

Using that average figure, we can make some broad quantitative inferences about the state of the fleet: if every individual 'classic' Hornet averaged 168 flight hours per year since it was delivered, the fleet as a whole will have performed 340,200 flight hours. A flight-hour ceiling of 6,000 for each Hornet would mean that Australia's Hornet Fleet have flown approximately 80% of their recommended total hours as of 2015. Additionally, at 168 hours per year, each Hornet would reach its individual 6,000 flight hour limit at less than 36 years of age. The first six Hornets delivered in 1985 will reach this age in 2021, and the last four in 2026.

The overall situation might be a little better than that because the fleet has been carefully managed on an aircraft by aircraft basis and a number of aircraft underwent structural refurbishment work as part of the Hornet upgrade project. Nonetheless, it does not seem prudent to plan on keeping a substantial number of Hornets beyond the early 2020s.

ATTACHMENT: RELATED ASPI PUBLICATIONS

1. Graph(s) of the week: F-35 costs re-re-revisited

Published on the ASPI Strategist blog (here)
Andrew Davies, December 5, 2014

While the Australian Government has already made its decision to go ahead with procuring a total of 72 F-35 Joint Strike Fighters, there's still cause to watch the progress of the development program. Australia will most likely take delivery of the bulk of its aircraft about five years from now, which given the lead times for major components, means we'll start paying for them around 2017 or so. But at the moment we don't know what the final bill will be, so ASPI will continue to monitor the F-35 cost data.

I've reported on F-35 costs and schedules a few times before on The Strategist—most recently after the release of this year's USAF budget papers. That contained some good news, pointing towards stability in program costs over the past few years. But the USAF is far from being a dispassionate observer of the F-35 program, as it's in desperate need of new aircraft to recapitalise its tactical fleet. So it's worth looking at the data provided by the Government Accountability Office (GAO) as well.

The Pentagon and the GAO have often seen the F-35 program through quite different lenses. The GAO was especially critical of the management and performance of the program in the period 2002–2010, while the Pentagon tended to play down the problems. The verdict of history is pretty unequivocal on that one: the GAO was right, and after the program breached a Congressional threshold for cost overruns in 2010 it was subjected to a major re-baselining.

Since then, things have been running relatively well. The program has had some setbacks—including the grounding of the fleet due to an engine fire earlier this year—but seems to be tracking more reliably than was previously the case. We can be more confident of that than was formerly the case because, significantly, the Pentagon and GAO figures are now telling the same story.

Let's start with the program cost—the total amount required for all of the R&D as well as the production of the aircraft and the ancillary equipment required to operate it. To an extent that's not Australia's problem, as we won't pay any extra for R&D because of our membership of the F-35 international program. We'll only pay for the aircraft and related equipment, not for further development work. The US shoulders that alone, which is why the program cost gets the attention of Congress. In the worst case, that could cause American procurement numbers to be cut, production rates to be slowed and unit prices to go up for all customers.

Figure 1 shows how the F-35 is tracking compared to the disastrously expensive F-22 and the successful F/A-18 E/F Super Hornet programs. The graph shows indexed costs, relative to the

initial program estimates. As F-22 R&D costs spiralled upwards, numbers were cut successively from over 700 to 188 when production ceased—and the gross cost per aircraft ended up at over US$400 million (today's prices) as a result. After tracking the same way for a while, the F-35 is showing signs of levelling out. We have to be a little careful, because development programs often look stable for a while before jumping upwards again, but the recent trends are good.

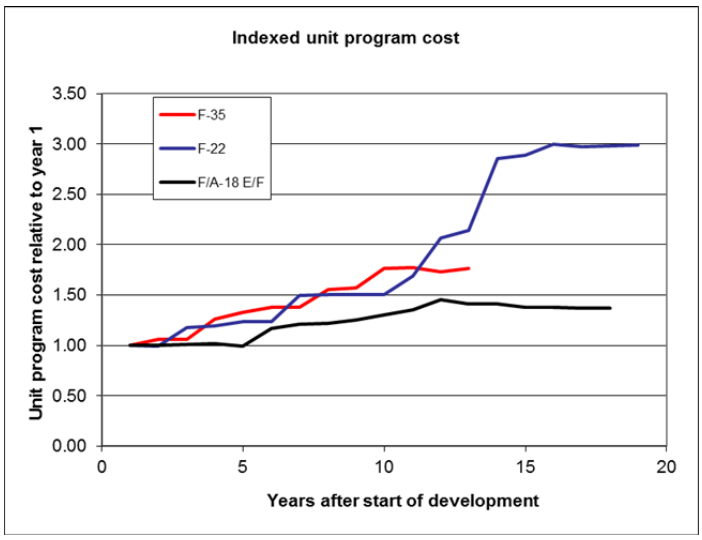
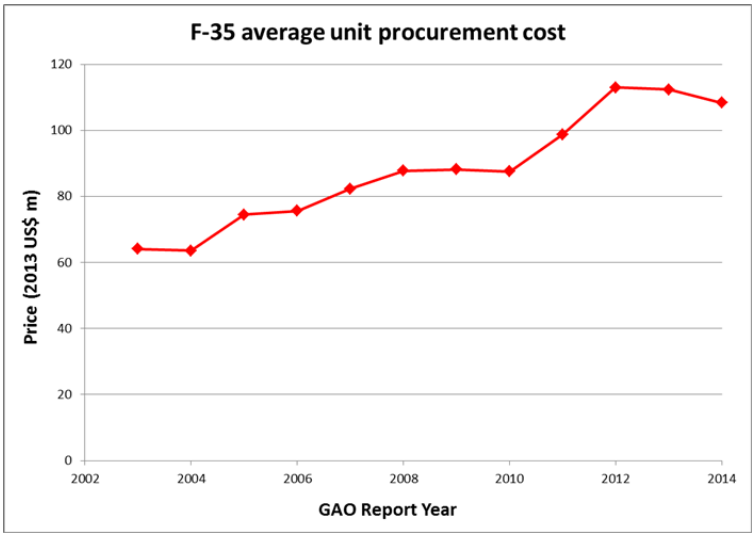


Figure 1. Indexed program costs for three American tactical aircraft programs.
Source: Pentagon Selected Acquisition Reports

Figure 2 shows the average procurement cost per aircraft, which is the price without the R&D component. The figures are averaged over all three types of the F-35, and Australia is buying the least expensive, so the graph over-prices the Australian purchase. The trend since the 2010 baseline was established is downwards, once we allow for a time lag in the GAO data because they work on Pentagon data from the previous reporting period. That's a first for the F-35 program, but is a feature also visible in the Super Hornet data once that program reached maturity. The GAO observes that 'the production line continues to show efficiencies and quality metrics show positive trends', consistent with the Pentagon reporting US$11.5 billion of savings (about 3% of the total cost) due to more efficient processes.



F-35 average procurement cost as reported by GAO from 2002.
Source: Annual GAO Assessments of Selected Weapon Programs (2014 here)

Finally, a caveat. The GAO reporting notes that critical technologies for the F-35 aren't yet mature, and that a substantial amount of testing remains to be done—all while production is ramping up:

The F-35 program … plans to have 530 aircraft, more than 20% of its total procurement quantity, under contract at a cost of approximately $57.8 billion before developmental testing is completed in 2017.

Until all of the testing is complete, we can't be completely sure of the future trajectory of the F-35 program metrics, so we'll be keeping an eye on them. But for now the report card would read 'has made significant progress—must stick with it'.

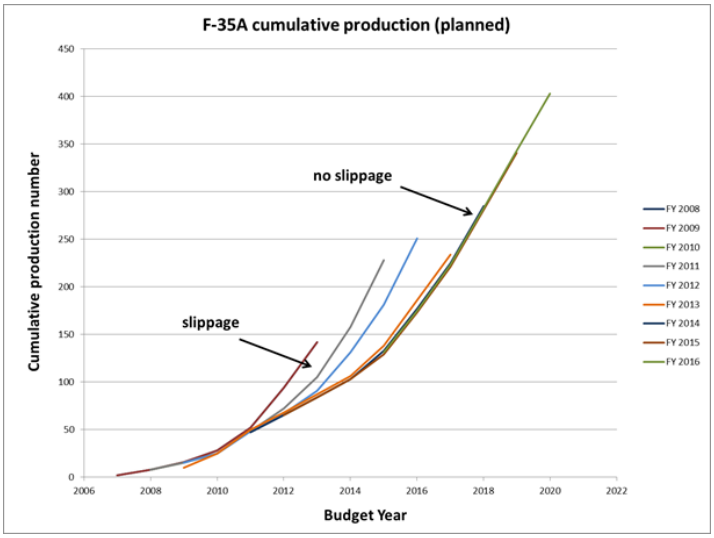
Andrew Davies is senior analyst for defence capability and director of research at ASPI.

2. Graph(s) of the week—F-35A budget update

Published on the ASPI Strategist (here)
Andrew Davies, September 10, 2015

For the past couple of years I've been keeping Strategist readers updated with the status of USAF planning for procurement of the F-35A Joint Strike Fighter at each pentagon budget cycle. (See here for 2013 and 2014.) When the Pentagon budget papers{ were released in March of this year I re-did the analysis. It'd be unseemly and uncollegiate of me to blame the blog editing team for misplacing my submission, but the blog editing team misplaced my submission. So, six months late, here is the 'latest' look at the USAF's F-35 budget plans.

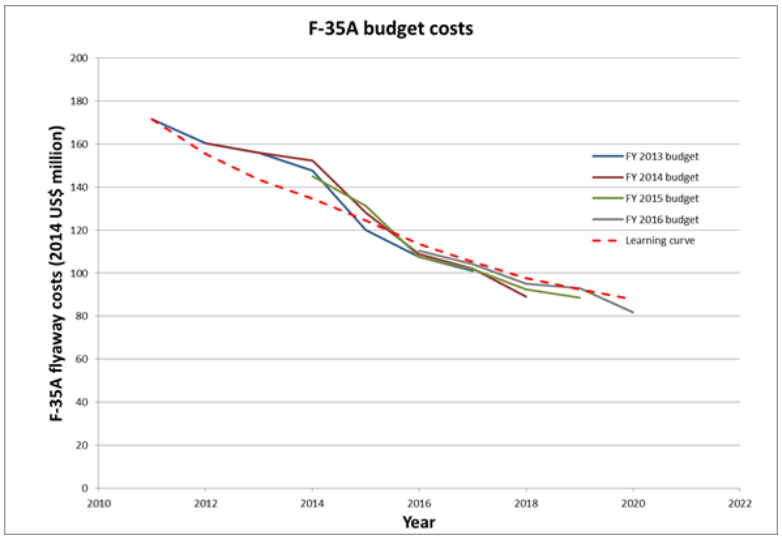
The story this year is that the trends identified in the past couple of updates are holding. The USAF is planning to acquire more than 250 aircraft in the next five years, and the prices they expect to pay are pretty stable. Figure 1 shows the planned production numbers from the nine most recent budget requests. The delays in ramping up production in the early years (the part of the graph labelled 'slippage') have now disappeared.



Source: USAF budget requests FY2008 through FY2016

The increased production rate's important for the RAAF because they're looking to get the bulk of their aircraft later this decade and early next. To get the best deal (and the most effective aircraft), the higher the production rate and the more stable the design the better.

The second graph shows why the numbers produced matter. It plots the budgeted flyaway (aircraft only) cost from the past four budget requests, along with an industry standard learning curve. Each time the production quantity doubles, the cost reduces to 80% of the previous figure. So the 100th aircraft is 80% of the cost of the 50th, the 200th is 64% and the 400th is a little over half the price of the 50th. I fitted the learning curve to the production cost of the 50th aircraft, and the agreement with the budgeted costs is pretty good. (For those who care about such things, there's a description of learning curves in a previous post, with the applicable formulae in a footnote.)



Source: USAF budget requests FY2008 through FY2016 and ASPI calculations

I have to add the caveat that the future figures are probably based on learning curve calculations, so there's a danger of circularity in the argument. But the actual—as opposed to budgeted—figures from the past few years show a strong decline in costs, albeit a little slower than the learning curve would predict.

If I had to get my crystal ball out and make predictions, I'd suggest that production numbers will be pretty much as predicted, but actual costs will be a little higher than the current budget figures suggest. That's because the USAF faces a 'make or break' period as far as recapitalising its tactical aircraft fleet is concerned (see my previous analysis here . Provided that cost increases don't spiral out of control—and there's little evidence of that in recent years—then they'll buy plenty of F-35s. For Australia, that's a good thing.

As a footnote, I'll note the sparse data on defence projects that Australian taxpayers get compared to the quality and quantity of information provided to the American public.

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

ASPI Policy Analysis, 12 May 2011 (available here)

Andrew Davies

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.

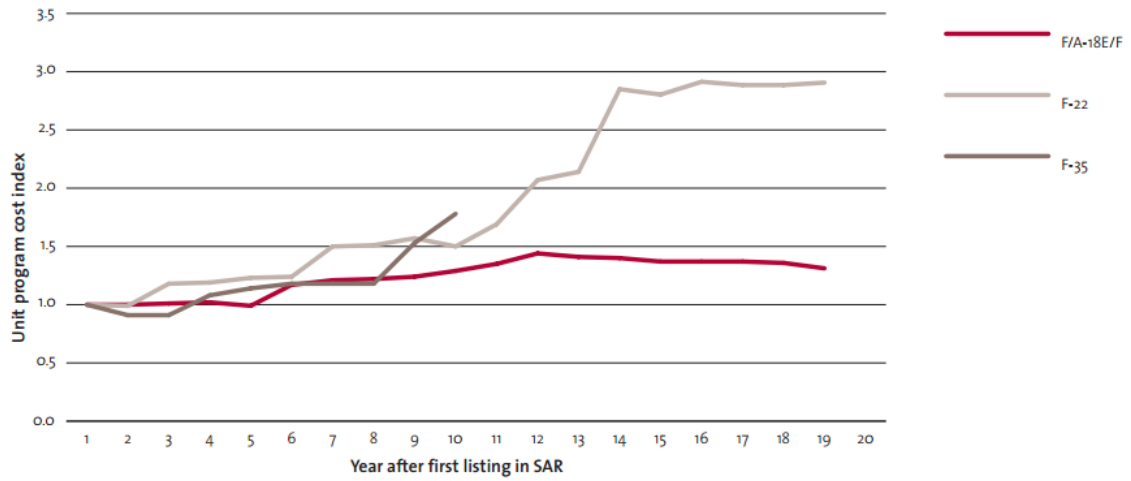
The most recent public reporting of the F-35 program is from the US Government Accountability Office (GAO). The program gets a mixed scorecard, as evidenced by the title of the report 'Joint Strike Fighter: restructuring places program on firmer footing, but progress still lags'. The GAO acknowledges 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

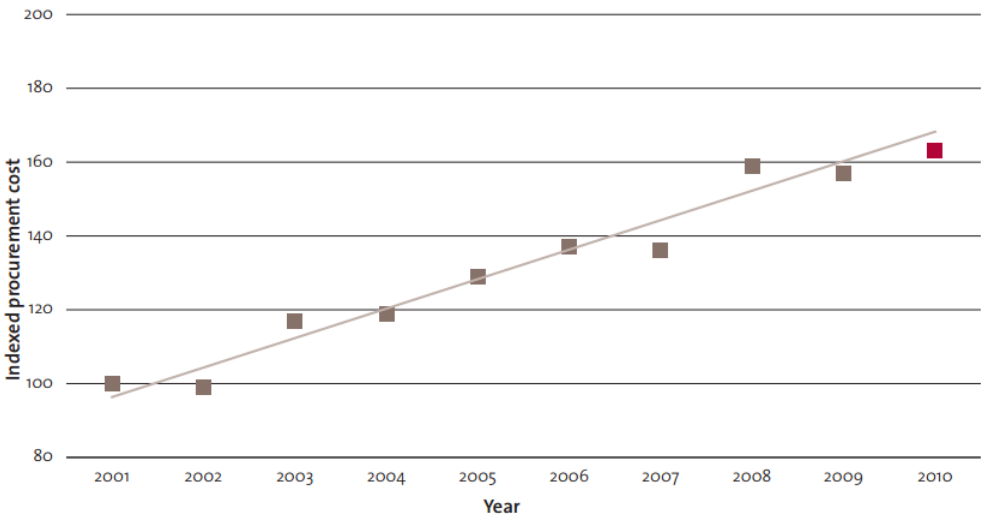
78% above the original estimate. Some care is needed here: the rapid increase in JSF cost at the nine and ten year marks is partly due to new US legislation (the Weapon System Acquisition Reform Act of 2009) that required an independent (and more conservative) cost estimate to be used rather than the 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

About the author

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4. US–Australia military interoperability II

Published on the ASPI Strategist blog (here)
Andrew Davies on March 25, 2013 @ 1:55 pm

In his recent summary of his Alliance 21 paper for this blog, ADM Gary Roughead cogently explained why Australia and the United States benefit from high levels of military interoperability. He also suggested several fertile areas where further developing shared approaches would pay dividends, including the establishment of a governance mechanism to move what has been a somewhat ad hoc (but often successful) approach onto a more formal footing. I'll resist covering the ground again here, other than to say 'what he said'. In any case, my perspectives on some of those issues can be found in my full length paper.

ADM Roughead's paper comes with the perspective you'd expect from someone with an impressive career as an operator of military capability. My paper takes a different tack and focuses on acquisition and industry policy, mostly here in Australia but also raises some issues where the United States could helpfully review its approach.

A couple of the recommendations for the development of Australia's defence industry policy have appeared in my previous ASPI publications on off-the-shelf procurement and naval shipbuilding:

- off-the-shelf materiel solutions from the United States come with built-in interoperability (and 'Australianising them' often reduces it) and should therefore be the default option
- there's an inexorable trend in defence industry towards Australian companies becoming part of a global supply chains, and efforts to artificially support or protect local suppliers introduces inefficiencies and often results in less value for money, reduced and less interoperable capability or both

From experience, I know there'll be some resistance to those observations. One of the objections is usually that there isn't a level playing field in the global defence marketplace—meaning that Australian companies would be placed at an unfair advantage. My usual response to that is that if other countries want to be inefficient in a way that lets us capitalise on their poor policy, we should let them. But I'm prepared to make an exception to that argument in the case of a close ally. After all, it's in our interest as well as America's for their procurement processes to be as efficient as possible.

For a start, I recommended that American systems should be developed with an expectation of export to close allies. This hasn't always been the case, but with increasing American expectations of their partners and allies doing more in the way of burden sharing—as seems to be the case in the Pacific region and was demonstrated in the Libya campaign last year where Europeans allies were concerned—it seems to be in the interest of both sides of the arrangement for allied capabilities to be at a high level. A step in that direction was the release to Australia of the EF-18G Growler airborne electronic warfare platform, which represents the first time such a capability has been exported.

I also saw some scope for the US to lower some of the effective barriers to Australian companies operating in the American market. Perth shipbuilder Austal has been very successful winning work for the USN, but had to establish a new yard in Alabama to do so. Not knowing the details of the business case, it's impossible to tell if that was the most efficient solution, but Austal already had a production facility in Perth, and an expansion on the existing base is likely to have been a cheaper all-round option—but wasn't consistent with US procurement policy.

I also see a problem with the way that work on the F-35 Joint Strike Fighter program has been allocated. In effect, the prime contractor (with the acquiescence of the US Government) has used contracts to attempt to 'tie' partner governments to acquisition of the F-35. Australian companies have won work on the program as a result of a limited competitive process. But the work is contingent on Australia continuing with its planned purchase of the aircraft—effectively adding a steep local political price to any decision to pursue an alternative, and recruiting the Australian industry lobby to the cause of the F-35. In effect, what could be an arms-length commercial relationship is instead being used to constrain the Australian Government's decision making on an important defence capability.

The disadvantages aren't one-sided either. The US will have trouble signing up partners and allies for future projects after this experience. From the contractor's side, the distorting effect of the 'pay to play' approach to industry has almost inevitably resulted in a less than efficient allocation of manufacturing contracts. And if partner countries with industrial work already under way defer, downsize or even abandon their F-35 acquisition, the disruption to production if work is taken away from local firms will introduce still further inefficiencies and delays into an already troubled program.

Finally, interoperability isn't just about the hardware. As well as the logistics, training and doctrine development that ADM Roughead discusses, there's also behind the scenes support in the form of intelligence. Systems such as the Growler, F-35 and cyber warfare require extensive intelligence support to operative effectively. Not just by keeping 'threat libraries' up to date, but also in near-real-time exchange of data to deconflict activities and coordinate manoeuvre. The deep intelligence relationship enjoyed in the signals intelligence world provides many of these benefits already. But it's not clear—at least from the outside—whether the intelligence sharing arrangements required across the board are as robust.

To summarise, on the American side:

- the allocation of work on American procurement projects to suppliers to Australia should be made on the basis of competitiveness, rather than being contingent on particular materiel acquisition plans by the Australian Government
- American systems should be developed with the assumption of export to close allies
- intelligence cooperation is increasingly important for the effective use of cutting edge systems. The Sigint model of cooperation might need to be extended into other realms—especially cyber.

Andrew Davies is a senior analyst for defence capability and executive editor of The Strategist. *Image courtesy of Flickr user Official US Navy Imagery.*

5. Taking wing: Time to decide on the F-35 Joint Strike Fighter

ASPI Strategic Insight , 24 March 2014 (available here)

Andrew Davies and Harry White

Executive summary

In the near future, the Australian Government will consider the second-pass approval of the acquisition of the bulk of the proposed F-35 Joint Strike Fighter (JSF) fleet. If approved, the acquisition will cement the JSF as the major part of Australia's air combat capability for decades to come. And it's not just an important security decision; it'll have a significant impact on the defence budget as well. This tranche will have a sticker price around $8–10 billion, and through-life costs will be well above that.

The ability to wield airpower effectively has been firmly established as a prerequisite for success at all levels of war fighting, especially the high-intensity end. And the capability to protect our air and maritime approaches is a core task for the ADF. The F-35 has been a part of that plan for over a decade and, after several false starts, we're now reaching the main decision point.

US Air Force F-35A Joint Strike Fighters from 58th Fighter Squadron, 33rd Fighter Wing over the northwest coast of Florida. Photo courtesy USAF.

The government will have to consider several issues when it sits down to make the decision. Delays in the delivery of the F-35—according to plans in 2002, it was meant to have entered service by now—resulted in an 'interim' purchase of 24 Super Hornet aircraft at an acquisition cost of over $3 billion and operating costs throughout the 2010s adding as much again. Entering service only a few years ago, these essentially brand new aircraft are likely to be in service until at least 2030. As well, in 2013 the government announced the purchase of 12 yet to be delivered Growler electronic warfare aircraft.

Because of those prior buys, and because the 71-strong 1980s vintage Hornet fleet will age out around the start of the 2020s, realistically the government has only two options. The first is to proceed with current plans and approve the acquisition of more F-35s, accepting the costs of operating a mixed fleet of three types (F-35, Super Hornet and Growler) for at least the next fifteen years, and accepting the opportunity cost elsewhere in the ADF's force structure. Within this option is the possibility of reducing the number of F-35s slightly to offset the additional cost of a mixed fleet, although it would also reduce the total air combat capability.

Alternatively, government could decline to pursue further F-35 purchases (perhaps including the 12 that are currently approved but not contracted) and consolidate the existing fleet with additional Super Hornets. This would result in a single-type fleet of strike fighters—the original goal of the F-35 acquisition plan—but at a lower level of overall capability than a mixed F-35/Super Hornet fleet would provide. In this instance it might be possible to augment the number of aircraft by reinvesting the funds freed up by consolidating on a single type.

Which of those options is chosen will depend on several factors. The first is the role envisaged for Australia's air combat capability. If it's about defence of Australia, either option would work. Projecting intercontinental power remains a formidably difficult task, and Australia's unlikely to come under direct threat from a major power in the foreseeable future. Super Hornets and the other enabling elements of air combat capability (air-to-air refuellers, airborne early warning and JORN over-the-horizon radar) would be likely to provide Australia with a sufficiently robust air combat capability for the next couple of decades. As well, in coalition operations, the provision of electronic warfare aircraft or air-to-air refuellers, either instead of or in addition to Super Hornets, would be a credible and valuable contribution.

But in the strike fighter role the F-35 is a far more capable aircraft than the Super Hornet and would give greater capability against a more capable adversary, including the ability to penetrate sophisticated air defences. If that's the criterion, then an F-35 purchase is the natural choice. The F-35 also provides more 'future proofing' against the acquisition of advanced aircraft and weapon system types around the region.

The ADF's anti-shipping strike capability will reside with the Super Hornet for the rest of this decade. While it will represent a step up from the previous capability, the ability to strike ships with sophisticated long-range defences will have to wait until a dedicated anti-shipping weapon is integrated on the F-35 in the early 2020s. That's after the planned delivery of Australia's aircraft, but retrofitting this capability onto Australia's F-35s should be relatively easy. In the meantime the Super Hornet will provide a credible maritime strike capability against most regional targets.

The F-35 program has been plagued in the past by schedule and budget overruns. The government will need to be satisfied that the program is on a stable enough footing to expect that the F-35 will be available and performing as required when we need it. In the wake of

significant recent efforts in the US to address program shortcomings, it now looks as though that's a reasonable bet. Costs have now stabilised and are trending downwards as the production rate increases, although the F-35 won't be the 'low-cost fifth-generation fighter' that it was initially billed as.

Other factors point towards a likely F-35 buy. Backing away from the F-35 would incur a political cost in Washington with the US Government, the Pentagon and the Congress. Because we're an international program partner on the JSF, the economies of scale for other buyers—including the US—will be reduced if we don't purchase the aircraft. Australian industry also has a stake in several substantial contracts for F-35 component manufacture, which are tied to Australian participation in the program.

In the final analysis, the government seems likely to be prepared to pay a moderate premium to maintain a high-end air-combat capability, and to preserve the other benefits to industry and the alliance with Washington. On balance, that looks like a reasonable decision for Australia.

Introduction

In the near future, the Australian Government will consider a proposal from Defence for 'second-pass' approval of the acquisition of a further tranche of 58 F-35[1] Joint Strike Fighters (which with a previously approved 14 aircraft would take the total number to 72). This is a big decision—the price of the 58 aircraft and associated support equipment and facilities included in this tranche is likely to be around $8–10 billion. At a time of intense government scrutiny of its budget commitments and curtailing of expenditure in other portfolios, the business case for the acquisition will have to be a strong one.

In fact, there's a pretty good case to be made for Australia to have a strong air combat capability. The ability to wield airpower effectively has been firmly established as a prerequisite for success in high-end war fighting. To be sure, there are many things that the ADF can be called on to do that don't require it, but it's a 'must have' if the nation ever faces a significant military threat. Given our geography, the possession of comprehensive airpower makes power projection—either by sea or by air—against Australia prohibitively difficult. This observation was made as early as 1935 by former prime minister Billy Hughes, who observed:

> If our resources will not suffice to furnish with all arms of defence, we must concentrate on aircraft. A strong air force is within our resources, no matter how conservatively these may be estimated. And there is no reason why Australia should not have an air force so strong as not only to overwhelm any enemy aircraft, to

[1] For readability we use F-35 in this paper as a shorthand to refer to the F-35A Conventional Take-off and Landing (CTOL) variant. Where other variants are mentioned the distinction will be made explicitly.

> destroy all transports, plane-carriers and supply ships accompanying the fleet, but also if desirable to disable, if not destroy, his armed vessels.
>
> To Australia the aeroplane has come bringing gifts in both its hands. We desire that it shall always be for us a messenger of peace, bearing our greetings of goodwill to all the world. But in case of need it can protect us from aggression more effectively than any other agency.

For well over a decade now, the F-35 has been a key part of Australia's plan for our future air combat capability. In 2002, the F-35 was being promoted as a low-cost 'fifth-generation' aircraft—the term's not entirely well defined, but implies a quantum leap in capabilities compared to older 'fourth-generation' designs, such as the Hornet. (To further muddy the waters, advanced fourth-generation aircraft such as the Super Hornet are often marketed as generation 4.5 or 4.75 aircraft—a description that blurs the line between the generations, thus misrepresenting the qualitative difference between them.)

When the opportunity to join the F-35 program as an international partner came along, the Howard government took the decision to elevate the F-35 to the status of preferred option for the replacement of the RAAF's 1980s-vintage Hornets. In doing so, the government curtailed a study that was being conducted into various options, which included the American F-15E Strike Eagle, F-22 Raptor and Super Hornet, the Eurofighter Typhoon and the Dassault Rafale from France.

But it hasn't been the smoothest of paths. Back in 2002, the 'flyaway' price quoted to Senate estimates hearings was US$40 million, or about US$52 million in today's money and US$58m in the 2019 dollars required for a comparison with the likely actual cost Australia will pay of around US$90 million (see the discussion of costs later). In 2002, the plan was for the aircraft to enter service with the armed forces of the United States before the end of the 2000s and with the RAAF in 2012, well in time to enable a smooth transition from the then Hornet and F-111 fleet. Time has shown both the cost and schedule numbers to be wildly optimistic. The intervening period has seen costs rise and Australia's planned F-35 in-service date slipped first to later in the decade and later into the early 2020s. In the first instance that was due to poor project management within the American program and greater than anticipated development problems, which collectively caused several major re-plans of the program. The program stabilised post-2010, and the most recent deferral of an ADF acquisition is most accurately ascribed to Australian budget adjustments.

That's had a significant impact on Australia's budget and force structure. To maintain Australia's air combat capability after the retirement of the F-111, successive governments purchased 24 'interim' Super Hornet strike fighters in 2006, augmented by 12 'Growler' electronic warfare aircraft in 2013. Including support costs, the total cost of these investments is just under $10 billion. Of course that's now a sunk cost, but the presence in the force structure of 24 essentially new combat aircraft and 12 electronic warfare aircraft can't be ignored in future decision-making.

The F-35 has received a lot of bad press over the years. Some of it has been deserved: the structure and management of the F-35 development program have left much to be desired, and the aircraft design itself has some significant compromises for multi-variant production. But some of the criticism has been hyperbolic and has only served to muddy the waters, at least in the public discussion

Today we have vastly more information than was available in 2002 and it's possible to be more confident about the timeline, cost and—to some extent, given the classified nature of some critical elements—the capability of the aircraft. As well, developments elsewhere allow us to make some predictions about the possible future operating environment.

When the government sits down to consider the proposal that comes forward from Defence, it'll have to weigh up a number of issues:

- What's the role for Australia's air combat capability? And, related, what's the likely operating environment?
- Is the F-35 now mature enough to justify committing to it as the backbone of Australia's air combat capability from around 2020?
- What will the F-35 cost, and how stable are the cost estimates?
- Are there credible alternatives to an F-35 purchase, and what are the cost and capability differentials between them?

This paper examines each of those questions in turn.

What's the role for Australia's air combat capability?

It's easy for any discussion of air combat capability to quickly devolve into a platform-centric 'type A versus type B' evaluation. If that's the basis for an acquisition decision, then it becomes a relatively simple matter of assessing the characteristics of the platform against credible adversary capabilities. That's the basis of 'capability-driven' decision-making.

The logic for the selection of the F-35 on capability grounds is simple: its advanced fifth-generation capabilities are the selling point. To paraphrase General Michael Hostage, head of the US Air Combat Command, by the middle of the next decade, older American aircraft would be very likely to lose in a straight fight with aircraft from capable adversaries like Russia and China. Each would be likely to have aircraft that can overmatch even significantly upgraded platforms, such as the F/A-18/EF Super Hornet. It makes good intuitive sense that you want to have platforms that are better than those of your likely adversary (at least if the numbers involved are similar—quantity matters, too). In the words of General Mark Welsh, Chief of Staff, US Air Force:

> When a fifth generation fighter meets a fourth generation fighter—[the latter] dies. We can't just dress up a fourth generation fighter as a fifth generation fighter; we need to get away from that conversation.

From an American perspective, that's entirely reasonable. American forces could be deployed at short notice to virtually any theatre globally, and would be expected to do the heavy lifting on Day 1, including projecting airpower into strongly defended situations where the defenders have the home-ground advantage. Being second best isn't good enough in that circumstance.

Australia's air combat capability, on the other hand, doesn't necessarily need to do that. As with all defence acquisition decisions, the most fundamental question is the role that the government sees for its investment into air combat. For example, do we want the capability to be able to conduct deep strike missions against a sophisticated integrated air defence system on Day 1 of a conflict—in which case, we're driven down the 'best platform' path—or is it sufficient to have the capability to implement Billy Hughes's essentially defensive strategy of maritime strike and air defence against credible levels of force that can be projected against Australia? In this approach, which could be termed 'scenario-based planning', the job is to find the most cost-effective way of achieving whatever limited objectives are deemed credible.

Unlike the US, Australia doesn't have global power projection ambitions (in contradistinction to being able to deploy forces in support of global interests—Australia's unlikely to do that unilaterally). Barring extraordinary changes to the regional environment, any threat to Australia will have to come from a medium power in Southeast Asia or from China—there are simply no other credible alternatives. So any future air combat capability should be weighed against those possibilities. And while the current government is yet to articulate its assessment of the future ADF operating environment, the declared position of the previous government— presumably informed by advice from the intelligence assessment agencies—is that no direct threat is anticipated from China. If that continues to be the case, then a reasonable working assumption is that the air combat threat to Australia's direct interests and territories is likely to remain modest in size for some time to come.

Note that Australia's ability to project air power from its own bases will be more limited in future than was the case previously, following the retirement of the long-range strike capability provided by the F-111. The operational radius of the F-35, while very handy by modern tactical aircraft standards, means that it would be able to fly operations just into the closer parts of the archipelago to our north without multiple air-to-air refuellings (Figure 1). Of course, the converse is also true: any adversary hoping to deploy airpower against Australia will face the same geography, and have the same difficulty in marshalling combat mass at a distance. Defending Australia is less demanding than attacking defended territories elsewhere.

The single most important task of the RAAF is to raise the costs and risks of threatening Australian territory to any would-be aggressor. A key part of the role of Australia's future air combat capability will be the way it enables or conducts maritime denial operations. But, at least in the initial phase of its service, the F-35 won't be able to deliver a dedicated anti-shipping weapon.

Maritime strike

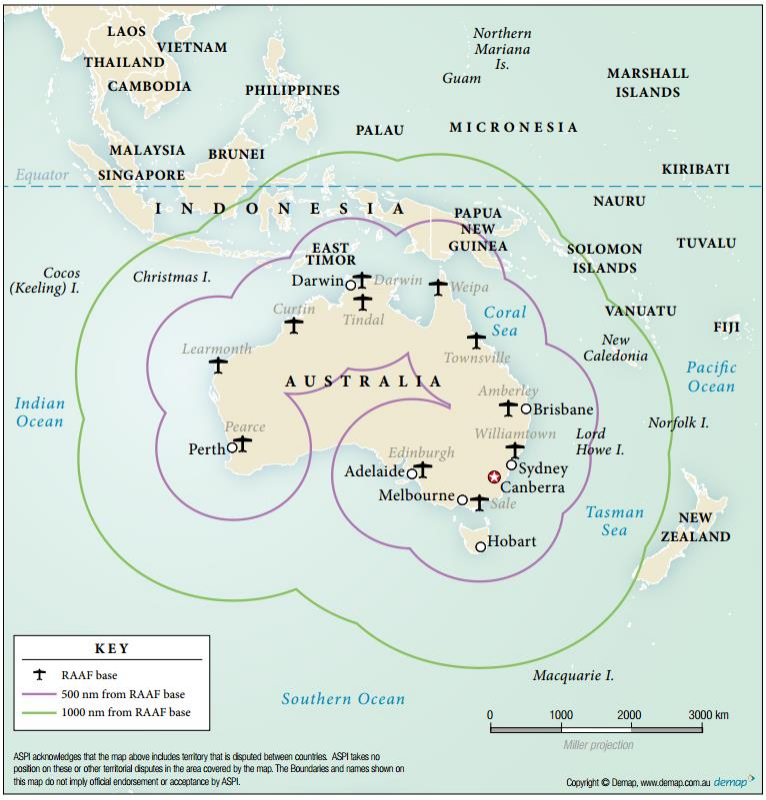
The capacity to raise the costs and risks of threatening Australian territory to any would-be aggressor is the single most important task of the RAAF. A key part of the role of Australia's future air combat capability will be the way it enables or conducts maritime denial operations. For the rest of this decade, the ADF's airborne maritime fast jet strike capability will primarily reside with the Super Hornet and the AGM-154C Joint Stand Off Weapon Glide Bomb (JSOW-C1). This weapon has a range of up to 100km, and has sensor and targeting packages to allow it to engage moving targets. This approach will be effective against low- to medium-capability shipborne defensive systems. Against 'top end' targets it's likely to prove less successful and riskier for the attacking aircraft. A greater stand-off distance and a more sophisticated weapon with greater terminal effect is likely to be required for mission success and survivability of the attacking aircraft.

When the F-35 enters service, it'll represent a substantial improvement, and will have a further growth path to a sophisticated capability to engage well-defended maritime targets. Its stealth will mean a lower chance of detection and it will be able to approach closer to the target before weapon release. At the time of delivery, the F-35 should be able to deploy the JSOW-C1 and probably the still developmental GBU-53/B Small Diameter Bomb Block II (SDBII). In effect, the ADF's maritime strike capability will improve markedly in terms of aircraft survivability and targeting capability, but will be limited by weapon effectiveness. But JSOW-C1 and SDBII are relatively slow weapons in the terminal phase and could be successfully engaged by close-in weapon systems.

At the moment plans are for the Norwegian-developed Joint Strike Missile (JSM) to be integrated onto the Block 4 or 5 F-35 aircraft in the early 2020s. (Like the JSOW-C1, retrofitting shouldn't be too hard.) Other weapons might follow in later blocks.

The combined capabilities of aircraft and missile will represent a sophisticated strike capability against most maritime targets. So given an F-35 purchase, the next 15 years would see Australia's maritime strike capability progressively improve from good to excellent.

Figure: F-35 combat radius with and without a single air-to-air refuelling



Coalition operations

One other factor that needs to be considered in selecting an air combat platform for Australia is the contribution that Australian forces could make to US-led operations, either in the Asia–Pacific region or beyond. That's important, because it essentially brings together the 'worst case' capability-based considerations and the scenario-based ones. Australia would have to decide whether it would be a part of high-intensity operations early in a conflict against sophisticated opposition—in which case, high-end capabilities are at a premium—or whether its contribution could come later, or at the margins of the main conflict. This point is covered in more detail below.

It's important to note that air combat is only one of many roles the ADF might be asked to perform by government, and it's far from the most likely one any time soon. Since the Vietnam War, Australia's air combat operations have been limited to the deployment of a squadron of Hornet aircraft to Iraq in 2003, which flew strike operations in a fairly permissive environment. But as well as actual combat, it's worth noting that Australia's sophisticated air combat capability plays a deterrent role as well during times of tension—the very reason the F-111 strike aircraft were purchased in the first place. Ultimately it's the government's judgement of the relative importance of air combat capability that'll decide its relative priority for spending.

F-35 program status

The F-35 program has had a troubled and well-documented history and risks remain. The delays in the program can be attributed to ambitious initial scheduling, the enormous complexity of the project, and management errors, including a concurrent development and construction approach. But the management of the program has improved markedly in the past few years and, after years of steady cost increases and deferred production numbers, successive Selected Acquisition Reports and Pentagon budget papers show prices trending downwards along a 'learning curve' and planned production numbers holding largely unchanged.

In March 2012, the US Department of Defense announced a revised timetable for the program, in part reflecting the restructuring that the JSF program had undertaken since 2010. The new schedule appears to have taken into account the difficulties the program had faced to that point, and has in broad terms proved realistic. Barring a major setback in development and testing— always possible in a development project, but increasingly unlikely—it seems that the aircraft will be available for service with US forces from 2016.

In line with that revised baseline, the Australian Government announced in May 2012 that 12 of the 14 aircraft that Australia had committed to purchasing would be delivered two years later than planned, with the first two still to be delivered in 2014 as per contract. That amended schedule appears likely to be met: the first aircraft are on track to be delivered in July and August this year and the first Australian pilots will begin training at the start of 2015. At this stage, Australia seems likely to achieve its planned Initial Operating Capability (IOC) in 2020, allowing the government to begin the phased retirement of the Hornet fleet.

However, due diligence necessarily entails understanding the remaining risks in the F-35 program. This is especially important, given the Australian National Audit Office's observation of a limited ability to sustain the Hornet fleet much beyond 2020. And, while progress continues to be good, significant amounts of flight testing and software development are still to be completed.

Mid-2013 testimony from the US Government Accountability Office notes that, while the program completed more test flights than scheduled, it fell short of its goal for test outcomes, highlighting the potential for further slippage. But subsequently the 2013 flight test program met most of its targets. The development of the enormously complicated software for the aircraft is another concern. There have been suggestions that delays in software development and integration could delay the planned mid-2015 IOC for the US Marine Corps short take-off/vertical landing (STOVL) variant, although a late 2015 date appears to be manageable. And despite these concerns, at the end of January 2014 the F-35 program office in the US said that it was confident that the aircraft would be ready in time for the Marines' target IOC. The Government Accountability Office has also noted improvements in software development management practices and greater success in meeting targets, suggesting that the program's on a better footing than in the past.

Structural issues remain possible but are increasingly unlikely. Problems that were identified in earlier testing now have engineering solutions that will be built into future aircraft. The most recently reported issue was cracks that have appeared in aircraft bulkheads in stress testing after 9,400 hours of simulated flight. Any program setback will have an impact beyond the specific model, but this issue won't directly affect Australia's F-35A CTOL model.

Another prominent issue has been the difficulty in getting the specified performance from the F-35's helmet-mounted display. The program began to develop a second, less ambitious and less capable, helmet to hedge against the risks in working on the full-spec version, but it's since reverted to the more capable option, which is expected to be performing as desired by the end of 2015. Test pilots anecdotally report that the helmet-mounted display is already fit for purpose and, more importantly, a substantial step forward from previous technologies.

On balance, the risks described above, while not negligible, look unlikely to prevent the aircraft from being available to the ADF when required.

Costs

As for any weapon system, both the acquisition and the through-life costs of the F-35 have to be factored into planning. After years of escalation, the acquisition costs now appear to be predictable, having stabilised—albeit at a substantially higher 'sticker price' than was initially promised. In fact, the F-35 is set to become a gold-standard example of the value of historical trends for estimating the cost of future platforms. While the initial estimate was well below the extrapolated past data, the final cost is likely to sit squarely on the long-term trend line.

The table below shows the most recent US Air Force budget planning figures for the next five years. Note that the figures are planning figures derived under Pentagon procurement rules and that actual contract prices have been less than the planning figures in the past two years, a trend the program office and service customers expect to continue. The 2019 figure should therefore be treated as an upper bound of the price Australia might pay for aircraft around that time. A figure of US$90 million (2019 dollars) probably represents a reasonable estimate.

Table: F-35A 'flyaway' costs for the 2014–2019 period (in then-year US$ million)

	2014	2015	2016	2017	2018	2019
F-35A flyaway cost	145.1	133.7	111.7	107.8	99.6	97.1

Source: US Air Force FY 2015 budget request, March 2014

The flyaway cost isn't the total cost of acquisition, which needs to include all ancillary items, initial spares and support equipment. A good rule-of-thumb is that the aircraft cost is about two-thirds of the total acquisition cost. As indicated in previous ASPI reports, there seems to

be no danger of the acquisition cost of the F-35 exceeding the budget of Project Air 6000. Recent reductions in successive F-35 production contract prices only reinforce this conclusion. (It's not clear why the project has such a comfortable budget margin, given that the initial price projection was substantially lower than the likely actual price, but we'll be generous and ascribe it to prudent planning.)

Much less certain is the through-life cost of the aircraft—which is hardly surprising, given that it's still in development and is still two years away from even initial operating status. And there do seem to be a number of issues that could affect running costs. Alarming projections of support costs have made headlines in the defence press (and sometimes the mainstream press). Some of that can probably be safely put down to the usual Beltway politics of large projects and competing acquisition priorities. But it's likely that there have also been substantial increases in projected F-35 support costs as well as the acquisition cost.

ASPI's 2008 work on costing force structures found that the 20-year support cost of aircraft types was, to a very good approximation, around twice the acquisition cost. That makes sense, as both the acquisition and through-life costs are driven by system complexity. The net result is that support costs for the F-35 are likely to be substantially higher than those for its predecessor, the F-16. In fact, given that the acquisition costs of the F-35 and Super Hornet are similar, the through-life costs are also likely to be similar

The most difficult to estimate quantity is the 'fixed cost' of an F-35 fleet. (The significance of this is explained below.) Until the model for support is decided, it won't be possible to get a handle on these costs. If Australia opts for support as part of a global arrangement, economies of scale should be possible. The more 'sovereign' the support model, the higher the cost. But in any case it's expected that facilities for in-country F-35 operations and support will cost well over $1 billion. The best guess—and it's admittedly little more than that—is that the fixed costs for F-35 operations would be around $2 billion initially, with an annual ongoing cost of about 10% of that figure, or $200 million per year. In comparison, and providing a 'sanity check' on that estimate, the support cost of the initial tranche of 24 Super Hornets was initially budgeted at $230 million per year, after 'set-up' costs of around $1 billion.

Options

If we were starting to build an air combat capability from scratch, or were looking at block obsolescence across the current tactical aircraft fleet, the solution that emerged from either the capability-based or scenario-based approaches would be the same. Given that there's not likely to be much difference in acquisition or through-life costs between the F-35 and alternatives, its additional capability would make it a clear choice, assuming what now seem to be manageable risks to schedule and cost.

But that isn't the case. Thanks largely to delays in the F-35 program, Australia now has an air combat fleet that consists of 71 1980s-vintage Hornet airframes that won't be fit for purpose much beyond 2020, and 24 essentially new Super Hornets, with 12 Growler electronic

warfare aircraft still to arrive from the production line. It's expected that those new aircraft will be in inventory for at least the next 15 years, meaning that the fixed costs that come with any aircraft type will be on the books over that period. It's worth recalling in this context that the basis for the original decision to go down the F-35 path was to rationalise the air combat fleet into a single type as the F-111 and the Hornet reached the end of their useful lives. Introducing the F-35 in addition to the existing fleet will bring with it another set of fixed costs, and a mixed fleet of Super Hornets, Growlers and F-35s is bound to be more expensive to maintain than a two-type fleet.

Because of those prior buys, and because the 71-strong 1980s vintage Hornet fleet will age out around the start of the 2020s, realistically the government has only two options. The first is to proceed with current plans and approve the acquisition of more F-35s, accepting the costs of operating a mixed fleet of three types (F-35, Super Hornet and Growler) for at least the next fifteen years, accepting the opportunity cost elsewhere in the ADF's force structure. Within this option is the possibility of reducing the number of F-35s slightly to offset the additional cost of a mixed fleet, although it would also reduce the total air combat capability.

Alternatively, government could decline to pursue further F-35 purchases (perhaps including the 12 that are currently approved but not contracted) and consolidate the existing fleet with additional Super Hornets. This would result in a single-type fleet of strike fighters—the original goal of the F-35 acquisition plan—augmented by electronic warfare aircraft. But those savings would come at the cost of an overall lower level of capability than a mixed F-35/Super Hornet fleet would provide. In this instance it might be possible to augment the number of aircraft by reinvesting the funds freed up by consolidating on two types instead of three.

In broad terms, Option 1 would provide greater unit and overall capability in the air combat fleet, give Australia the ability to conduct high-end operations in even highly contested spaces in coalition contexts, and would carry less risk of being overmatched by potential adversaries in the future. But it would also come at a higher cost. If necessary for budget reasons, that cost could be offset by a reduction in the number of F-35s purchased. For example, with 14 F-35s already approved, the government might consider approving an additional 50, rather than the proposed 58, which might save in excess of $800 million—though at the cost of a reduction in depth and/or readiness in the air combat capability.

The 'further Super Hornets' option is almost certainly less expensive (see next section), and would provide adequate capability against the range of credible threats that Australia could face in the foreseeable future. The Super Hornets, operating in conjunction with Growlers, Wedgetail early warning aircraft and air-to-air refuellers, and with the support of sensors such as JORN over-the-horizon radar, will constitute a very capable air defence capability for many years to come. But it would also bring a budget penalty in the next few years, as the Super Hornet production line is winding down and any new aircraft would need to be paid for sooner rather than later—in effect undoing the short-term budget savings that accrued by slipping the F-35 to later years.

In contributions to coalition operations, the F-35 is the tactical aircraft type that would provide the most flexibility, being able to be deployed into frontline operations anywhere US forces are committed. The Super Hornet won't be as capable as the F-35 or likely to be committed to the more dangerous spectrum of missions. But the US Navy will also have Super Hornets in inventory until at least 2030, allowing Australia to augment US operations in less than top-end environments.

And, in any case, it's not clear that the best contribution Australia could make to US operations is the provision of a small number of strike fighters, whether they be F-35s or Super Hornets. In high-level sustained air operations, air-to-air refuellers and electronic warfare aircraft are almost always oversubscribed—effectively making them key enablers of operations by other types. If called upon in extremis by the US, it might be those 'force multipliers' that constitute the most significant contribution Australia could make.

Two other factors—neither of them capability or program management issues—need to be taken into account in decision-making. First, by committing to the F-35 as an international partner early on, there's now alliance capital invested in Australia's purchase of the aircraft. Second, Australian industry participation in the manufacture of F-35 components is contingent on our acquisition of the aircraft, and the numbers are a factor in how much work can be awarded.

In terms of political impact, this would be a bad time for Australia to back away from the F-35. The program is in no small way predicated on large production numbers giving economies of scale, and partner purchases form a substantial fraction of the proposed production run. The issue of affordability per unit is of course vitally important to the Pentagon, and analysts have raised concerns of a 'death spiral': the fewer aircraft that are ordered, the fewer over which the costs of development and capital costs of manufacturing processes will be distributed, so the higher the unit cost. If one country pulls out, that will raise the costs for those that remain in the program, and so increase the incentives for them to pull out as well. However unlikely large-scale withdrawals are at this stage, the Pentagon doesn't want to be left standing on its own and bearing all costs when the music stops—especially when facing its own budget problems. That said, the Australian Government has a responsibility to guard against similar decisions by other partner nations, and even by the US itself—the US Navy announced a reduction of 33 aircraft in its acquisition plans over the next five years, citing budgetary pressure.

Australian industry has been successful in winning substantial contracts to manufacture F-35 components, with a total value of over US$300 million so far and possibly US$5 billion over the lifetime of the program. But that work is 'tied' to an Australian purchase. In effect, the prime contractor, Lockheed Martin, with the acquiescence of the US Government, has used contracts to attempt to lock partner governments into acquisitions of the F-35—effectively adding a steep local political price to any decision to pursue an alternative, and recruiting the Australian industry lobby to the cause of the F-35. In effect, what could be an arm's-length

commercial relationship is instead being used to constrain the Australian Government's decision-making on an important defence capability—and it's likely to prove to be an effective strategy. The demise of the local car industry and pressure on other defence manufacturing, such as shipbuilding, can only add to the political pressure to maintain F-35 work in country.

Conclusions

On balance, the decision that appears to meet government priorities for capability, industry participation and alliance management with the US seems to be a further purchase of the F-35.

Risks to both schedule and performance seem sufficiently under control to make that a responsible decision. Although the development program could still throw up surprises, it looks like the F-35 will be ready in time to retire the vintage Hornet fleet as scheduled, and will perform as required. However, delays to date now mean that there's little additional scope for further slippage in an Australian in-service date.

Moving to the acquisition of additional F-35s on top of the Super Hornets and Growlers currently in service or under order will necessarily mean that the costs of a mixed fleet are now unavoidable. One option for offsetting those costs is reducing the number of aircraft purchased. That would complicate the management of the fleet and its readiness, but it would still provide a good basis for an expansion with further F-35 buys of later block aircraft should the future strategic circumstances warrant it.

Acronyms and abbreviations

ADF Australian Defence Force
IOC Initial Operating Capability
JORN Jindalee Operational Radar Network
JSF Joint Strike Fighter
RAAF Royal Australian Air Force

Disclosure

Lockheed Martin, the prime contractor on the F-35 program, and Boeing, supplier of the Super Hornet and Growler, are both corporate sponsors of ASPI.

About the authors

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