The 2015 RAND report on Australian naval shipbuilding

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Summary

Commissioned in late 2014 under a $2.5 million contract, the RAND report *Australian's Naval Shipbuilding Enterprise: Preparing for the 21st Century* was released on April 16 2015. The government says it's developing an 'enterprise-level Naval Shipbuilding Plan…informed by the expert, independent advice from the RAND review'. It's important therefore that RAND's analysis is carefully evaluated. RAND come to two key policy-relevant conclusions:

- Building four Offshore Patrol Vessels commencing in 2017 would provide a 'cost-effective transition' between the end of the AWD program and the commencement of the future frigate program.
- Adopting a 'continuous-build' program for the future frigates and subsequent classes of surface combatant would help create a sustainable naval shipbuilding industrial base.

The RAND report does not provide a persuasive case for either conclusion. The proposal to build four OPV seeks to maintain skilled workers in the sector so as to (1) reduce the cost of the subsequent future frigate program, and (2) reduce delays in the future frigate program predicted by a RAND computer simulation. RAND fails to quantify either the savings or the cost of the four OPV. But, under reasonable assumptions, the savings amount to only $89 million (c.f. the $5.5 billion labour cost of the future frigates) and the four vessels will cost in the vicinity of $890 million. Thus, the net cost of the proposal is around $801 million for four vessels, for which there is no identified strategic need at this time. For technical reasons explained in this paper, RAND's prediction of delays to the future frigate program is far from certain.

RAND proposes that the future frigate program be slowed from a 12 month to 24 month pace of ship delivery with the aim of creating a 'continuous build program'. Setting aside the additional cost and capability shortfall (16 ship-years) from not replacing the existing Anzac frigates when they reach their 30-year life-of-type, the end result would be that the final future frigate would be delivered 6 years before the first AWD is due to be retired. That's the same gap that we now face between the end of the present AWD program and the first delivery of a future frigate. Thus, continuity remains elusive. A continuous build program is possible by replacing vessels more frequently or by increasing the number of vessels—but either option would cost billions of dollars more.

RAND says that by adopting a continuous build program and reforming shipbuilding practice, the current 30% to 40% cost premium (RAND's estimate) could be reduced by half by mid-way through the future frigate program. But if the OPV program only saves $89 million on the future frigate program, the remaining savings must be predominately due to the reforms to shipbuilding practice rather than from continuity. RAND own conclusion thereby further undermines the case for a continuous build program.

Background

The RAND report seeks to addresses three requirements:

- provide an understanding of the current Australian shipbuilding capability and gauge how alternative acquisition strategies might affect both the capacity of the industrial base and the total cost of the enterprise
- compare the costs of Australia's naval shipbuilding industry with overseas manufacturers that produce platforms of comparable size and scope
- assess the economic costs and benefits of government investments in Australia's naval shipbuilding industrial base under the various enterprise options.

At the time of the report's launch in April 2015, more than a little consternation accompanied the revelation that RAND was not asked to include submarines in its analysis. In comparison, the Gillard government's 2013 shipbuilding plan included both submarines and ships, as did the Howard government's 2002 plan. The omission of submarines is regrettable; it would have been good to see some analysis of building submarines and frigates concurrently. On the one hand, there would be competition for skilled labour from concurrent programs; on the other hand, the two programs would have made it easier to sustain skills and careers in the specialised areas common to both—at least so long as they were both running.

At 297 pages, the RAND report presents a wealth of data, analysis and modelling about naval shipbuilding in Australia. Amid the myriad details, the report comes to six policy-relevant conclusions:

- The economic benefits of domestic shipbuilding are unclear and largely depend on broader economic conditions.
- A healthy naval ship repair industry is not dependent on building vessels in Australia.
- The pause in shipbuilding between the end of the AWD program and the commencement of the future frigate program in 2020 will increase the cost and delay the schedule of the future frigate program. As a result, there will be a 10 ship-year capability gap as the Anzac class retires.
- The gap between the end of the AWD program and start of the future frigate program could be filled with a four-vessel Offshore Patrol Vessel (OPV) program with two benefits:
    - The delay in replacing the Anzac frigates is reduced to two ship-years.
    - Most of the labour cost of the OPV program is offset by improved productivity in the future frigate program due to the transition of skilled personnel from the OPV program.

- The price premium for building naval vessels in Australia is 30% to 40%.
- By moving to a continuous build model for surface combatant construction and adopting new shipyard and design practices, the price premium could be halved.

The remainder of this paper examined each of these conclusions in turn. Further reading on each topic can be found in the bibliography at the end.

The economic benefits of domestic shipbuilding are unclear and largely depend on broader economic conditions.

In recent times, state governments, industry groups, shipbuilders and unions have all published reports extolling the economic benefits of building ships and submarines in Australia. They will surely be dismayed that RAND has come to such an ambivalent verdict. But although RAND's discussion of the issue runs to a mere five pages, its conclusion is justified. Other analyses—including by this author—are even more sceptical of the claimed economic benefits.

A healthy naval ship repair industry is not dependent on building vessels in Australia.

Although the counter-assertion is often used to justify domestic construction, Australia's experience with foreign-sourced ships and aircraft unambiguously supports RAND's conclusion.

The pause in shipbuilding between the end of the AWD program and the commencement of the future frigate program in 2020 will increase the cost and delay the schedule of the future frigate program. As a result, there will be a 10 ship-year capability gap as the Anzac class retires.

RAND says that, on the basis of current plans, we face a 10 ship-year delay (i.e. an average 15 month delay for each of the eight vessel fleet) relative to the retirement of the Anzac class assuming a 30 year life-of-type. In RAND's analysis, the delays are a consequence of the gap between the end of the Air Warfare Destroyer (AWD) program and the start of the future frigate program. The 'cold start' on the latter leads to unproductive labour-hours as personnel are trained, which, in turn, leads to delays.

All this sounds entirely plausible, but caution is required in interpreting RAND's modelling and the conclusions drawn from it—especially given that RAND go on to propose a costly interim OPV build to bridge the gap between the end of the AWD and start of the future frigates.

Are the retirement dates correct?

There are two problems with RAND's analysis. The first concerns the assumed retirement dates for the Anzac frigates. RAND assumes a 30 year life-of-type for the Anzac frigates and defines it as commencing from the date of commissioning. Table 1 below gives the commissioning dates of the eight Anzac frigates and the calculated retirement date. Figure 1 compares the 30 year life-of-type retirement dates for the Anzac frigates (black bars) with those actually presented in the RAND report (pink diamonds). The differences are significant. Using the RAND retirement dates the first six vessels are late by an aggregate 11.2 ship-year delay. In comparison, using the

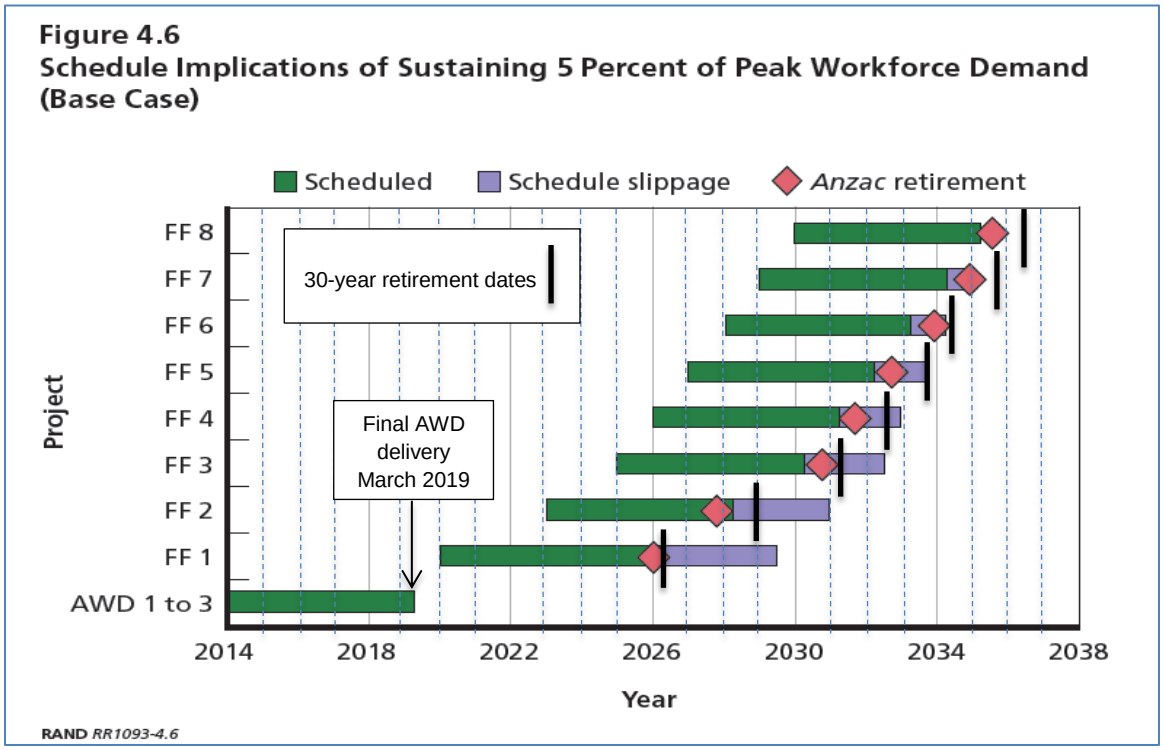
actual 30 year life-of-type sees only the first four vessels delivered late (resulting in a 7 ship-year delay) and the last three vessels are delivered early by an aggregate 2.4 ship-years. The resulting 38% reduction in total delay (not counting early deliveries) is significant given the emphasis placed on delays in the first part of the RAND report.

Table 1: Anzac retirements dates

Vessel	Commissioned	Retire
Anzac	18 May 1996	18 May 2026
Arunta	12 December 1998	12 December 2028
Warramunga	21 March 2001	21 March 2031
Stuart	17 August 2002	17 August 2032
Parramatta	4 October 2003	4 October 2033
Ballarat	26 June 2004	26 June 2034
Toowoomba	10 October 2005	10 October 2035
Perth	26 August 2006	26 August 2036

Source: commission dates from www.defence.gov.au

Figure 2: Anzac retirement dates—RAND verses 30-year life-of-type



Source: RAND report page 59.

The aggregate delays in RAND's calculation depend upon the date at which work begins on the second and third vessel. As shown in Figure 2, there's a three-year delay between commencing work on the first and second vessels in the program, and a two-year delay between the start of work on the second and third. In contrast, the Anzac ship project produced vessels in quick succession, with work commencing on the second vessel with twelve months of the first and so on. The apparent larger than one-year gaps in the commissioning of the second and third Anzac vessels only arose because the second and fourth vessels in the ten-ship Anzac program went to

New Zealand rather than Australia. It looks as though RAND have assumed a *production schedule* based on the *delivery schedule* of Anzac frigates to Australia (perhaps they are unaware of the two New Zealand vessels). In any case, the absence of New Zealand hulls this time around means that we could bring forward work on the second and third vessels to help alleviate the gaps predicted by RAND's modelling for ships two through eight.

How much confidence can we place on the RAND modelling?

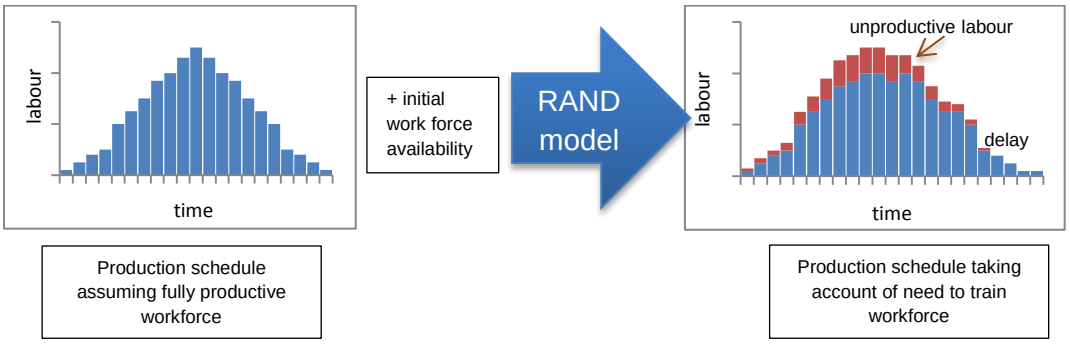
In addition to problems with RAND's assumed Anzac retirement dates and its scheduling of vessel construction, its modelling is problematic.

RAND starts by assuming an initial production schedule for the future frigates that could be executed given the availability of 'fully productive' skilled personnel. It then feeds that initial schedule (along with assumptions about the available workforce) into a computational model.

The computational model then simulates the production taking into account the time needed to train personnel when they are not available. Thus, on a quarter-by-quarter basis, the model introduces delays as the requisite personnel are recruited and trained. Importantly, the model doesn't look ahead. Instead, an essentially Markovian approach is taken whereby 'decisions to grow or shrink the workforce are made on the basis of the current quarter's demand irrespective of future demand'. That is, the project is executed as if the managers are blindfolded to the demand for labour beyond a ninety-day horizon.

The model is depicted schematically in Figure 2.

Figure 2: Schematic of RAND modelling methodology



In essence, the RAND model tells us what would happen if we planned a project assuming the instantaneous availability of a skilled workforce and then proceed to train the workforce in a piecemeal fashion as we discovered that we didn't have the people we needed, all the while deliberately ignoring future demand. RAND goes on to use their model to estimate the unproductive labour-hours that the future frigate would entail as a function of the percentage of peak workforce demand available at the start of the program.

Not surprisingly, with the future frigate program scheduled to begin several years after the AWD workforce has dispersed, the RAND model predicts delays and additional costs due to the need

to train new staff. But while there's no question that a cold start project will present challenges and that start-up costs will be incurred, how realistic is RAND's estimate of the delays and additional costs? The best way to answer that question is to compare RAND's approach to what would happen in practice.

In the real world, a plan would be developed for the future frigates taking account, from the start, of the need to train personnel to meet demand across the life of the project. The resulting plan would differ from RAND's simulation in two important respects.

First, the real plan would anticipate the need for personnel and take steps to train them on longer than a 90 day planning horizon. This can't help but reduce the delays relative to the RAND estimates. Indeed, prudent planners may well decide to start training new staff well before the commencement of construction. In the Anzac program, there were 27 months between contract award (August 1989) and the first cutting of steel (March 1992). In the AWD program, there was around four years between the selection of the shipbuilder in mid-2005 and the commencement of fabrication in mid-2009. In each instance, there was ample opportunity for the shipbuilder to commence training well ahead of the actual demand for labour. The future frigate program can, and should, be structured to provide timely selection of the shipbuilder and any third-party module fabricators.

Second, the real plan will make trade-offs between labour costs and schedule. There's a limit to how much money is worth spending to avoid a temporary capability gap—those costs are as real as start-up costs. In practice, project planners will try to optimise the project taking account of the relative importance of avoiding additional costs and delays. Given that the Anzac class is currently undergoing a substantial upgrade and will remain a potent warship for quite some time, it's likely that delays will be accepted to contain costs.

The essential point is this: there's no reason the think that RAND's approach yields anything resembling the plan that would result from, well, actually planning the project. The RAND methodology will unavoidably yield a more pessimistic result than is possible. After all, it begins with a production schedule that's doomed to fail, and then simulates its execution by managers with zero foresight.

But what about the AWD project?

Given the mounting delays in the AWD program (27 months expected to grow to 39 months for the first vessel) surely the RAND analysis is correct? Well, yes and no. There's no denying that the AWD program has been plagued with delays and cost overruns, and the worst may be yet to come. But there are important differences between the problems in the AWD program and the mechanism simulated in the RAN model—a mechanism that begins and ends with the need to hire and train workers.

The White-Winter report into the AWD program identified four causes for the cost and schedule issues; the initial program plan, inadequate government oversight, the alliance's limited capacity to respond to issues, and the performance of ASC and its subcontractors. Nowhere is there a

mention of delays due to finding and training skilled workers. Similarly, the RAND report itself contains an informative and thoughtful analysis of problems with the AWD program (p. 43-47) without once mentioning problems arising from the need to find and train personnel—notwithstanding that the AWD program ran through a period where the demand for skilled labour was high due to the resources boom. Thus, there's a fundamental disconnect between our current understanding of problems in the AWD program and the mechanism underlying the RAND model.

The gap between the end of the AWD program and start of the future frigate program could be filled with a four-vessel Offshore Patrol Vessel (OPV) program with two benefits: First, the delay in replacing the Anzac frigates is reduced to two ship-years. Second, most of the labour cost of the OPV program is offset by improved productivity in the future frigate program due to the transition of skilled personnel from the OPV program.

Having used their computer simulation to predict delays and a cost premium for a cold-start future frigate program, RAND then looks for ways to 'fill the gap' and maintain the core of a capable workforce to transition onto the future frigate program. Their goal is two-fold. (1) Replace unproductive labour-hours on the future frigate program with productive work on the 'fill-in' project. (2) Reduce the projected delay in replacing the Anzacs as they retire.

Ignoring the shortcomings of RAND's computer simulation, its best option for filling the gap is problematic in and of itself.

Having effectively rejected (for good reasons) the bringing forward of the frigate program, RAND explore the possibilities of a fourth AWD or a new program building a number of Offshore Patrol Combatants (OPV) in the 1,700-1,800 tonne range. The report focuses on the latter and says:

> *In essence, the four OPVs could be built basically for "free," given that they are sustaining productive labor that reduces the costs of unproductive labor when building the workforce for the Future Frigate construction.*

Better still, doing so reduces the delay in future frigate delivery from ten ship-years to two ship-years.

Of course, the OPVs aren't actually free, even if RAND's estimates are correct. The offset only refers to *labour costs* associated with the build. Materials and equipment aren't included, nor are the costs of crewing and operating the vessels throughout their life.

So how large an offset do we get, and how large are the other undisclosed costs? According to the RAND report, the labour cost of building four OPV would only add $130 million to the base labour cost of acquiring eight frigates ($5.49 billion) with the remainder offset by a reduction in the cost of unproductive labour in the frigate program. Curiously, RAND omits the actual labour cost of building four OPV so we can't immediately see how much is actually saved in their

proposed strategy. But with a little arithmetic, it's possible to estimate what RAND fails to disclose—but first a technical point needs to be cleared up, see Box 1.

Box 1: Learning about learning curves

Learning curves take account of the productivity improvements over time in a production program. RAND says: 'In this report, we define unit learning curve as the percentage of man-hours required to construct an additional ship compared with the number of man-hours required to produce the previous ship' (p. 53 and again on p. 169) . For a 95% learning curve, that corresponds to a geometric difference equation, where:

$$L_n = 0.95\, L_{n-1}$$

where L_n is the quantity of labour required for the nth vessel, and L_{n-1} is the quantity of labour required for the previous vessel.

However, learning curves more usually refer to the power law relationship:

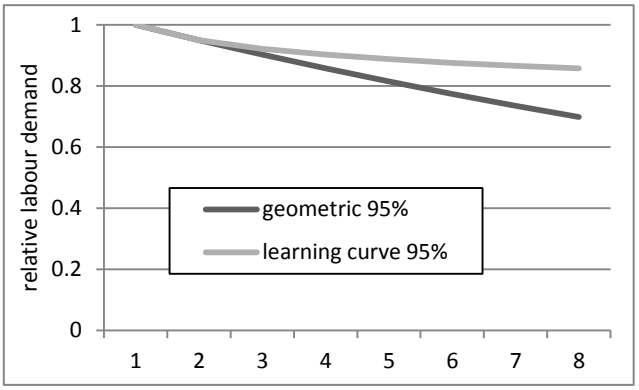
$$L_n = L_1 n^{\lambda}$$

where L_n is the quantity of labour required for the nth vessel, L_1 is the quantity of labour required for the first vessel and λ for a 95% learning curve is defined as

$$\lambda = \frac{\log(95/100)}{\log(2)} = -0.074$$

Confusingly, RAND describe a learning curve consistent with this standard approach on page 182. It is not clear what approach they have actually used.

Although the two approaches yield similar results for small numbers of vessels (2 or 3), the outcomes diverge significantly for 5 or more vessels.



All learning curve calculations in this paper use the latter standard methodology, which gives a slightly higher value for the savings claimed for building four OPVs, and so is a conservative approach.

We are told that the first OPV requires 700,000 labour-hours to build, which implies around 2,642,094 labour hours for the four vessels using the report's assumed 95% learning curve. Turning now to the ASC Limited 2014 annual report, we see that the firm employed 2,600 employees and incurred labour expenses of $393,618,000 corresponding to an average per capita cost of $151,400. Assuming an output of 48 weeks at 38 hours per week, the hourly rate comes out to be $83 per hour. (It's possible that the actual number is smaller due to overtime.) In any case, the figure of $83 per hour yields a labour cost of $219 million for the OPV, meaning that only $89 million of the labour cost is offset by removing 'unproductive' labour hours from the future frigate program, see Table 2. Thus, far from the 'labor cost of producing these additional ships [being] largely offset by the savings that stem from sustaining a productive workforce', we'll be lucky to get a 41% discount on the labour component. And this will be an even smaller share of the total price—to which we now turn.

Table 2: OPV estimated labour costs and 'savings'

Vessel	Labour hours (95% learning curve)	Cost at ASC $83/hour
OPV 1	700,000	$58,100,000
OPV 2	665,000	$55,195,022
OPV 3	645,344	$53,563,526
OPV 4	631,751	$52,435,292
Total	**2,642,094**	$219,293,841
Additional labour cost		$130,000,000
Saving in future frigate program		**$89,293,841**

The UK is purchasing three OPV at a cost of £349 million. Assuming a 95% learning curve, the four vessels will cost (ignoring the lower productivity and higher wage rates in Australia) around £459 or $889 million at today's exchange rate of £1 = A$1.94 for which we get an $89 million discount, see Table 3. And that's before the cost of crewing and operating the vessels is taken into account. Even if our estimate of program costs is artificially inflated by the current relative strength of the British pound to the Australian dollar, the fact remains; $89 million is a small fraction of the acquisition, let alone through-life cost, of four OPV. Note that the learning curve has been applied to the entire cost of the vessels rather than just its (unknown) labour component, this will tend to *underestimate* the cost of a fourth vessel.

Table 3: UK OPV costs extrapolated to a four vessel program

Vessel	Vessel costs (95% learning curve)	A$ @ $1.94 per £
OPV 1	£121,522	
OPV 2	£115,446	
OPV 3	£112,033	
Total	**£349,000**	
OPV 4	£109,673	
Total	**£458,673**	**$889,826**

UK program costs from *The Telegraph* online, 12 August 2014.

None of this comes out in the RAND report, instead we are told that 'four additional OPVs are added to the RAN fleet at very marginal costs' adding that 'delays in delivering replacement ships are reduced to almost zero'. This is difficult to accept. An $89 million saving on a

$890 million program does not constitute a purchase ‘at very marginal costs’, and a reduction from 10 ship-years to 2 ship-years is not ‘almost to zero’. More importantly, far from being inevitable, the delay is a product of RAND’s inherently pessimistic modelling. They’ve created a schedule problem that might not exist and propose that the taxpayer foot the bill for four ships as a solution (at a net cost of $890 million - $89 million = $801 million) for which there is no identified strategic need at this time.

Perplexingly, having justified the option of buying four additional vessels, in part, on the basis of foreclosing a supposed gap in the delivery of replacements for the Anzac frigates, RAND goes on to propose that we incur an even larger ship-year gap by moving to a slower-paced continuous-build scheme for the replacement of the Anzac frigates.

The price premium for building naval vessels in Australia is 30% to 40%.

RAND benchmark the price of Australian build warships by three independent techniques and concludes that ‘the various methods all indicate a modal Australian naval shipbuilding premium of about 30 to 40 percent for ships built entirely in Australia’ adding that the premium ‘can be significantly influenced by foreign exchange rates’.

While there’s no doubt that low productivity and high wages impose a price premium on local naval construction, local shipbuilders will be disappointed that the recent depreciation of the Australian dollar appears not to have been taken into account. The proffered premium of 30% to 40% is narrow compared with recent movements in the value of the Australian dollar. At the time of writing the Australian dollar was worth 77 US cents, only a few years ago it was 43% higher at 1.09 US dollars. In terms of the average post-float (post-December 1983) performance, at 77 US cents the Australian dollar is still marginally above its long-term average of 76 US cents. What’s more, the RBA is eager to see the dollar depreciate further to make Australian manufacturing more competitive.

More generally, RAND’s price benchmarking analysis is unsatisfying because it fails to present and employ a model that takes account of how foreign exchange, labour rates and productivity combine to determine production costs/prices. So although a wide range of data has been assembled, it’s never transparently brought together. A contour plot of the cost premium as a function of the USD-AUD exchange rate and relative labour productivity would have been useful.

Finally, for the purposes of comparisons with other sectors of the economy, it would have been useful to have also the premium expressed as the ‘effective rate of assistance’ to allow comparison with other industries where the government provides subsidies or protection.

Schedule performance—why bother?

On schedule performance, RAND compare the keel-to-commission duration of the Australian AWD and Anzac programs with comparable overseas programs. Having noted that the ‘Australian Anzac class is faster than the average’ and the ‘AWD average time is comparable

with the average', they nonetheless conclude that Australian shipbuilding is 'slightly longer with respect to schedule'—which is only the case in recent times. The apparent inconsistency would be a concern if comparisons of schedule duration were useful, but they aren't. Shipbuilding isn't a race. The optimal production schedule will depend on the specifics of the available facilities and workforce, along with many other factors—most especially the relative priorities placed on cost and schedule. Shorter schedules are not always better. Cost-schedule trade-offs are a central component of rational project planning. Delays to scheduled production are pertinent, and a benchmarking of variations between planned and achieved schedule would be useful, but that's *not* what's been done.

By moving to a continuous build model for surface combatant construction and adopting new shipyard and design practices, the price premium could be halved

The RAND report's executive summary says:

> *In the long term, a continuous build strategy of building major surface combatants with a drumbeat of 1.5 to two* [years between builds] *should sustain a healthy and cost-effective shipbuilding industrial base. Building OPVs during the short-term gap will provide a cost-effective transition to the lower demands of a Future Frigate program resulting from a [production] drumbeat greater than one. But adopting this option will present challenges with a number of pre-conditions required to achieve it, including starting [OPV] production by 2017, using an existing design without modifications, and strategically scheduling the build program to complement the Future Frigate workforce profile. And the end of the Future Frigate build program would flow into the build of the next major surface combatant. There will be challenges during the replacement of the Anzac class, but these challenges might be met with careful planning of delivery schedules and extended usage of the existing fleet.*

There's a lot of analysis underpinning this scheme, and it's fair to say that the authors have addressed many of the issues relevant to a continuous build. For example, they are aware that building future frigates at a rate of less than one per year will complicate the replacement of the Anzac class as they leave service. Nonetheless, there are a couple of points requiring closer scrutiny.

Firstly, if we build future frigates at the rate of one every 18 or 24 months, how exactly will the future frigate program 'flow into the build of the next major surface combatant' if we maintain our present fleet of eight frigates and three AWD? RAND seems confident that this can occur, observing that; 'assuming a six-year build for the replacement ship, construction would start in 2041, at approximately the same time as the build of the Future Frigates would end (assuming a drumbeat of two)'. They are even nonplussed by the prospects of an eighteen month drumbeat observing that 'a drumbeat of 1.5 would end Future Frigate construction a few years before the start of the AWD replacement, thus creating a short gap in workforce demand.' Hence their

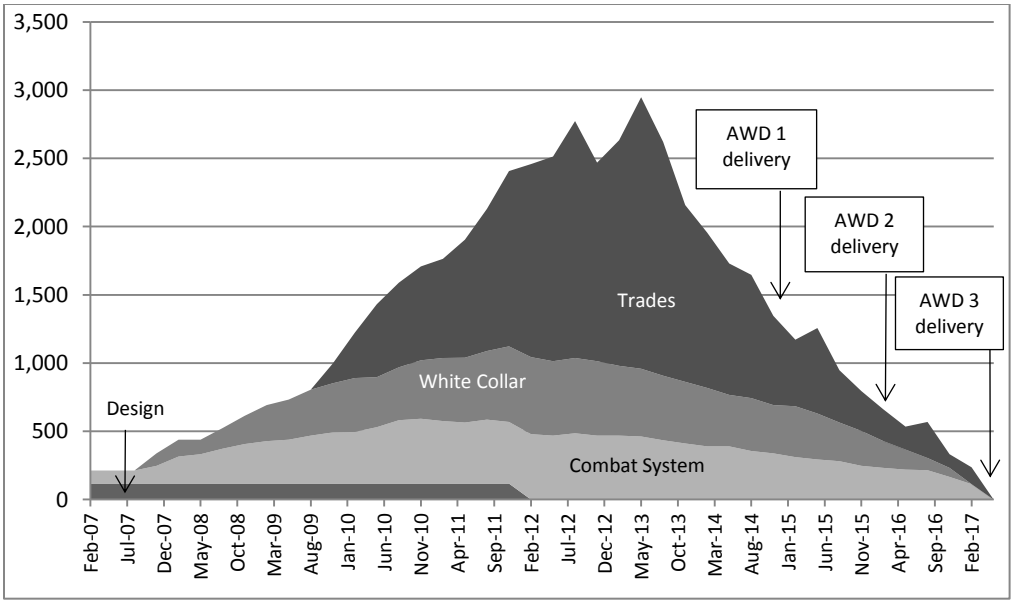
conclusion quoted above that 'major surface combatants with a drumbeat of 1.5 to two [years between builds] should sustain a healthy and cost-effective shipbuilding industrial base.'

A reality check is called for. Consider Figure 3, which depicts the situation assuming a 30 year life-of-type for the AWD and that the anticipated additional 12 month delay in their delivery eventuates (which appears to be a forgone conclusion). There is a *six-year gap* between the delivery of the last future frigate and the replacement of the first AWD—precisely the same situation we face today between the end of the AWD program and the delivery of the first Anzac. Note that the end of end of the future frigate program (2041) and the commencement of the AWD replacement program (2047) agree with the dates put forward by RAND.

Can it really be that today we face a productivity sapping boom-and-bust discontinuity, but when the same situation occurs again in three decade's time it's part of a 'healthy and cost-effective shipbuilding industrial base.'? With an eighteen month delivery schedule, see Figure 4, the gap increases to 9.2 years. Yet we are told that this is not only a short gap but that it is still consistent with a 'continuous build strategy'.

If a 9 year gap is consistent with a continuous build program, we've had one since 1985 when the keel first Australian FFG was laid down. The was no gap between the FFG program and the Anzac program, and the gap between the delivery of the last Anzac frigate in August 2006 was only 8.3 years prior to the planned delivery of the first AWD in December 2014. Clearly this is not the case. A six (let alone nine) year gap would mean that precious little carryover would be possible between the two programs. Indeed, the workforce completing the fit out of the last future frigate would be nothing like the design and planning workforce that would be needed to initiate the AWD program, as Figure 3 for the AWD program makes clear. A continuous build program requires overlapping work on successive similar vessels. The scheme proposed in the RAND study does not achieve that.

Figure 3: AWD program as originally planned

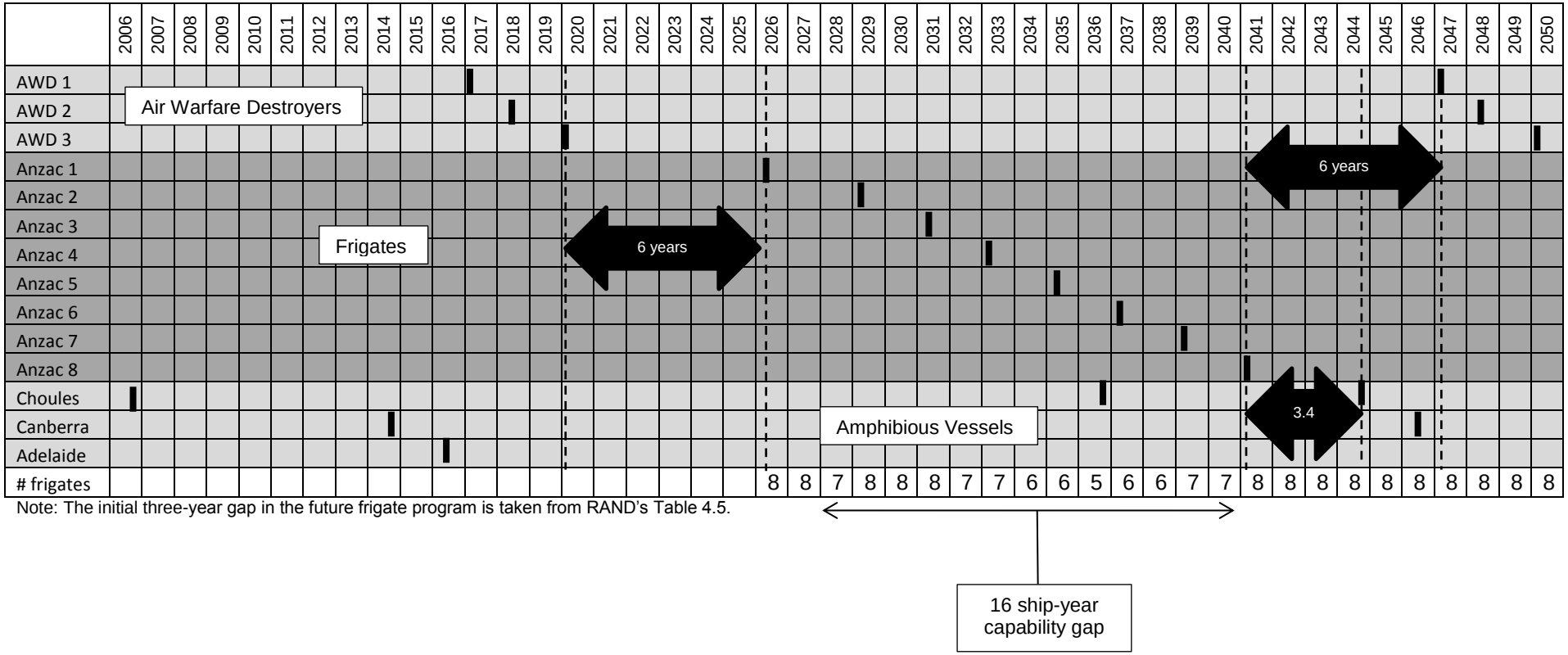


The one vessel per 24 months approach proposed by RAND will also result in a shortfall in frigate numbers between 2028 and 2040. In aggregate, 16 ship-years will be lost, with a maximum deficit of 3 vessels in 2035. Not only is this undesirable from a strategic perspective, it will would also be difficult to manage from the standpoint of personnel management. It took years to recover from the delayed transition from a declining Oberon fleet to the Collins class. The resulting capability gap with an eighteen-month production interval would be less, but the resulting production gap before the AWD replacement would be longer.

There are two further problems with a two-year drumbeat. First, facilities and corporate overheads per vessel would be roughly twice as high for a two-year production interval than for a one-year production interval. With a slower production rate, shipyard executives would be neither less numerous nor less well remunerated. All other things being equal, a two-year drumbeat production schedule will cost more than the regular one-year drumbeat approach.

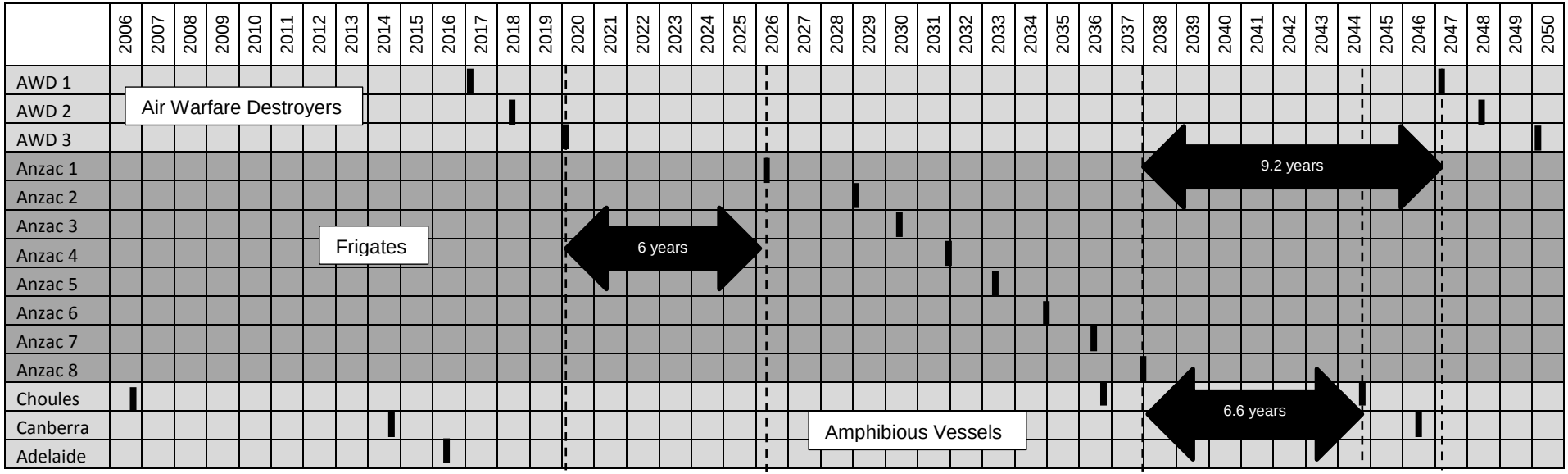
Second, a stretched production schedule would make it difficult to maintain a single configuration across the fleet. Technological improvements and obsolescence would inevitably forces changes during the execution of the program. An eight vessel program with a two-year drumbeat would extend across 14 years, or 19 if the five-years to build the first vessel is included. In practice, the vessels would be produced in batches, each varying in important ways. This would complicate maintenance, training and logistics, albeit with the compensating advantage of progressive capability improvement.

Figure 3: The not-so-continuous build program—two-year production interval



Note: The initial three-year gap in the future frigate program is taken from RAND's Table 4.5.

Figure 4: The not-so-continuous build program—eighteen-month production interval



Why would we even consider adopting two-year drumbeat production schedule for the future frigates with its additional costs and resultant capability gap if it simply brings us back to the situation we face today? It would be a case of back to the future with 2020 replaced by 2040.

A continuous build program could also be achieved by retaining vessels for a shorter life-of-type. To provide continuity beyond the future frigate program we'd need to replace the first AWD in early 2043. But at that point the youngest AWD will be at most 26 years old. The consequences for the remainder of the fleet would be greater. With a major surface combatant fleet of 11 vessels and a drumbeat of 2 years, vessels have to be retired every 22 years rather than every 30.

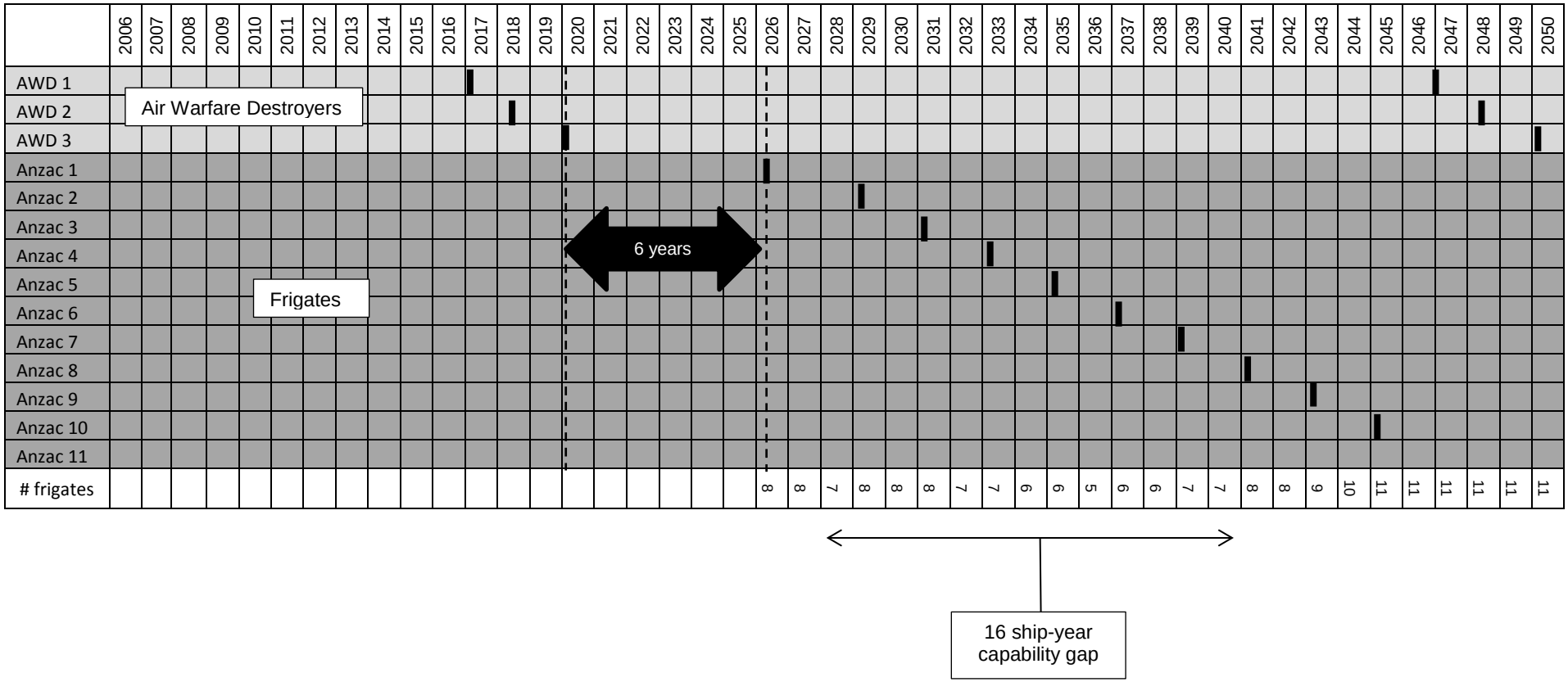
By reducing the life-of-type by 8 years, the amortised capital cost rises by 36%. That is, the average procurement cost of the fleet is at least 36% higher. In theory, this can be partially offset by removing the need to upgrade vessels mid-life—though the bar is set high. Although the RAND report examines shorter life-of-type options (p. 79), it fails to acknowledge that a shorter life-of-type for vessels would constitute a new and significant source of additional long-term costs.

Another way to create a continuous build program would be to increase the size of the destroyer-frigate fleet beyond the currently planned three AWDs and eight Anzacs. Indeed, the main body of the report does include an analysis (Table 4.4) of the number of combatants needed to sustain a continuous build program. Options include 17 vessels with a 25 year life-of-type built one every 18 months, and 15 vessels with a 30 year life-of-type built one every 24 months. Nonetheless, RAND's modelling focuses on an 8 vessel future frigate program throughout the report. The closest we get is a reference to the White Paper considering a future frigate fleet in the range of 8 to 10 vessels, but with only 3 destroyers that's still well short of the 15 to 17 vessels required to meet RANDs estimated continuous build schemes.

As Figure 4 shows, by building 10 or 11 future frigates the gap can be closed. But then to complete the scheme, we'll then need to build 4 or 5 replacement destroyers around mid-century. Thus, to properly accommodate a continuous build program, 2 or 3 additional frigates and 1 or 2 additional destroyers would be needed to achieve a 30 year life-of-type. A still larger number of vessels would be required to accommodate an 18 month drumbeat.

The RAND authors must realise that for Australia to have a 'continuous build strategy of building major surface combatants with a drumbeat of 1.5 to two' some combination of more combatants and shorter in-service lives are necessary. And expanding the size of the fleet, or reducing the life-of-type of vessels, will each increase the overall cost of ownership. Yet no attempt is made in the RAND report to compare these additional costs with the claimed savings from a continuous build program. RAND's focus on the price premium per vessel fails to take account of what really matters; the long-term amortised cost of maintaining a navy consistent with our strategic needs. A larger fleet might be attractive if such an increase was planned on strategic grounds in any case, but certainly isn't if it's a case of the sustainable industry tail wagging the ADF capability dog.

Figure 5: But if we build another two or three future frigates…



Within the body of the RAND report, a variety of options for the post-Future Frigate workload are examined. There's an examination of having a follow-on Littoral Multirole Vessel (LMRV) program, but they aren't major surface combatants. As RAND observes, 'littoral multirole ships will provide some demand for new ship construction after the Future Frigates. However, they are not large, complex surface combatants.' The scale of demand is also very different, a LMRV would require 500 workers compared with the almost 3,000 needed for the build of a major surface combatant.

Even adding the RAN's amphibious vessels into the mix fails to retrieve the situation, see Figure 5; the gap is only reduced to 3.5 years. (The first amphibious vessels will need to be replaced midway through the future frigate program, which is problematic if the build occurs in Australia).

Bringing forward the replacement of the final two amphibious vessels would allow the gap to be reduced to around 2 years. But the large amphibious vessels make very different demands of facilities and workforces to technology-intensive surface combatants, and a two-ship build would be dominated by start-up costs. As was the case with the present Canberra class LHD, the business case for buying a vessel from an existing overseas yard is likely to be very strong, so it's unsurprising that the RAND study does not bother to model a continuous build program including amphibious vessels. To the contrary, they talk explicitly about a 'continuous build strategy of *building major surface combatant* [my italics]'.

Where does this leave us?

The RAND report poses itself the rhetorical question:

> *Is it possible for Australia's naval shipbuilding industrial base to achieve a continuous build strategy, and how would such a strategy's costs compare with the current and alternative shipbuilding paths?*

If only RAND had gone the extra step to answer the question. Not only is the cost of building four OPVs omitted (in fact it's actively downplayed), but the cost of a workable continuous build program for surface combatants (in terms of either more-frequent recapitalisation, a larger major combatant fleet or both) isn't properly acknowledged, let alone costed. Instead, we're offered a plan that, implemented as presented, would impose additional costs and substantial capability shortfalls. And when all is said and done, in 2040 we'll be right back where we are today looking at a six-year gap between one class of surface combatant and the next.

It's as if we're being offered a scheme designed to keep Australian shipbuilders busy for the next couple of decades busy irrespective of the costs and force structure consequences of doing so.

In return, we're promised that although 'building ships in Australia carries a 30% to 40% price premium compared with buying the ships from foreign shipbuilders…that premium could drop to approximately half that level over time with a steady production program that leads to a productive workforce.' Moreover, RAND say that 'it is achievable mid-way though the build of the future-frigate program.'

Of course, as explained already, focusing on the acquisition cost premium risks obscuring the larger question of the long-term cost of maintaining the fleet. Nonetheless, halving the current 30% to 40% cost premium (RAND's estimate) for domestic shipbuilding would deliver substantial saving: if frigates cost $1 billion each absent a premium, they'll cost around $1.35 billion with a 35% premium and around $1.175 billion with half that premium. Across just the last half of the program, that would amount to savings of (4 x $175 million =) $700 million.

Thus, RAND's claim of being able to halve the premium around half way through the future frigate program warrants close attention. In the conclusion (p. 149) the claim is made contingent only on 'a steady production program that leads to a productive workforce'. Elsewhere, in the executive summary (p. xxxvii) and in the conclusion (p. 146), the claim is contingent upon both a continuous build program and other changes, including the use of more-mature designs and a shift to a continuous-improvement culture in shipyards. The question must therefore be asked: to what extent is the reduction in premium contingent on a continuous-build scheme, and to what extent does it depend on the other changes?

RAND doesn't break down those dependencies. But an important inference can be drawn from their claim that the reduction is achievable mid-way through the future frigate program. Given that the three-vessel OPV 'gap filler' only results in an $89 million dollar cost reduction in the future frigate program, the benefit through continuity of building OPVs is entirely marginal compared to a 30% to 40% cost premium on a multi-billion dollar program. Thus, the promised halving of the cost premium midway through the future frigate must be almost entirely the result of factors other than continuity of work. So why should we even consider building additional vessels or trying to smooth demand?

Anyone for monopoly?

The RAND report takes a largely production engineering approach to shipbuilding, with very little attention paid to the commercial arrangements. This is a worrying omission. A continuous shipbuilding program would create an effective domestic monopoly involving a single consolidation yard and a single module builder. The resulting power of the firms, unions and host state government involved would preclude any credible threat of going offshore for future builds. With commercial pressures all but absent, the task of improving and maintaining productivity would be very difficult. Conversely, a program-by-program approach would keep local industry on its toes through foreign competition. None of this seems to have been taken into account in the RAND report.

Similarly, the critical question of what to do with the government-owned ASC Limited is conspicuous by its absence. A shipbuilding enterprise is much more than production schedules and charts of workforce demand. As the AWD program shows, contracts, incentives, governance arrangements and corporate management are central to the success or failure of any shipbuilding program. Until these fundamental issues are addressed, any plan for Australian naval shipbuilding is an exercise in hoping for the best. Soviet style central planning will deliver Soviet levels of efficiency. A lesson from the United Kingdom is illustrative.

The idea of building OPV as a gap-filler isn't a new idea. The United Kingdom is building three OPVs 'to sustain key industrial capability' between the end of the Queen Elizabeth class aircraft carrier and beginning of the Type 26 frigate program. But there's more to the story—under an agreement with the shipbuilder, the UK would be 'liable to pay the costs of maintaining these skills whether or not any shipbuilding was taking place at UK yards'. The oldest of the vessels the OPV will replace is only 12 years old at the moment. Such are the joys of managing a monopoly shipbuilder.

Further reading

The RAND report provides an extensive list of references. Nonetheless, there are several Australian publications that do not appear. These are listed below for readers interested in a local perspective. For completeness, all government reports and articles on submarines are included.

Government reports

Department of Defence, Naval Shipbuilding and Repair Sector Strategic Plan, 2002.

Department of Defence, Future Submarine Industry Skills Plan: A plan for the naval shipbuilding industry, 2013. (A critical analysis of this plan can be found in Chapter 7 of the 2013-14 ASPI Defence Budget Brief.)

Industry and union papers

Tasman Asia Pacific, *Impact of Major Defence Projects: A Case Study of the ANZAC Ship Project*, 2000.

Tasman Asia Pacific, *Impact of Major Defence Projects: A Case Study of the Minehunter Coastal Project*, 2002.

DefenceSA, Naval Shipbuilding: Australia's $250 billion Nation Building Opportunity, 2010.

Defence SA, Guarding our edge: Building and sustaining the future submarine in Australia, 2012.

Australian Manufacturing Workers Union, Australian Naval Shipbuilding, 2013.

Other Publications

Mark Thomson, Setting a Course for Australia's Naval Shipbuilding and Repair Industry, ASPI Strategy series, 2002.

Mark Thomson, Weapons of Mass Construction: Australian naval shipbuilding, ASPI Insight series, 2004.

Australian Strategic Policy Institute, Naval gazing: The future of Australia's naval shipbuilding and repair sector, ASPI Special Report, 2010.

Andrew Davies, Henry Ergas and Mark Thomson, *Should Australia Build Warships: An economic and strategic analysis*, Proceedings of the RAN Sea Power Conference 2012, p. 275.

Andrew Davies and Mark Thomson, Mind the gap: getting serious about submarines, ASPI Insight series, 2012.

Sean Costello and Andrew Davies, How to buy a submarine: Defining and building Australia's future fleet, ASPI Insight series, 2012.

Andrew Davies, What price the future submarine?, ASPI Policy Analysis, 2012.

Andrew Davies and Mark Thomson, How to buy a submarine: Part 2, ASPI Insight series, 2014.

Peter Briggs, Why Australia should build its own submarines, ASPI Insight series, 2015.