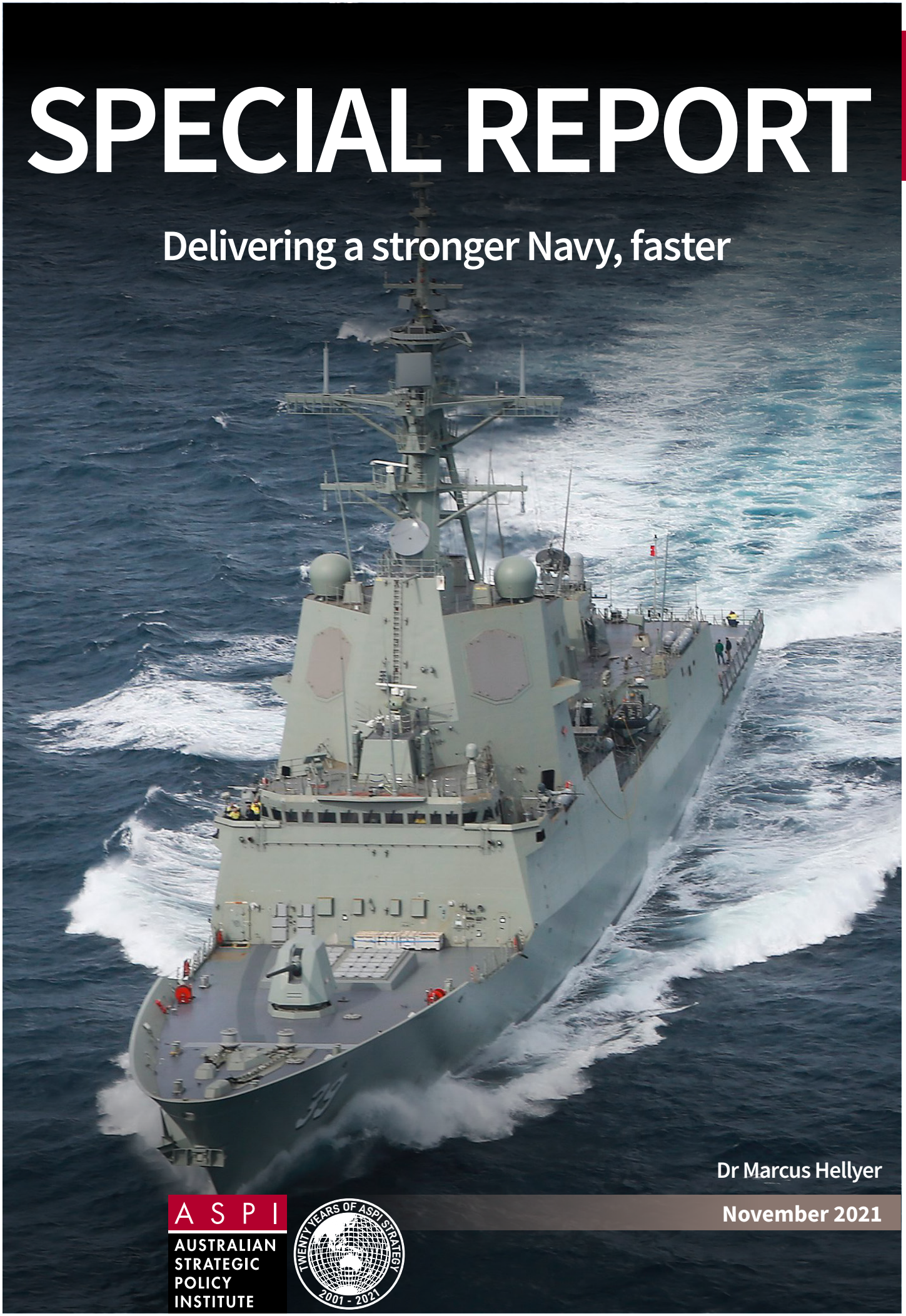
SPECIAL REPORT

Delivering a stronger Navy, faster



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November 2021

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AUSTRALIAN STRATEGIC POLICY INSTITUTE

About the author

Dr Marcus Hellyer is a Senior Analyst focusing on defence economics and military capability. Previously he was a senior public servant in the Department of Defence, responsible for ensuring that the government was provided with the best possible advice and recommendations on major capital investments. He also developed and administered Defence's capital investment program. Marcus has also worked in Australia's intelligence community as a terrorism analyst. Before joining the public service, Marcus had a career as an academic historian in the United States.

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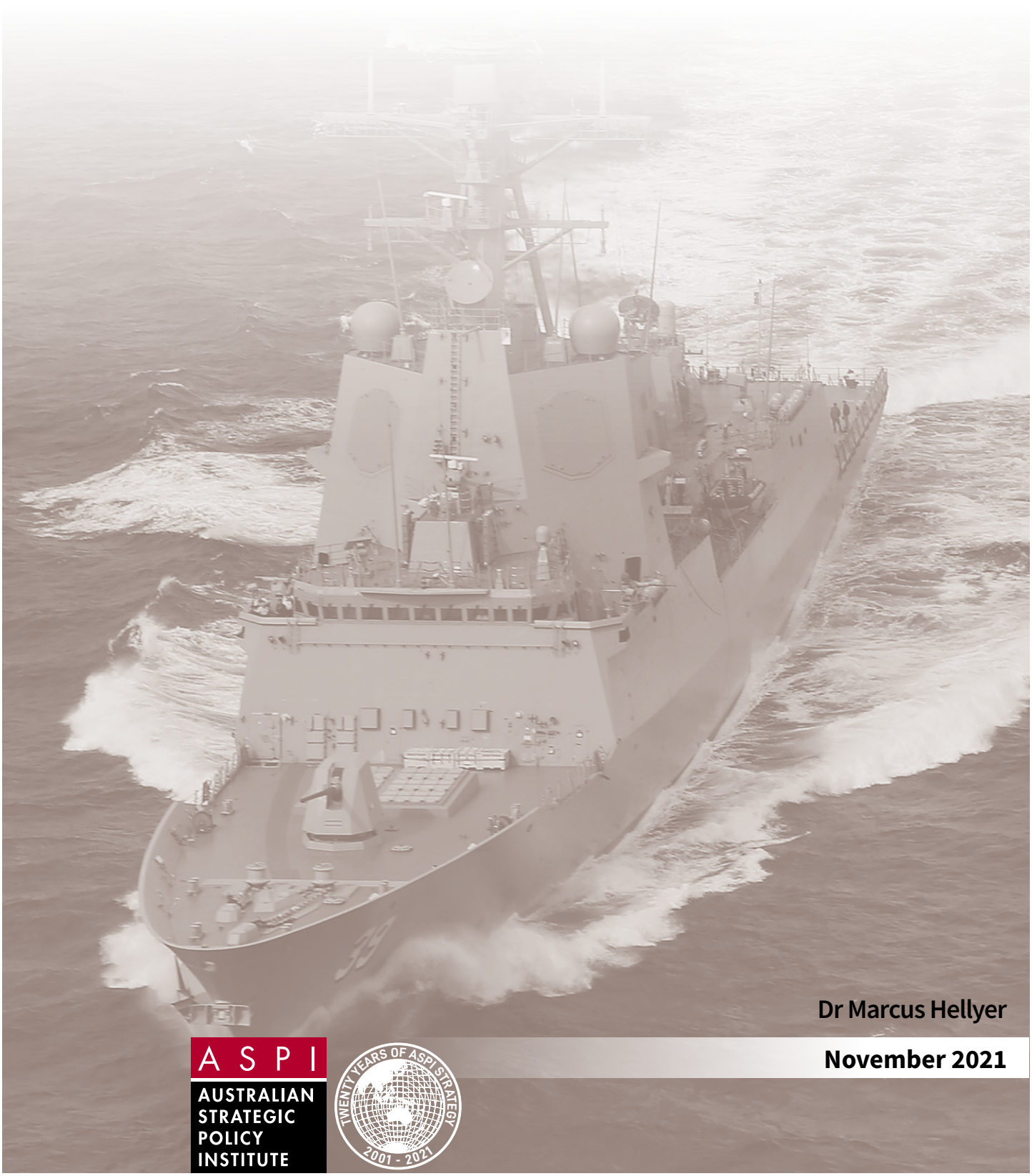
Cover image: NUSHIP *Hobart* conducts sea trials off the coast of Adelaide, South Australia, Defence image library, online.

Delivering a stronger Navy, faster



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Executive summary

Serious risks are being realised in the Royal Australian Navy's twin transitions in its surface combatant and submarine fleets. As Australia's strategic circumstances become more dangerous, Defence needs to adopt hedging measures to actively address the capability risks in its acquisition plans.

The government's recent announcement regarding the acquisition of nuclear-powered attack submarines (SSNs) is about addressing capability risk in the long term, but with delivery of the first future submarine now delayed probably to the late 2030s, in the short to medium term the proposal exacerbates those risks.[1]

To address those risks, this paper details an approach that will:

- deliver valuable additional maritime capability to the Navy significantly earlier than the current plan;
- sustain, and indeed grow, the workforce that will be essential to our long-term ship and submarine plans;
- develop the industrial ecosystem needed for naval construction in Adelaide and nationally; and
- provide a timely return on the funding that the Australian government has already planned to invest in naval capability this decade without requiring additional funding.

In order to deliver on the government's ambitious plans for future shipbuilding capability, the urgent task today is to develop a bridging strategy that delivers short term capability wins and boosts vital industrial capability. This plan presented here does both by offering a viable way forward to an expanded defence capability and industrial base into the future.

Even before that announcement, the mounting delays in the Hunter-class frigate program prompted commentators to suggest building more Hobart-class air warfare destroyers to provide more maritime capability sooner. That concept makes even more sense now.

There's an urgent need to deliver more maritime combat power before the Hunter and SSN programs deliver. The first Hunter frigate is already delayed to around 2033 and, with the program facing complex integration challenges and vanishing design margins, there are no guarantees that it won't slip further.

Even when the Hunter starts coming into service, it's under-gunned for the threat environment of the 2030s: its missile capacity is the most glaring shortfall. With the lethality of anti-ship missiles increasing, its 32 missile cells mean it's taking a knife to a gunfight. Plus, it's going to have limited capacity to carry the Tomahawk strike missile, another of the government's recent announcements. Meanwhile, the Navy's Anzac frigates will have to serve into the 2040s, even though they only have eight missile cells.

The Navy needs combat power—and it needs it before the Hunters turn up on the lethargic two-year delivery drumbeat built into the current Naval Shipbuilding Plan.

To deliver that, we need to rebuild the shipbuilding plan. With the cancellation of the Attack-class submarine, the plan to build Australia's industrial capability is in disarray. Thousands of skilled jobs that were to be created and sustained by that program are indefinitely deferred. However, we can grasp this as an opportunity to deliver military and industrial capability sooner.

We've created the foundations of a national naval shipbuilding machine by massive investments in modern, digital shipyards. But under the current plan this enterprise isn't delivering anything before the mid-2030s besides very lightly armed offshore patrol vessels (OPVs), despite tens of billions of dollars flowing into it this decade. We need to take advantage of this industrial capacity and investment to give the Navy more offensive power well before then.

We need to refocus public debate around shipbuilding towards the original purpose of the shipbuilding enterprise: delivering the maritime capability the Navy needs when it needs it to defend Australia. That means adjusting the shipbuilding enterprise's order book as strategic circumstances demand. The true value of a continuous naval shipbuilding capability is in its ability to switch production between classes and to accelerate builds as necessary. Rather than locking in particular vessels on a slow and steady drumbeat to guarantee jobs for the grandchildren of current workers, the enterprise needs to protect the Australians currently paying for it. The government's Defence Strategic Update from last year says we no longer have at least 10 years of warning time to prepare the ADF to participate in major conflict. We simply should not accept that the Navy can't acquire major new combat capabilities over this next 10 years.

There are two parallel near-term shipbuilding approaches, both taking advantage of the production machine that the government has invested in.

ASPI has already discussed the first: building vessels based on the OPV hull but fitted with missile systems and smart autonomous systems—air, surface and undersea.[2] Not every maritime platform needs to be able to do every task and defeat every threat by itself. Breaking this mindset opens new possibilities. An armed version of the OPV that doesn't pretend to be a multi-role platform but has useful offensive or sensor capabilities looks attractive as a near-term addition to the Navy's lethality that complicates any adversary's decisions. They won't be multi-role vessels, which avoids the spiralling complexity and cost we see with the Hunter, but would operate in tailored taskforces with other vessels.

This approach would be part of a broader strategy of making greater investments in the 'small, smart and cheap'—disaggregated uncrewed or minimally crewed systems that employ autonomous technologies to generate distributed mass and effect.

The second approach—the focus of this paper—is the option of building more Hobart-class air warfare destroyers. We've already been through the pains and challenges of getting the design right and learning how to build them. While they mightn't have quite the same antisubmarine warfare capability as the Hunter is intended to have, they're still very capable antisubmarine platforms. Moreover, their 48 missile cells offer advantages over the Hunter in air defence and strike—and for deploying missiles made in Australia through the emerging guided weapons enterprise.[3] With the design mature and the build process well understood, there's the realistic prospect of getting a second batch of three Hobarts into service before the Hunter program delivers, the first of them well before the end of the decade.

As with any complex undertaking, there will be challenges, such as managing facilities and workforce between the major shipbuilding programs at Osborne in South Australia and restarting supply chains, but the shipyard was designed to have more capacity than simply producing one frigate every two years. The reason the government retained ownership of the shipyard (and the taxpayers funded its development) was to retain the flexibility to produce different vessels from different designers as required.

Moreover, a new air warfare destroyer program will help generate the ecosystem of skilled tradespeople, designers, engineers, combat systems integrators, project managers and local suppliers that will be needed for the build and sustainment of the future SSNs. It would avoid a cold start to the SSN program and so help mitigate its schedule risks.

For those concerned about what this means for ultimate numbers of Hunter-class frigates, we can be agnostic for now on that issue. But there's nothing carved in stone that says the magic numbers for the Navy's major surface combatants are three destroyers and nine frigates for a total of 12. In fact, one of the fundamental problems with

the current shipbuilding plan is that it locks us into 12 surface combatants until the 2050s—that's despite the government's assessment that we're facing the most demanding strategic period for our country since World War II. Building a second batch of Hobarts would allow us to grow the fleet faster, whatever the final goal may be.

Certainly, major warships such as the air warfare destroyers are expensive, but they'll be substantially less so than Hunters, in part because they're significantly smaller and in part because we already know how to build them. Moreover, the $1–2 billion annual spend freed up by the cancellation of the Attack class can be put to good use building maritime and industrial capability. Most importantly, that spend can deliver capability much faster than the Hunter program.

If the National Naval Shipbuilding Enterprise can't deliver meaningful capability well before 2030, then its entire purpose needs to be reconsidered. Ultimately, delivering actual capability in strategically relevant time frames will address risk as well as rebuild public confidence in the shipbuilding enterprise.

Strategic risks are being realised in the Navy's capability

The misalignment between strategy and schedule

Two major pieces of government policy have pulled the rug out from underneath its Naval Shipbuilding Plan.[4] The first was the 2020 Defence Strategic Update (DSU). It assessed that we can no longer rely on having 10 years of warning time for inter-state conflict involving Australia—which simply can't be reconciled with the schedules of the major planks of the shipbuilding plan. The second, the government's announcement that Australia would acquire nuclear-powered attack submarines (SSNs) pushes the timelines of one of those planks even further into the future. If the achievement of initial operating capability in the early 2030s seemed inadequate when the preferred designs for the future submarine and frigate projects and their schedules were announced several years ago, the revised dates of the mid-2030s for the future frigate and late 2030s for the SSNs are completely unacceptable in the light of the DSU's strategic assessments.

We need to acknowledge that the Navy's entire combat power is at risk.

It's not just the delivery schedule of the first of class, but a lethargic two-year delivery drumbeat that's designed to ensure jobs for the grandchildren of shipbuilders in the late 2040s and minimise the start-up costs of distant classes of ships whose requirements and design can only be in the realm of conjecture, rather than delivering capability now to ensure the security of the Australian taxpayers who are funding the program. Neither the schedule for initial operational capability nor the delivery drumbeat can be reconciled with the government's own assessment of our strategic circumstances.

Moreover, the Navy's short- to medium-term capability plans are difficult to reconcile with the DSU's assessment that:

> maintaining what is a capable, but largely defensive, force in the medium to long term will not best equip the ADF to deter attacks against Australia or its interests in the challenging environment this document sets out.

The DSU states that Defence requires:

> … a different set of capabilities. These must be able to hold potential adversaries' forces and infrastructure at risk from a greater distance, and therefore influence their calculus of costs involved in threatening Australian interests.

Those capabilities include long-range strike.[5]

Yet, due to Naval Shipbuilding Plan's moribund schedule, the Anzac frigate will remain the backbone of the surface Navy well into the 2030s and be in service into the 2040s. But there's little that can be done to enhance its strike capability. It only has eight vertical launching system (VLS) cells, and they'll be required for its Evolved Sea Sparrow Missile (ESSM); there's no capacity left for offensive weapons such as the Tomahawk missile that the government has announced it will acquire. And even when the Hunter eventually arrives, the situation won't necessarily improve, as I discuss below.

Wishful thinking has reigned

Wishful thinking has reigned in the future frigate program. The result is that the predicted date for initial operational capability is now 2034—thirteen years away. Let's review the history of the program and its schedule.

In August 2015, concerned about the prospects of a shipbuilding 'valley of death' between the close of the air warfare destroyer (AWD) project and the start of construction on the future frigates, the government announced that it was bringing forward the frigate program. Construction was now to start in 2020—that is, construction would start in five years, even though the government hadn't yet selected a design, let alone funded any work on it.

Later that year, the government commenced a competitive evaluation process to identify a reference ship design that was mature, in the water and in service. However, it said that it also required five significant modifications to the successful design: integration of the Australian CEA radar, the Aegis combat system, US weapons that were already in Australian service, the MH-60R Seahawk maritime combat helicopter and any modifications necessary to meet Australian regulatory requirements. Reconciling what were essentially completely contradictory requirements—mature yet fundamentally redesigned—would prove difficult.[6]

The list of contenders was whittled down to three, who were funded to conduct activities such as assessing the risks of modifying their designs. Those risks forced the government to acknowledge that it wasn't possible to meet the 2020 construction deadline',[7] so the 2020 milestone was redefined as the start of 'prototyping' (that is, demonstrating, as BAE has recently, that the new shipyard in South Australia worked by making 'representative ship blocks' that will not actually be used in a frigate[8]), while the start of construction of actual ships was moved to the end of 2022. The prototyping deadline can only be described as a face-saving measure that was completely unrelated to any meaningful design milestone in the frigate itself.

In June 2018, the government announced that it had chosen BAE Systems' Global Combat Ship based on the Type 26 frigate being built in the UK. That was in some ways surprising, since the Type 26 was the only one of the three contenders that was not mature, not in the water and certainly not in service. The build and sustainment benefits offered by the digital technologies used to design the vessel and the flexible capability provided by the ship's multi-role mission bay no doubt played a role in the decision. Nevertheless, we've continued to see instability in the reference ship's design. Nor did the reference design incorporate the CEA radar, Aegis combat system, in-service weapons or MH-60R helicopter required by Australia. In essence, the government accepted Defence's recommendation to choose the least mature design and then perform fundamental modifications to it.[9] It's impossible to reconcile this with the requirement to select a mature design to reduce risk and enable a rapid start to construction. Moreover, it piled more risk on top of the risk in the submarine program.

Figure 1: An artist's impression of the Hunter-class frigate

Source: Defence image library, online.

In that light, the four and a half years available to achieve the start of construction by late 2022 seem quite inadequate. The growth of the Hunter's design from around 8,800 tonnes to over 10,000 tonnes confirms the immaturity of the initial design.

If we add into the mix the facts that the UK's program still requires design resources, the Canadians have also selected the Type 26 and are also seeking to implement substantial design changes, and Covid-19 has disrupted everybody's plans, it's perhaps not surprising that Defence has revealed a further 18-month delay to the start of construction.[10]

However, Defence officials recently informed a Senate committee in August 2021 that, while construction has been delayed by 18 months, delivery of the first ship has been delayed by two years, to 2031.[11] Since Defence's master schedule indicates a further two-year testing and evaluation phase before the first ship is deployable, that suggests that initial operational capability has now moved two years to the end of 2033. Or, put another way, even though the government's 2020 DSU said we can no longer rely on 10 years of warning time, we're looking at 12 years until the first of nine planned Hunter-class frigates provides useful capability (and around 18 years for the first SSN).

From the public information, it isn't possible to determine how badly compromised the design is, or what further adjustments to capability or increases to cost and schedule will be required to finalise an acceptable design.

A high-level schedule for the surface combatant transition based on the latest information from Defence is in Figure 2.

What does that delay mean? It would appear that the desperate attempt to bridge the valley of death by short-circuiting the selection and design processes for the future frigate has achieved little except to inject additional risk into the program. The 18-month delay to the start of construction—presumably to mid-2024—will create uncertainty for the ramp-up of BAE's workforce and its suppliers and partners. The first two offshore patrol vessels are being built in Adelaide to ensure some continuity of workforce after the completion of the AWDs, but they're due to be delivered in late 2021 and 2022 (noting that there are also signs of some delay there). It's hard to see how 'prototyping' activities can serve as useful work for three and a half years.

Figure 2: Plan A—The current schedule for the surface combatant transition

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053
Total # surface combatants	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	12
Anzac (4/1996)												36																					
Arunta (12/1998)														36																			
Warramunga (3/2001)															34																		
Stuart (8/2002)																34																	
Parramatta (10/2003)																		35															
Ballarat (6/2004)																				36													
Toowoomba (10/2005)																						37											
Perth (8/2006)																								38									
DDG 1 – Hobart (9/2017)																												31					
DDG 2 – Brisbane (10/2018)																														32			
DDG 3 – Sydney (5/2020)																																32	
Hunter 1 – Hunter																																	
Hunter 2 – Flinders																																	
Hunter 3 – Tasman																																	
Hunter 4																																	
Hunter 5																																	
Hunter 6																																	
Hunter 7																																	
Hunter 8																																	
Hunter 9																																	
DDG replacement 1																																	
DDG replacement 2																																	
DDG replacement 3																																	

Notes:
Anzac- and Hobart-class lines provide age at retirement. Figure assumes Anzacs will be retired as Hunters enter service. Hunter delivery schedule incorporates Defence testimony to the Senate that delays to the start of construction will be recovered by the delivery of Ship 4. DDG replacement assumes no interruption to the two-year delivery drumbeat.

Sources:
Defence testimony to Senate estimates hearings. Defence testimony to the Senate Economics Reference Committee inquiry into Australia's sovereign naval shipbuilding capability, 6 August 2021.
Australian National Audit Office, Major projects report 2019–20.

The maritime capability picture

A high-level summary is as follows. Under the current shipbuilding plan, despite the $575 billion that the government is spending on defence in the decade to 2029–30—of which $270 billion is going on new capability—Defence isn't getting a single new warship to sea or even a single new VLS cell. Defence will have 12 new OPVs but, under the current plan, they'll be equipped with nothing more lethal than a 40-mm gun. In short, the $270 billion isn't delivering much additional maritime combat power. We'll unpack that in more detail.

The Anzac-class frigates

That means under the current plan we'll have to rely on the vessels we have already. The core of the surface fleet will remain the Anzac frigates for a long time to come. If we assume that an Anzac retires as a Hunter enters service, the last will retire around 2044, meaning that it will need to continue to serve for 23 years, and for 11 years after the Hunters start their dilatory delivery (that's assuming the Hunter program can indeed make up the lost schedule as Defence officials have suggested[12]—historical experience suggests major projects delayed at this stage of development don't recover schedule and often face additional delays). Their average age at retirement will be 36, well beyond their original design life. As a comparison, the Adelaide-class frigates averaged 28 at retirement. The last two Anzacs will be 37 and 38. In fact, if the Anzacs are retired in the order they were commissioned, the last three aren't even halfway through their service lives. And with HMAS *Perth* potentially serving until 2044, there are likely to be many members of its crew who have not yet been born.

Defence and its industry partners have done well to enhance the Anzacs' capability over their life to date. They're far from being the infamous 'floating targets' fitted for but not with capability that they once were.[13]

Figure 3: Anzac-class frigate HMAS *Arunta*, recently upgraded with the CEAFAR long-range air search radar

Source: Defence image library, online.

With the latest round of upgrades under the Anzac Midlife Capability Assurance Program well underway, Defence is commencing planning for a life-of-type extension to manage obsolescence issues and ensure the platform remains a relevant capability. But, considering that the last of the class will be in service for at least another 20 years, the wish list will be long. While some much-needed enhancements might be space and weight neutral, such as a new maritime strike missile to replace the venerable Harpoon, others will inevitably have additional space, weight and power requirements, such as a towed-array sonar, for which Defence recently issued a request for information to industry.

However, with the 'industry standard' for new classes of multirole frigates now in the 7,000+ tonne range, the Anzacs will necessarily be limited with only 3,600 tonnes. Perhaps the greatest limitation facing the Anzacs is magazine depth. While the class's eight VLS cells can carry 32 quad-packed ESSMs, its radar and combat management systems are incompatible with the longer range SM-2 and SM-6. An Anzac might be able to shoot down a missile, but it won't be able to shoot down the aircraft before it launches the missile. And with design margins largely consumed by capability enhancements over the past 20 years, it's unlikely that the number of VLS cells can be increased. The Anzac's ability to operate outside of the air defence umbrella provided by the Hobart class or a similar allied vessel will be increasingly limited in the face of a peer or near-peer adversary.[14]

The Hobart-class destroyers

The early travails of the AWD program have been well covered.[15] Just as happened with the Collins-class submarines, early bad publicity has tainted their reputation, and the public perception is one of delays and cost blowouts. However, with the program now complete, it's possible to take stock and offer a more complete assessment.

Since the restructuring of the program in 2014, it has delivered on the revised schedule. Also, while the program received a $1.2 billion budget increase, it's likely that less than half that will be required.[16]

The class achieved final operational capability in August 2021, and the Chief of Navy has praised its capabilities.[17] The class's advanced air defence capabilities based on the Aegis combat management system, AN/SPY-1D radar and SM-2 air defence missile have been demonstrated, as has its cooperative engagement capability (CEC), which allows other platforms to provide targeting data—provided they also are equipped with CEC, which so far is a small number of platforms, such as other AWDs. Moreover, the class has performed well in trials of its antisubmarine warfare (ASW) capability, and its acoustic signature is reportedly better than that of the Anzacs, which was the previous benchmark for a good ASW platform. Ironically, the AWD is the Navy's only vessel equipped with a towed-array sonar and is therefore its most capable ASW vessel.

Figure 4: The Hobart-class destroyers achieved final operational capability in August 2021

Source: Defence image library, online.

While the class is relatively new, Defence is already embarking on an upgrade to its combat management system, installing Aegis Baseline 9. In conjunction with CEC, this will allow it to employ the SM-6 missile's long-range, over-the-horizon air defence capability, as well as its ballistic missile defence capability—which is increasingly urgent in the light of China's development and deployment of anti-ship ballistic missiles.

Despite its strengths, the Hobart has weaknesses. As a class, it will have capacity constraints. Since the Navy only has three Hobart AWDs, its ability to consistently deploy more than one will be limited. Moreover, while the Hobarts' 48 VLS cells are a huge improvement over the Anzacs' eight, that's still a limited number compared to other warships in the region, many of which have 96 or even 128. While the government has announced the acquisition of the Tomahawk land strike missile for the Hobart, it's highly unlikely that will result in a credible strike capability with only three AWDs in the fleet.[18] With the Anzacs' limited magazine depth, the Hobarts are likely to have to load most of their VLS cells with air defence missiles, leaving little or no capacity for other weapons. Even then, in protracted operations against an adversary such as China, which can employ combinations of air-, sea-, land- and submarine-launched cruise missiles, anti-ship ballistic missiles and probably hypersonic missiles, the Hobarts' air-defence arsenal could be depleted.

Also, the Hobart's eight Harpoon maritime strike missiles provide no improvement over the Anzacs. The Harpoon is dated and, even if it's replaced later this decade with a more advanced weapon, there's little capacity to increase the number of weapons on the ship. In short, while the Hobarts have the ability to protect themselves and the vessels they're escorting, they have limited lethality.

But, while noting the shortfalls, the Hobart Class is an impressive maritime combatant—and in Australia's strategic environment, making the perfect the enemy of the good seems both dangerous and wrong.

Capability risk in the Hunter-class design

So, is the Hunter the answer for a more offensive ADF? The answer is no, as the shortcomings of the Hobart in offensive power are even greater in the Hunter.

Let's review the Hunter's capability. The Hunter class started off as a large ship for the capability it provided. It was around 8,800 tonnes full-load when it was selected—bigger than the Hobart-class destroyer—yet it will have fewer VLS cells, at 32. Over the past three years of design work to integrate the required modifications, the design has now reached 10,000 tonnes, according to Defence officials. It also has only eight maritime strike missiles, the same as the Anzac and Hobart. Overall, of all contemporary warships, it seems to be the most expensive for getting missiles to sea. That's not good news in light of the DSU's assessments about growing threats and the need for offensive capabilities.

Despite the large size, the design has minimal growth margins. Defence officials have stated that its target margins are around 270 tonnes, which equates to around 2.5%.[19] That compares with the Hobart class's roughly 600 tonnes at delivery for a smaller vessel. Defence officials have argued that the small margins are acceptable because the ship will be delivered with all the capabilities it requires. That's a highly optimistic statement that isn't supported by the life cycles of other vessels. The multi-mission bay seems to require design margin if it is to be used as originally conceived—to expand the ship's capabilities over its life. It also presumes a reliable understanding of the future threat environment—something that's inconsistent with the highly dynamic and rapidly evolving picture set out in the DSU and Defence's demonstrated inability to predict the future.[20] Already, the margins seem incapable of addressing what's the major capability shortfall in the Hunter: the small number of VLS cells.

While the substantial increase in weight has caused some commentators concern about the performance of the propulsion system, Defence officials have testified that the performance will meet requirements. It does, however, seem to defy the laws of physics that a 15% increase in weight will have no impact on speed, efficiency and endurance.

The cost of the future frigate has also grown from $30 billion in the 2016 Integrated Investment Program to $35 billion in the 2017 Naval Shipbuilding Plan to $45.6 billion in the 2020 Force Structure Plan, which stated that the increase was in part driven by the drawn-out schedule adopted by the current approach to continuous shipbuilding.[21] It's possible that underestimation of the complexity of the design modifications and the spiralling weight increases have also played a role in the 50% cost increase.[22]

While the Attack-class submarine attracted the bulk of public criticism of the Naval Shipbuilding Program, concern is growing about the Hunter.[23] In the light of the schedule and inherent capability limitations of the class, some of that concern appears to be warranted.

Defence officials have repeatedly told Senate committees that they're confident about stabilising the design and getting the spiralling weight issue under control. That would mean that the best-case scenario is that in 12 years' time Australia gets the first ship of a design that will be significantly under-gunned for a major surface combatant in the age of missiles and has limited margin for improvement. The worst case is that the Hunter is caught in a design spiral that's unrecoverable, resulting in a severely compromised design that falls well short of requirements, encounters further schedule delay and doesn't deliver value for money.

Analogous programs

While it may be tempting to believe that the challenges facing the Hunter class are due to poor leadership and that a change of management or structure in the Naval Shipbuilding Program will solve all its problems, that's probably just not true—the issues are deeper than that. Analogous programs overseas have similar problems.

The trajectory of the Canadian program is virtually identical, for much the same reasons. Canada also chose the Type 26 as the reference ship for its future 15-ship surface combatant class. It, too, is seeking significant modifications to the reference ship design to increase the vessel's air warfare capabilities. Consequently, the Canadian vessel's weight is growing. That's also caused schedule delays. Both have resulted in an increase in cost, according to the independent Canadian parliamentary budget office.[24] The office also provided costs for different solutions, including mixes of high/low-capability ships that came at substantially lower cost.

So far, Canada has stuck to its original plan of 15 large frigates, but, in the face of its own budget pressures, the UK has adopted a high/low-capability mix. The Royal Navy aspires to an escort fleet of 24 ships—eight destroyers and 16 frigates. However, the UK found the Type 26 frigate to be unaffordable and is only acquiring eight for the Royal Navy instead of its originally planned 13 (only three have been ordered so far). Instead, it will achieve its numbers through the acquisition of five smaller, significantly less capable frigates: the Type 31.[25] In fact, the Type 31 has no maritime or land strike capability, no towed array and only local air defence, making it essentially a patrol vessel rather than a major surface combatant. A follow-on class (potentially called the Type 32) to reach the objective number of frigates looks like being Batch II of the Type 31 rather than having the size, capability and cost of a Type 26. Early analysis indicates that the Type 32 will rely heavily on automation and autonomous systems.[26]

Another emerging issue with the UK's Type 26 is that it looks like being delivered in a fitted-for-but-not-with configuration for key systems such as long-range air defence and anti-ship missiles. While that may have allowed construction to progress and keep costs within the contracted £3.7 billion for the first three ships, it will inevitably affect capability.[27] That in itself isn't a problem for Australia's Hunter program, but it confirms that there's no way to square the circle—demanding capability aspirations drive cost and schedule.

The US Navy selected the FREMM, which was one of the unsuccessful contenders for Australia's future frigate program. While early cost estimates made it appear to be a bargain, independent Congressional Budget Office estimates suggest that the US Navy estimates are extremely over-optimistic.[28] Moreover, despite describing the design as mature, the Navy is implementing design changes that are altering the hull, which will be likely to introduce cost and schedule risk.[29]

These brief comparisons illustrate a number of points. There's no magic solution to the cost–capability spiral—if you want highly capable, crewed, multi-role vessels, they will cost a lot. Modifying designs will only increase cost and schedule. Attempts to reduce cost by stripping out capability are likely to result in vessels that aren't survivable (as we've also seen with the US Navy's littoral combat ship and may be the case with the UK's Type 31). However, selecting mature, proven designs can reduce cost and schedule risk, particularly if navies can resist the temptation to do major design modifications.

The submarine transition

We've seen that the surface combatant transition is facing major risks. When faced with risk, organisations can seek to hedge. In the RAN's context, that would suggest relying on other capabilities to balance the risk in its surface combatant program. The strategic challenge for Defence is that the other half of the Navy's combat power—its submarine capability—is facing even greater risk than its surface combatants.

The government's recent announcement that it will acquire, with assistance from the US and the UK, a fleet of SSNs may mitigate capability risk in the longer term, but in the shorter term it only exacerbates it. According to the government, the delivery of the first SSN is a long way off in the late 2030s. That's even further away that the Attack class was. Moreover, the number of new SSNs will grow only slowly after that, perhaps on a three-year drumbeat. When we examine the submarine capability transition from the Collins fleet to the SSN fleet, it hard to avoid the conclusion that there will be significant risk of decline in capability during the transition—potentially one that will be very difficult to recover from.

As with the Anzacs, an extensive program of upgrades is planned for the Collins-class submarines under the life-of-type extension (LOTE) program. According to Defence, this will have an ambitious scope, involving a new main motor, new diesel generators and new electrical distribution systems. Since even minor design changes to submarines can have major implications for space, weight, power and trim across the whole boat, this extensive program brings substantial design risks. While Defence has expressed confidence in the progress of design work on the LOTE to date, the minimal expenditure so far and the lack of involvement by the original designer of the Collins (Saab Kockums, which also has substantial experience in upgrades of other Swedish-designed submarines) suggest that there are still outstanding design risks and much work to be done.

The government has finally signalled that it will put all six Collins through the LOTE, yet that provides little additional risk mitigation. Even with a LOTE, the Collins can't bridge the gap to the new SSN fleet. If the LOTE encounters technical challenges, they will either result in schedule delays, resulting in fewer submarines being available, or the LOTE could be de-scoped, meaning that capability enhancements would not be delivered. And if both the SSNs and the LOTE are delayed, the capability shortfall compounds.

By the time Collins boats are replaced by SSNs, they'll be well into their forties. That's older than the KRI *Nanggala*, the ageing Indonesian submarine that sank with all hands earlier this year. It's hard to imagine them still being the 'regionally superior capability' that Defence said it's aiming for. Their ability to undergo a second LOTE and still be relevant, as the Chief of Navy recently suggested, strains credibility.[30]

Moreover, operating small fleets of ageing boats is a receipt for disaster in terms of availability. Canada is attempting to do this with a fleet of four second-hand conventional British boats. Despite years of repairs and upgrades, the entire fleet still did not achieve a single sea day in 2019.[31] The Chief of Navy has suggested that growth from the current 900 qualified submariners to around 2,300 will be required. Without boats that can regularly go to sea, it will be extremely challenging to maintain the Navy's submariner numbers, let alone embark on a path to grow the much larger numbers that will be required for the future SSN fleet.[32]

It's impossible from outside Defence to fully understand the risks to both transitions or appreciate how Defence is mitigating them, but it's clear that both fleets (submarines and surface combatants) are facing very similar sets of risks. What that means is that it's dangerous to rely on one to cover capability risks in the other. There are no guarantees that risks won't be realised (as indeed we're seeing already) in both.

A table illustrating the submarine transition is shown in Figure 5.[33]

Figure 5: The submarine transition plan

	26/27	27/28	28/29	29/30	30/31	31/32	32/33	33/34	34/35	35/36	36/37	37/38	38/39	39/40	40/41	41/42	42/43	43/44	44/45	45/46	46/47	47/48	48/49	49/50	50/51	51/52	52/53	53/54	54/55	55/56	56/57	57/58	58/59	59/60
Total # of submarines	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	6	5	5	5	5	4	5	4	4	5	5	5	6	6	6	7	7	7	8
CCSM 1 – Farncomb – 1/98	LOTE									Age = 40																								
CCSM 2 – Collins 7/96			LOTE									Age = 43																						
CCSM 3 – Waller – 7/99					LOTE									Age = 42																				
CCSM 4 – Dechaineux – 2/01							LOTE									Age = 43																		
CCSM 5 – Sheean – 2/01									LOTE									Age = 45																
CCSM 6 – Rankin – 3/03											LOTE									Age = 45														
SSN 1																																		
SSN 2																																		
SSN 3																																		
SSN 4																																		
SSN 5																																		
SSN 6																																		
SSN 7																																		
SSN 8																																		

Key to figure

Total number of submarines in service	Collins service	Life of type extension	Future submarine service

Notes:
Collins line provides age at retirement. Figure assumes a Collins boat will be retired as an SSN enters service. SSN delivery drumbeat based on current Astute drumbeat which averages around three years.

Sources:
SSN schedule based on the government's announcement. Collins schedule based on Defence testimony to Senate estimates hearings.

Plain speaking about the National Naval Shipbuilding Enterprise

With the cancellation of the Attack-class submarine program, the naval shipbuilding enterprise is now in disarray. That has potentially disastrous consequences for the Navy's capability. It's time for some clear thinking about the purpose of the enterprise and what can be done to salvage it.

The purpose of continuous shipbuilding

The continuous shipbuilding enterprise exists for one purpose only—to deliver maritime capability to the ADF. Essentially, the enterprise is itself an industrial capability that's been established to deliver the military capability the ADF needs when it needs it. Its purpose isn't to deliver a particular number or kind of vessel *per se*. The order list is what's set out in the Naval Shipbuilding Plan and Force Structure Plan, but that list will need to change as strategic circumstances require. Much discussion, however, conflates the overall enterprise with the current order list. Moreover, 'continuous' has become the end in itself in order to preserve jobs in future decades.

Continuous naval shipbuilding has potential benefits. That could include saving money, but the current approach to it drives higher costs for the following reasons:[34]

- Artificially stretching out a program through a two-year delivery drumbeat is extremely inefficient.
- Artificially stretching out a program also increases costs by providing more time for inflation and other cost indices to take effect.
- Basing a continuous build program on a fleet of 12 vessels (the number for each of the planned surface combatant and the Attack-class submarine fleets), even with a stretched out two-year drumbeat, means vessels are replaced after 24 years, well before their economic life of type.
- Continuous build based on a fleet of eight SSNs would drive an even more lethargic delivery drumbeat of around four years.[35]
- Start-up costs are a small percentage of costs, particularly for large programs delivering nine or 12 vessels, and are outweighed by the overheads of slow delivery schedules.

The total investment in the shipbuilding program is frequently mentioned by the government and media. We should note that the $90 billion figure often cited was an understatement of Defence's actual $130 billion estimate for the original build program of frigates, Attack-class submarines and OPVs. That's even before the DSU added new classes to the future order book, such as logistics ships. And of course, that number will grow again, since the SSNs program will inevitably cost significantly more than the Attack class.

But a more relevant number is the annual cash flow the enterprise is absorbing. Before the cancellation, the ship-building enterprise planned to spend $2.5 billion in 2021–22, several years before the Attack and Hunter classes were to start construction. Once they started construction, the enterprise would likely have been spending $4 billion per year. Consequently, by the end of the decade, the Attack and Hunter programs would have spent over $20 billion—years before they deliver a single vessel. The number could have reached close to $35 billion by the time the first

of each class has entered service—but it's likely to be more by the time we get to the first SSN. Of course, the cancellation of the Attack class means less money will be spent this decade (more on that later), but the pursuit of SSNs simply makes most numbers even larger.

We need to ensure that those huge sums are delivering a timely capability return on investment. Otherwise, we're at risk of establishing, at vast expense, a naval shipbuilding enterprise that's designed to deliver jobs in Adelaide in the 2040s and 2050s, rather than using our newly established industrial capability to deliver maritime war-fighting capability in the most strategically uncertain period of the past 75 years.

If the naval shipbuilding enterprise can't deliver strategically relevant capability well before 2030, then its entire purpose needs to be reconsidered. If it can't deliver real capability when we need it—despite the government's investment of $270 billion in new capability over the decade to 2030 (and $575 billion in total defence spending over that period)—it has failed its purpose.[36]

Rebuilding shipbuilding

While the delays to the Hunter's schedule have affected the ramp-up of Australia's shipbuilding capability, that is small compared to the impact of the cancellation of the Attack class. If the government achieves its goal of starting construction on SSNs by the end of the 2020s, that means that the start of construction for the Future Submarine Program will have been deferred by at least five years.

It's hard to quantify what impact that has for small- to medium-sized enterprises that had planned and invested to prepare themselves to contribute to the Attack program. Around a month after the cancellation was announced, the Australian Industry Group told a Senate inquiry that the cancellation had profound implications for Australia's industrial base. The Australian Industry and Defence Network informed the same inquiry that Naval Group had planned on having 2,000 local suppliers; 600 local companies had already qualified for Naval Group's supply chain, and 200 had received actual contracts. Those that had qualified had spent an average of $200,000 to do so—a substantial investment for small enterprises. The Australian Industry and Defence Network also stated that local companies were already laying off employees in the wake of the cancellation.[37]

We can quantify the longer term disruption to the workforce by looking at Defence's own estimates of the numbers that were to be employed on the Attack class. Defence's estimate of the growth of the shipbuilding workforce over the decade is given in Table 1. We should note that these are only direct jobs; the government and Defence have stated that, once the workforce involved in supply chains is included, the total number is around three times greater.[38] We can see that the cancellation of the Attack class has eliminated or put at risk over a quarter of current Australian shipbuilding jobs. By the middle of the decade that grows to over a third of planned jobs and to 42% by the end of the decade.

Table 1: Expected direct Australian jobs in the Attack-class submarine program

	2020	2021	2022	2023	2025	2030
Attack-class jobs	700	1,270	1,440	1,530	2,010	2,660
Total direct shipbuilding jobs	3,205	4,540	5,005	4,810	5,370	6,125
Attack-class jobs as percentages	21.8%	28.0%	28.8%	31.8%	37.4%	43.4%

Source: Senator the Hon Linda Reynolds CSC, Minister for Defence, 'Correspondence regarding naval shipbuilding workforce figures,' 22 October 2020, online.

If those companies and workers—and the industrial capability they embodied—were simply no longer needed in Australia's shipbuilding plans, that would be unfortunate for the individuals, but it wouldn't be strategic loss. However, since the government is intending to build the future SSNs here, the abrupt interruption does indeed have strategic consequences. A cold start to the SSN program is likely to push its delivery schedule even further into the

future. And with an expected tonnage substantially greater than the Attack class—potentially twice as great— even more workers will be required. A larger, healthier, and more capable shipbuilding ecosystem is absolutely essential to mitigating risk in the SSN program. The only way to develop that ecosystem is to build ships.

The government has announced a program to move companies and workers from the Attack program. While every effort should be made to retain these capabilities in the ecosystem, the intent is to redirect them to existing programs. Since those programs were already in the shipbuilding plan, they aren't a net increase. New programs are needed to build additional industrial capability and prepare for the SSN program.[39]

The cancellation also has financial implications. $2.3 billion has been spent on the Attack program to date. More is to come as we settle with Naval Group, Lockheed Martin and their subcontractors. Defence will also need to negotiate outcomes with companies that invested in becoming certified suppliers but didn't receive contracts.[40] That's extremely regrettable.

But looking forward we can see a similar effect to the workforce picture in the loss of cash flow that was to generate industrial and consequently military capability (Table 2). Well over one-third of spending on domestic shipbuilding projects has evaporated, with a billion-dollar annual spend cancelled. That amount was likely to grow to around to around $2 billion per year and 50% of the total once construction of the Attack class ramped up.

Table 2: Attack-class as a percentage of total shipbuilding cash flow (A$m)

	2017–18	2018–19	2019–20	2020–21	2021–22
Attack-class	262	358	553	719	982
Total domestic shipbuilding	1,030	976	1,439	1,619	2,486
Attack class as percentage of total	25.4%	36.7%	38.4%	44.4%	39.5%

Source: Defence Portfolio Budget Statements, *Defence annual report*.

That means that billions of dollars in capability is not being built. It also means that thousands of jobs related to maritime capability aren't being generated along with the skill sets needed to fill them. Those skills, however, will still be needed when the SSN program commences.

The amount that would have been spent on the Attack class over the coming decade could have been over $12 billion. That cash flow has now been freed up, presenting Defence with a range of opportunities that it can grasp.

Changing the plan

Despite being announced by the government in 2016, the continuous shipbuilding enterprise won't deliver war-fighting capability until 2033, when the first Hunter-class frigate achieves initial operational capability. Changing the plan is necessary. With its SSN announcement, the government has indicated that it's willing to change the plan, but more is needed to meet capability risks and develop shipbuilding capability.

The true value of a continuous naval shipbuilding capability is in its ability to switch production between classes and to accelerate builds as necessary. That means reconsidering whether the projects currently planned to be delivered as the first tranche of the continuous naval shipbuilding enterprise will deliver the capability the ADF needs when it needs it and to adjust the enterprise if necessary. Modifying the plan as necessary is built into the concept of continuous naval shipbuilding, which is why the frigate program has adopted a batch or tranche approach.

Those adjustments could take a range of forms—including changes in the near term as well as in the distant future. One is to accelerate the delivery drumbeat, but that can only be done once the designs are mature and in production. At the moment, the key challenge in the surface combatant program is that the design for the Hunter class is not mature, and there are worrying signs that it might not ever be without compromise to capability and the premature consumption of capability growth margins.

Large enterprises are inherently difficult, and if we walked away from them as soon as any challenges arose we would never achieve anything. But we also need to be clear-sighted about the need to adjust the enterprise when necessary and not be excessively wedded to the original plan if it isn't meeting the purpose of the enterprise. The government changed the plan in the submarine program. We need to consider whether that time has come in the surface combatant stream. That doesn't mean cancelling the Hunter-class program, but it does require considering other approaches to delivering the capability we need until the Hunter program delivers.

Having created an industrial machine for building maritime capability, we can now decide how to use it effectively to meet our changing strategic circumstances.

Hobart Block II

We need to adjust the plan for the surface combatant fleet. But if we're trying to address the compounding risks in the shipbuilding program and maritime capability, we must at all costs avoid the path taken with our submarine capability. Starting from scratch with a new frigate design never produced in Australia simply increases risk. Suggestions such as reorganising the management of the shipbuilding enterprise to get things back on track is another idea that sounds attractive but is likely to deliver only marginal changes to timelines—you can't simply short-circuit the design work needed in the frigate and submarine programs.

The concept

But there is one option that we could consider: building more Hobart-class destroyers.

The idea of building more than the original three Hobart-class vessels isn't a new one. We've known at least since the publication of the 2009 Defence White Paper and its underpinning investment plan that there would be a shipbuilding gap between the close of the AWD program and the start of the replacement for the Anzac class, resulting in a 'valley of death' for continuity of workforce and skills.[41] Many commentators have proposed the construction of one or more AWDs to bridge the gap.[42]

Why we haven't is one of the most perplexing questions in Defence's very mixed history of capability decisions. Quite frankly, why we didn't start our continuous shipbuilding enterprise with some actual continuous shipbuilding by extending an existing program, which was achieving substantially greater efficiency with each vessel, is mystifying. Regardless of the reason, no government adopted this path, resulting in the rushed process to accelerate the construction of the OPV and future frigate to bridge the impending valley of death. As we've seen, that process was permeated with wishful thinking, particularly about the time frames needed to perform the design changes necessary for the Hunter class, with the result that even desperate measures such as the construction of the first two OPVs in Adelaide haven't been able to bridge the valley.

A standard argument deployed against the acquisition of additional AWDs has been the hoary old chestnut of 'balance'—the argument that having more than three AWDs would 'unbalance' the Navy. Balance is one of the pieces of theology that thrive in Defence. It's theology because it has the status of revealed truth handed down from on high, it's not based on any rigorous evidence, and it's used to shut down debate or the airing of alternative viewpoints. The theology of balance relies on certain magic numbers that are themselves, of course, part of the theology. For example, a balanced surface combatant fleet supposedly consists of three destroyers and nine smaller, less capable ships for a total of 12. Where those numbers come from isn't clear, other than historical precedent—the Navy previously had three Perth-class destroyers for air defence, for example, and before that three Daring-class destroyers.

Three air defence vessels are in fact a strange number, since there's another number three that has more rigour to it and that's the rule of thumb that, for every three platforms you have, you can reliably get one to sea. So the Navy can reliably get one air defence vessel to sea, which is a rather inadequate number in the light of Australia's vast area of strategic interest.

At the heart of the 'balanced force' case for rejecting further AWDs was the assumption that the AWDs are too big and too expensive for a fleet of 12 surface combatants. For the ASW role, the Navy could manage with smaller, more affordable ships. Those arguments have evaporated: the size and cost of the Hunter exceed those of the Hobart. In fact, the Hobart and the Hunter are very similar vessels despite one being called a destroyer and the other a frigate. The Hobart has 16 more VLS cells, which gives it an advantage in the air defence role, while the Hunter will be likely to have somewhat better ASW performance by virtue of its quieter propulsion system. However, with the same combat management system, very capable radar and CEC, they're likely to be largely interchangeable in many roles. While the Navy once thought that more than three AWDs would unbalance the force, it's essentially acquiring 12 destroyer-sized vessels.

The big advantage that the Hobart has over the Hunter is that it's an existing design that's been successfully delivered and entered service. With the operational test and evaluation process for the Hobart successfully completed on the way to the declaration of full operational capability in August 2021, the vessels are a known quantity. That doesn't just include advanced air warfare but also very good ASW capabilities by virtue of its integrated sonar suite, which includes a medium-frequency hull-mounted array, low-frequency active towed array, and Seahawk Romeo with an active dipping sonar. In short, the ship exists and it works. Moreover, any additional vessels will immediately be able to leverage an existing support system.

Figure 6: A Seahawk MH-60R 'Romeo' maritime combat helicopter with a dipping sonar

Source: Defence image library, online.

This then raises the question of whether the construction of a further number of Hobart-class vessels, essentially a Hobart Block II, can provide a hedge against the risk in the Navy's capability transitions and a faster boost to the ADF's offensive capability than is likely to be possible through the Hunter program alone. I'll look at the advantages before I consider the challenges.

Figure 7 shows a transition that includes the build of three Hobart Block II vessels before the first Hunter.

Figure 7: A possible Plan B involving the build of three Hobart Block II DDGs

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053
Total # surface combatants	11	11	11	11	11	11	11	12	12	13	13	13	13	13	13	13	13	14	14	14	14	14	14	14	14	14	15	15	15	15	15	15	15
Anzac (4/1996)											35																						
Arunta (12/1998)													35																				
Warramunga (3/2001)															34																		
Stuart (8/2002)																34																	
Parramatta (10/2003)																		35															
Ballarat (6/2004)																				36													
Toowoomba (10/2005)																						37											
Perth (8/2006)																								38									
DDG 1 – Hobart (9/2017)																												31					
DDG 2 – Brisbane (10/2018)																														32			
DDG 3 – Sydney (5/2020)																																32	
DDG 4																																	
DDG 5																																	
DDG 6																																	
Hunter 1 – Hunter																																	
Hunter 2 – Flinders																																	
Hunter 3 – Tasman																																	
Hunter 4																																	
Hunter 5																																	
Hunter 6																																	
Hunter 7																																	
Hunter 8																																	
Hunter 9																																	
DDG replacement 1																																	
DDG replacement 2																																	
DDG replacement 3																																	

Notes:
Figure assumes a three-ship build of a Hobart Block II, with the build taking six years and a two-year drumbeat. Hunter-class schedule is delayed by an additional year to allow design to stabilise and be de-risked. First two Anzacs are retired one-year earlier than under Plan A, but the remainder follow the same retirement date as Plan A. Overall, this allows the fleet to achieve 15 vessels. Figures in the final box of each row indicate the ship's age at retirement.

Sources:
Defence testimony to Senate estimates hearings. Defence testimony to the Senate Economics Reference Committee inquiry into Australia's sovereign naval shipbuilding capability, 6 August 2021. Australian National Audit Office, *Major projects report 2019–20*.

The final Hobart-class destroyer required four and a half years from being laid down to commissioning. Of course, with the interruption to the program, it would be unreasonable to assume that the first of a second batch could be built as quickly. Let's assume a rapid approval process and a build taking around six or seven years. The first could enter service around 2028. With the second following in 2030 and the third in 2032 (or sooner), the Navy could have three additional, highly capable combatants before the first Hunter is scheduled to achieve initial operational capability.[43] While it would be important to limit modifications to avoid replicating the problems encountered by the Hunter, Navantia has done early design work to integrate the Australian CEA radar, improve its noise signature and install a second hangar, allowing the operation of two helicopters. The last two measures would provide a significant boost to the vessel's ASW capability.

The capability advantages of this proposal are clear. It would get a large number of VLS cells to sea this decade, unlike the current shipbuilding plan that does not get any more to sea until 2033. It would also double the number of towed sonar arrays in the surface fleet. It would provide three more vessels that could provide area air defence to amphibious and support vessels and to less capable combatants, whether they're Anzacs, modified OPVs or new classes of uncrewed or minimally crewed vessels.

This proposal is agnostic on the final size of surface fleet and on the issue of how many Hunters should be acquired. If, despite all the changes over previous decades in our strategic circumstances and the clear-headed assessments of the DSU, the magic number for surface combatants is still 12, the revised plan would achieve that number of surface combatants by around 2028. Moreover, it would allow two Anzacs to retire several years earlier. If readers are concerned that having six Hobarts obviates the need for the final three Hunters, one might respond that it's strange reasoning that prioritises ships that won't be delivered until the 2040s ahead of our current pressing capability requirements. Moreover, with Hunter 7 not due to start construction until the late 2030s, we still have around 16 years to work out how we'll ensure continuity of naval shipbuilding.

If, however, we accept that our circumstances have changed and a larger fleet is needed, it would grow the fleet to 13 vessels by around 2030 and 14 by 2038 with the arrival of the fourth Hunter.[44] In contrast, the current plan does not reach 12 until 2053 and never gets beyond that number (refer to the schedules in figures 2 and 6). With a larger fleet of 15 surface combatants, the serene clockwork of the shipbuilding plan need not be disturbed: all nine Hunters would be built, and the first Hobart replaced as currently scheduled.

Unlike the current plan, this approach would provide a return on the expenditure on shipbuilding this decade. It would also demonstrate to an increasingly sceptical Australian public that the continuous Naval Shipbuilding Plan that they're paying for is about building ADF capability, not merely jobs in Adelaide.

Implementation

After the troubled early stages of the AWD build, the subsequent reform program established a very successful management and implementation model. The key was bringing in Navantia, the original designer, to manage construction. ASC remained as the builder but essentially worked under Navantia's instruction. Raytheon remained as the combat systems integrator.[45] The reformed management arrangements delivered all three ships to the revised schedule, and most of the budget increase won't be required. The key to the successful delivery of a Hobart Block II would be to retain the management structure adopted under the reform program.

The only viable shipyard in Australia for the project is the surface shipyard at Osborne South in Adelaide. It's important to remember that the Australian Government paid for the $535 million upgrade to the facility and retained ownership of it. The government-owned enterprise Australian Naval Infrastructure owns and manages the shipyard and is responsible for meeting the requirements of its tenants. The government implemented this arrangement precisely so that it could choose whichever designs and shipbuilders met its requirements. Defence has confirmed that, in accordance with the Naval Shipbuilding Plan, the Osborne Naval Shipyard was 'flexibly designed to accommodate the potentially varying needs of future shipbuilders'.[46] In short, the shipyard wasn't designed to build only Hunter-class frigates.

There may be some concerns that the original build strategy, which relied on the construction of blocks in various yards before finally assembly at Osborne, can't be replicated. It's true that the industrial landscape has changed—BAE's Melbourne shipyard, which built blocks for the original project, no longer exists—but such fears are probably exaggerated, for two reasons. The first is that the redesigned and now functioning Osborne shipyard has the capacity to build blocks itself. The second is that, despite concerns about the valley of death, the Australian naval shipbuilding ecosystem has developed significant capacity. Forgacs, which built blocks for the AWD project at Tomago, near Newcastle, was acquired by the highly capable engineering company Civmec as it built its shipbuilding credentials to compete for the OPV project. Civmec has demonstrated those credentials in the build of the OPV. It's entirely possible that Civmec could build blocks for a second tranche of Hobarts. In fact, the concept of a South Australian and a Western Australian shipyard feeding into the one production line is the model envisaged in the RAND Corporation's 2015 report on the future of Australian naval shipbuilding.[47]

Implementation challenges

There are of course implementation challenges that would need to be resolved. We'll look at three key ones.

Radar selection and integration

The first is that some systems used on the Block I Hobart are no longer available in the same configuration. A key one is the radar. Under Defence's current investment plan, the Hobart class is to undergo an upgrade to its combat management system, moving to the latest version of Aegis, which is Baseline 9. It's also going to have its tactical interface (the system that runs all the other parts of the combat system and integrates them with Aegis) replaced. Currently, it uses the Australian Tactical Interface (ATI) produced by Kongsberg. As part the Navy's programmatic approach to combat management systems, which mandates Saab's combat management system for all classes in the surface fleet, the ATI will be replaced by Saab's Australian Interface (AI). This will ensure commonality with the Hunter, which will also use Aegis in combination with Saab's interface.

So, the choice of combat management system is straightforward (noting that the combination of Aegis and Saab's AI isn't yet in service), but the choice of radar is not. The AN/SPY-1D radar used on the Block I Hobart is no longer the current version being installed by the US Navy, which has moved to the AN/SPY-6 radar for its Flight III Arleigh Burke-class destroyers. The Australian Government has mandated that the Hunter use CEA Technologies' CEAFAR radar. Consequently, a Hobart Block II would need to use either the AN/SPY-6 or the CEAFAR.

Both approaches would have issues. Defence apparently has no plans to replace the AN/SPY-1D radar on the Hobart class with either the AN/SPY-6 or the CEAFAR radar. Therefore, if the Hobart Block II installed the AN/SPY-6, the Navy would have three different configurations on its major surface combatants, which is not desirable. Installing the CEAFAR radar on the Hobart Block II would provide commonality with the Hunter class but would require design work. Fortunately, some of that has been done already for the competitive evaluation process for the future frigate. Integration work already done for the Hunter could also be leveraged.

Making an informed decision on this issue will require robust technical analysis, including a frank assessment of schedule risk arising from any integration risks, but an initial review of the public information suggests that the integration of CEAFAR is achievable and, overall, the better path to take.

Shipyard capacity at Osborne

The only viable shipyard in Australia for the Hobart Block II is the redesigned surface shipyard at Osborne in Adelaide. Construction of the Hobart Block II and the early Hunters would overlap at some point. However, Defence officials have stated that the new shipyard was designed with the capacity to produce vessels significantly faster than the currently planned two-year drumbeat for the Hunter program. Moreover, the whole idea of the national shipbuilding enterprise was to be able to construct different designs in the same facilities, and that's what drove the

huge investment in the modern, digitally enabled shipyards. Also, if there are capacity issues at Osborne, there are other ways to address them, for example by drawing on Civmec's developing shipbuilding expertise and having it build blocks in Western Australia.

Funding

The cost of a Hobart Block II vessel will no doubt be substantially less than that of a Hunter, if for no other reason than that the Hobart is substantially smaller. The fact that Australia has already built three would be likely to have cost benefits, even though the original program has been completed and the management and workforce dispersed. While Defence doesn't publish the unit sail-away cost of its vessels, it's likely that the cost of the final AWD was under $2 billion in current dollars.[48] If we take the $45 billion out-turned budget for the Hunter program, remove program-level costs (design, project management, intellectual property and so on) and convert it to current dollars, it's hard to see its unit cost being much less than $3 billion and certainly more than $2.5 billion in current dollars.

Nevertheless, as a new entry into Defence's investment program, a Block II Hobart build would require a funding line. The issue isn't just about the total funding required, but about managing annual cash flow. To date, the Hunter program has failed to spend as planned. With the program delayed by a further two years, that will inevitably continue, and some funding currently programmed for the Hunter will become available, at least in the short term. But, at some point, when both the Hunter and a Block II Hobart program are in construction, the cash-flow requirement will be substantially greater than Defence currently plans for the major surface combatant stream.

But the problem facing Defence is not a shortage of cash, but a massive surplus. First, the rapid ramp-up of Defence's acquisition funding line set out in the 2020 DSU, combined with the impact of Covid-19 on global supply chains and defence industry's ability to operate, has meant that Defence has underspent its acquisition budget. In 2020–21, the shortfall was around $1 billion.[49] With another large increase in acquisition funding planned for 2021–22 and the effects of the pandemic still not resolved, it's likely that there will be another shortfall.

The second source of funding is the huge amount of cash freed up by the cancellation of the Attack-class program, as discussed above. Defence planned to spend around $1 billion in 2021–22, and it's likely that would grow to around $2 billion per year in the second half of the decade. The total over the decade could have been more than $12 billion. Certainly, the ramp-up of the SSN program will require funding, but that's still years away and there's simply no way it can absorb all that cash flow. Investing part of it in a Block II Hobart build ensures that funding will deliver military and industrial capability.

Developing the shipbuilding ecosystem

We discussed earlier the need to rebuild the shipbuilding ecosystem. Spending those funds on a Block II Hobart build also means that we'll start developing the ecosystem needed to support the SSN program. While it may appear that a Block II Hobart program in Adelaide will compete with the Hunter for resources, in particular workforce, it's more useful to regard it as the only way to grow the workforce, skills and supply chains so that the shipbuilding enterprise is ready for the challenge of the SSN program.

Virtually all observers have noted that the biggest risk to the Naval Shipbuilding Program is the availability of workforce, particularly in Adelaide. Defence's own workforce analysis predicted that the direct workforce in Adelaide would grow to around 5,000 by the end of the decade, or over 80% of the total nationally (Table 3).

Table 3: Percentage of total direct shipbuilding workforce in Adelaide before cancellation of the Attack class

	2020	2021	2022	2023	2025	2030
South Australia	1,890	2,850	3,250	3,230	4,040	5,015
Total domestic shipbuilding	3,205	4,540	5,005	4,810	5,370	6,125
South Australia as percentage	59.0%	62.8%	64.9%	67.2%	75.2%	81.9%

Source: Linda Reynolds, 'Correspondence regarding naval shipbuilding workforce figures,' 22 October 2020, online.

With the fundamental revision of the future submarine plan, the nature of the workforce challenge has changed—the requirement will ramp up more slowly, but the workforce will likely need to be bigger. And even more of that will need to be generated in Adelaide. We need to start growing that workforce now, and the growth needs to be in addition to projects that were already in the shipbuilding plan and the Force Structure Plan.

Certainly, there are differences between building surface ships and submarines, but it's easier to retrain an experienced maritime tradesperson to transition from one from the other than it is to train them from scratch. And the complex project management skills that will be needed in the SSN program take years, even decades, to develop. We need to retain what we've generated already and build on that though a second Hobart build. We can make similar argument about the small- to medium-sized enterprises that will form the supply chain for an SSN program.

Hedging against a range of futures

We can't know the future. That's why we adopt hedging strategies. The best ones hedge against a range of possible futures. A Hobart Block II does that. As I've discussed, one future is the currently planned transition from Anzac to Hunter. But there are in fact many possible future force structures. Another one involves growing the surface combatant fleet beyond 11 or 12 vessels.

Another potential force structure element that hedges against risk involves enhancing the OPV so that it can contribute to combat missions. That could include installing anti-ship missiles or towed-array sonars. The OPV could also contribute to ASW by being the mothership for uncrewed aerial vehicles that can drop sonar buoys or deliver ASW weapons such as the very lightweight torpedo currently under development. Once we free ourselves from the mental shackles of the idea that every maritime platform has to be able to do every task and defeat every threat by itself, vast possibilities are opened up.[50] An armed version of the OPV that doesn't pretend to be a multi-role platform but has useful offensive or sensor capabilities looks attractive as a near-term addition to the Navy's lethality that complicates any adversary's decisions.

Some OPVs could be equipped with a limited air defence capability. That could include Mk-29 or Mk-41 launchers for small numbers of ESSMs, or the RIM-116 Rolling Airframe Missile (SeaRAM), but those have relatively short ranges. They could be supplemented by new active self-protection technologies as they become available, such as versions of systems made by Australian companies Droneshield and EOS. Nevertheless, the vessel itself is likely not to have the space, weight and power margins for a large air defence radar array or deep missile magazines. That means that, in higher threat environments, it would need to operate under the air defence umbrella of a major surface combatant such as a Hobart-class destroyer.

Acquisition of a Hobart Block II would also de-risk the transition to what may well be our eventual future, which is a disaggregated mix of crewed and largely uncrewed naval platforms enabled by maturing autonomous systems. While 'the small, the smart and the cheap' have much to offer in terms of disaggregating expensive capabilities and providing greater mass and 'attritability', they'll be likely to operate in teams with crewed vessels for at least their first several generations. Moreover, they'll also require air defence from a platform such as the Hobart, although they could also contribute to it by providing greater magazine depth in the form of uncrewed or minimally crewed arsenal ships, for example.

With no new submarines coming until the late 2030s at the earliest, surface action groups consisting of Hobarts and OPVs equipped with offensive weapons and serving as the motherships for swarms of uncrewed systems can provide some of the effects the ADF seeks from its future submarines, such as land strike, maritime strike and antisubmarine warfare. Certainly, those combinations of systems would perform those roles differently from submarines, but what choice do we have if we want more capability? Our obsessive search for the perfect submarine capability has resulted in us being further away than ever from having new submarines.

In sum, investment in a Hobart Block II is consistent with and de-risks a range of futures. They'll be part of a future in which the ADF continues to rely on large, crewed systems such as the Hunter, but they'll also be consistent with a future in which the ADF moves to a force structure based on crewed–uncrewed teaming. Even as it becomes more disaggregated, that latter force is going to be built around large, multi-role platforms for a considerable time to come.

Conclusion

Defence's decision-making processes have placed the Navy in an extremely precarious position and can only be described as a failure of strategic planning. The current approach makes strategic sense only if one can assume that Australia won't be involved in major conflict for the next 20 years and that, if we ever are, we can rely on the US for whatever assistance we need. Both of those propositions should not have been held as articles of faith when the shipbuilding plan was formulated in the second half of last decade; they're even more untenable today in the wake of the 2020 DSU.

Having embarked on a highly risky path with its submarine fleet, Defence didn't hedge strategic risk in the path it chose for the other half of its combat fleet. Unconstrained capability ambitions in both programs have resulted in unbounded cost, the need for time-consuming design work, and schedules extended far beyond what was envisaged when the programs were established. Despite the risks, Defence's main mitigation strategy is simply to extend the lives of current platforms and incrementally improve their capability at a time when threats, particularly to surface vessels, are rapidly growing. Even if the Hunter-class and the SSN programs deliver, the risks involved in the current plan mean that it can't continue without serious adjustments.

A Hobart Block II is potentially part of the solution. As a mature design that Australia has already successfully built and brought into service, it can provide real capability before the Hunter and SSN programs. But there's no one silver bullet. A broad range of mitigation measures are needed across the ADF's force structure to distribute capability and hedge risk.

Just as importantly, we must recognise that Defence's traditional decision-making processes brought us to this unacceptable position. A fundamental reconsideration of how Defence assesses its requirements and develops solutions for them is just as important as identifying remedies for the looming capability shortfalls that Defence has created for itself.

Notes

1 Scott Morrison, 'Australia to pursue nuclear-powered submarines through new trilateral enhanced security partnership,' media statement, 16 September 2021, online.

2 Marcus Hellyer, *From concentrated vulnerability to distributed lethality—or how to get more maritime bang for the buck with our offshore patrol vessels*, ASPI, Canberra, 2019, online.

3 Department of Defence (DoD), 'Sovereign Guided Weapons and Explosive Ordnance Enterprise', Australian Government, Canberra, 2021, online.

4 DoD, *Naval Shipbuilding Plan,* Australian Government, Canberra, 2017, online.

5 DoD, *2020 Defence Strategic Update*, Australian Government, Canberra, 2020, 27, online.

6 It became much more difficult once Defence did not recommend Navantia's candidate—the one vessel that already met most of the core requirements, including Aegis, US weapons, the Romeo helicopter and Australian design and regulatory standards.

7 Although it's been claimed that Navantia could have started construction by 2020 on blocks not affected by design changes. Without Defence releasing Navantia's response to the competitive evaluation process, it's not possible to confirm this.

8 BAE Systems, 'Hunter Class Frigate Program rolls out first steel unit', media release, 13 October 2021, online.

9 None of the three contenders used all of the systems mandated by the government (CEA radar, Aegis combat system, US weapons suite and Seahawk MH-60R helicopter); however, Navantia's offering based on the Hobart class had already successfully integrated them all, except the radar.

10 Cameron Stewart, 'Frigate hell: this could dwarf our submarine drama', *The Australian*, 31 August 2021, online.

11 Senate Economics References Committee (SERC), Inquiry into Australia's Sovereign Naval Shipbuilding Capability, public hearing, Australian Parliament, 6 August 2021, 21–22, online.

12 SERC, Inquiry into Australia's Sovereign Naval Shipbuilding Capability.

13 Note that these enhancements have come at significant cost and have taken a substantial part of the fleet out of the water for extended periods.

14 While 32 ESSMs may sound like a lot, in reality that number of missiles will run short quite quickly (assuming the vessel isn't sunk or damaged first). Effective missile defence needs to operate in depth. If we define three layers of defence as outer defence, area defence and self-defence, the ESSM is a self-defence weapon with some ability to provide limited area defence to a closely escorted high-value unit (such as an LHD). An Australian maritime taskforce doesn't have an outer defence layer because it doesn't have an organic fast jet capability. That means it has limited ability to complicate an adversary's targeting and overall attack plan, meaning that the adversary can optimise the size, direction and frequency of its salvos to best effect. An AWD can provide area air defence but will be forced to respond to salvos that have been optimised to overwhelm it.
A key factor in how many missiles are needed to defeat a threat is the number of opportunities the defender has to engage. An AWD will have multiple opportunities to shoot, assess the effect and then if necessary shoot again, potentially moving from SM-6 to SM-2 to ESSM. An Anzac, particularly if operating by itself, will have only the final layer. That means it may have only one opportunity to shoot, particularly against very fast threats. Consequently, it may need to fire many weapons to ensure a high probability of kill. That means its missile holdings could fall below a safe level even after a small number of engagements, each involving only a small number of threat missiles. Put another way, a small number of 'nuisance raids' involving relatively unsophisticated weapons could result in a mission kill, as the frigate would need to return to southern Australia to reload.
For a classic overview of this issue, see Ronald S Farris, Richard J Hunt, 'Battle group air defence analysis', *Johns Hopkins APL Technical Digest*, 1981, 2(4):302–307, online.

15 For example, Australian National Audit Office, *Air Warfare Destroyer Program*, Australian Government, Canberra, 2014, online. For a very accessible history of the program, see Robert Macklin, *Air warfare destroyer: the game-changer*, ASPI, Canberra, 2018, online.

16 In 2015, the government approved a $1.2 billion budget increase (a real cost increase, in Defence's terminology). According to the 2021–22 Defence Portfolio Budget Statements, the project is planned to close this year. With $8,147 million of its $9,094 million budget spent at 30 June 2021 and $238 million in further expenditure planned for 2021–22, the project should close with around $700 million remaining.

17 DoD, 'Navy's most advanced warships ready for operations', news release, Australian Government, 13 August 2021, online.

18 Scott Morrison, 'Australia to pursue nuclear-powered submarines through new trilateral enhanced security partnership,' media statement, 16 September 2021, online. I discuss the ineffectiveness of small numbers of Tomahawk missiles in Marcus Hellyer, 'Does the Royal Australian Navy need Tomahawk missiles?', *The Strategist,* 16 February 2021, online.

19 Foreign Affairs, Defence and Trade Committee, Defence portfolio, 2020–21 additional budget estimates, question on notice no. 36: 'The Hunter class frigate in-service weight growth margin target for Batch One is 270 tonnes.'

20 The US Navy is not assuming that the similarly equipped Constellation-class frigate will be able to meet all conceivable future requirements; a CRS report on Constellation says that the navy has a margin of 5% but it wants more to accommodate potential future directed-energy weapons or electronic attack systems. Ronald O'Rourke, *Navy Constellation (FFG-62) class frigate program: background and issues for Congress,* Congressional Research Service, 29 September 2021, 19–20, online.

21 As I discuss below, there's nothing carved in stone that requires a two-year construction drumbeat and the additional cost that imposes.

22 Or, as with the future submarine, Defence didn't share with the Australian public its real estimate of the cost, preferring to keep an unrealistically low figure in the public domain.

23 Cameron Stewart, 'Frigate hell: this could dwarf our submarine drama', *The Australian*, 31 August 2021, online; David Feeney, *SEA 5000 Future Frigate Program: continuous shipbuilding under the spotlight*, Strategic & Defence Studies Centre, Canberra, 2021, online.

24 Office of the Parliamentary Budget Officer, *The cost of Canada's surface combatants: 2021 update and options analysis*, Ottawa, 24 February 2021, online; David Larter, 'Canada's new frigate is getting heavier and more expensive,' *DefenseNews*, 27 February 2021, online; Timothy Choi, *What can we expect from the new Canadian surface combatant?*, CDA Institute, 26 May 2021, online; Murray Brewster, 'It will be at least a decade before Canada sees any of its new frigates', *CBC News*, 13 February 2021, online.

25 According to the UK's National Audit Office, the Type 26 program increased in forecast cost by 26% between early business cases and formal approval. The increase would have been greater if the number of vessels hadn't been reduced from 13 to 10. National Audit Office, *Improving the performance of major equipment contracts: Ministry of Defence*, UK Government, 24 June 2021, 25–26, online.

26 'Real hope for a bigger Royal Navy—the Type 32 frigate concept', *Navy Lookout*, 29 November 2020, online; 'Royal Navy frigate programme update', *Navy Lookout*, 20 July 2021, online.

27 Tom Sharpe, 'Under-gunned Royal Navy warships?', *Navy Lookout*, 22 May 2021, online.

28 The Congressional Budget Office (CBO) concluded that the US Navy's estimate would make the FFG-62 the navy's cheapest surface combatant per ton in decades, despite being more complex and capable than many other vessels, such as the inadequately armed Littoral Combat Ship. Not only was the US Navy's estimate significantly lower than for other surface combatants, it was less than a Coast Guard ship that didn't have anywhere near the same equipment or build standards. The CBO developed an independent estimate that's 40% higher than the navy's at $12.3 billion for the first 10 ships. Congressional Budget Office, *The cost of the Navy's new frigate*, October 2020, online.

29 In addition to integrating different sensors and weapons from the original design, the US Navy has marginally increased the length and beam on waterline of the ship. Cumulatively, the changes have resulted in a 10.6% increase in lightship weight and 7.5% increase in full load displacement. See US Navy briefing slide reproduced in O'Rourke, *Navy Constellation (FFG-62) class frigate program*, 7, online.

30 Senate Standing Committee on Economics (SSCE), Inquiry into Australia's Sovereign Naval Shipbuilding Committee, public hearing on 15 October 2021, Australian Parliament, online.

31 Murray Brewster, 'Canada's submarine fleet spent "zero days" at sea last year: government documents,' *CBC News*, 11 February 2020, online.

32 SSCE, Inquiry into Australia's Sovereign Naval Shipbuilding Committee, public hearing on 15 October 2021, Australian Parliament, online.

33 I discuss the submarine transition schedule based on what we currently know in Marcus Hellyer, 'No room for delay in Australia's transition to nuclear-powered submarines', *The Strategist*, 27 September 2021, online.

34 The government, Defence and commentators frequently refer to an influential 2015 RAND Corporation report commissioned by Defence. RAND found that Australia paid a 30%–40% premium for local shipbuilding (a conclusion disputed by some observers) but argued that continuous naval shipbuilding could halve that premium. However, the way we've gone about it bears little resemblance to the approach RAND recommended. Indeed, we've gone about it in a way that drives efficiency out of the enterprise and drives up costs.
Moreover, RAND's preferred approach to continuous shipbuilding wasn't to establish two separate shipyards building separate classes of ships to a slow drumbeat, as we have done. Rather, it advocated two shipyards feeding into one production line that would build classes of ships to an efficient schedule and move to new classes of vessels once one build was complete. That is, the enterprise would efficiently build frigates and then move to the multi-role littoral vessels envisaged in Defence's investment plan at the time.
The RAND report considered the option of building a fourth AWD to bridge the shipbuilding valley of death. It concluded that that would help to bridge the valley as well as mitigate schedule risk to the future frigate. However, it didn't recommend building a fourth AWD, but that was primarily because there was no stated requirement for a fourth AWD and, compared to other scenarios to preserve workforce through the valley of death (including paying workers to do nothing), building a fourth AWD did not provide savings. But, at that time, RAND was assuming a start of construction of the future frigate in 2020, the delivery of the first one in the second half of the 2020s (exactly when depended on various assumptions) and the delivery of the eighth frigate around 2036. In the light of the current schedule, we can argue that there definitely is a capability requirement for a fourth and even more AWDs. John Birkler, John F Schank, Mark V Arena et al., *Australia's Naval Shipbuilding Enterprise: preparing for the 21st century*, RAND Corporation, Santa Monica, 2015, online.

35 The UK has achieved a three-year drumbeat with the Astute class. That, however, does not seem to be driven by a conscious choice to maintain a continuous build cycle built around seven boats, but by the simple inability to build the submarines any faster.

36 While Defence frequently refers to the Naval Shipbuilding Program as the largest increase to naval capability since World War II, that description is not a good one. If the timelines for the current program were applied to one starting in 1939, it would not deliver anything until after the end of the Korean War, and some of its vessels would miss the Vietnam War.

37 SSCE, Inquiry into Australia's Sovereign Naval Shipbuilding Committee, public hearing on 15 October 2021, online.

38 For example, in the same correspondence, the former minister wrote that 'the Government and Defence remain confident when subcontract and supply chain workforce figures are included, the total number of jobs supporting the enterprise will deliver 15,000 Australian jobs.' Since the Attack class accounted for around one-third of the direct jobs, it's reasonable to assume that it would also have generated around one-third (or around 5,000) of the total jobs including indirect ones.

39 Melissa Price, 'Helping industry reap the benefits of the AUKUS deal', *Defence Connect*, 12 October 2021, online.

40 With the total expenditure likely to top $2.5 billion, the size of the loss will be two and a half times greater than in Defence's previous biggest failed project, the Super Seasprite helicopter, which expended nearly $1 billion before it was cancelled.

41 Although we should be cautious of the term 'valley of death', which is intensely politicised. Many of the workers involved in the AWD program were labour hires brought on for particular tasks. All shipbuilding programs adjust workforce, as demand is not constant at all times. This will necessarily be the case for the Hunter-class frigate with its two-year drumbeat. Having an enduring shipbuilding capability doesn't mean we need to have the same number of workers across every trade at all times. Many nations have effective ship design and construction capabilities without constant demand. The key is understanding which skills sets need to be maintained constantly and which can be expanded and contracted as necessary.

42 See, for example, James Mugg, 'How to do SEA 5000 with less risk and more capability', *The Strategist*, 14 September 2017, online.

43 The Hobarts were in fact delivered more quickly than a two-year drumbeat, as were the Anzacs and Collins.

44 These numbers are dependent on how long the Anzacs remain in service. If Defence keeps them beyond the average age of 36 in the current plan, the numbers would increase.

45 See Macklin, *Air warfare destroyer: the game-changer*, in particular chapters 11, 12 and 13, online.

46 Foreign Affairs, Defence and Trade Committee, Defence portfolio, 2017–18 supplementary budget estimates, Question on notice no. 88.

47 John Birkler, John F Schank, Mark V Arena et al., *Australia's Naval Shipbuilding Enterprise: preparing for the 21st century*, RAND Corporation, Santa Monica, 2015, online.

48 This of course is a different number from the total program cost of over $8 billion divided by three. That's because the program cost includes many other elements beyond the three ships themselves—design, intellectual property, the training system (which includes land-based facilities), infrastructure enhancements, spares, and so on. Also, the program demonstrated clear progress along the learning curve, so the sail-away cost of the third ship would have been significantly less than that of the first.

49 Marcus Hellyer, *The cost of Defence: ASPI defence budget brief 2021–22*, ASPI, Canberra, 2021, 23, online.

50 Stew Magnuson, 'Navy to field first torpedo in decades', *National Defense*, 23 December 2020, online; Jamie Sayer, 'UAVs vs subs', *Royal Aeronautical Society*, 6 August 2021, online.

Acronyms and abbreviations

ADF	Australian Defence Force
AI	Australian Interface
ASW	antisubmarine warfare
ATI	Australian Tactical Interface
AWD	air warfare destroyer
CEC	cooperative engagement capability
DSU	2020 Defence Strategic Update
ESSM	Evolved Sea Sparrow Missile
LHD	landing helicopter dock
LOTE	life-of-type extension
OPV	offshore patrol vessel
RAN	Royal Australian Navy
SSN	nuclear-powered attack submarine
UK	United Kingdom
VLS	vertical launching system

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