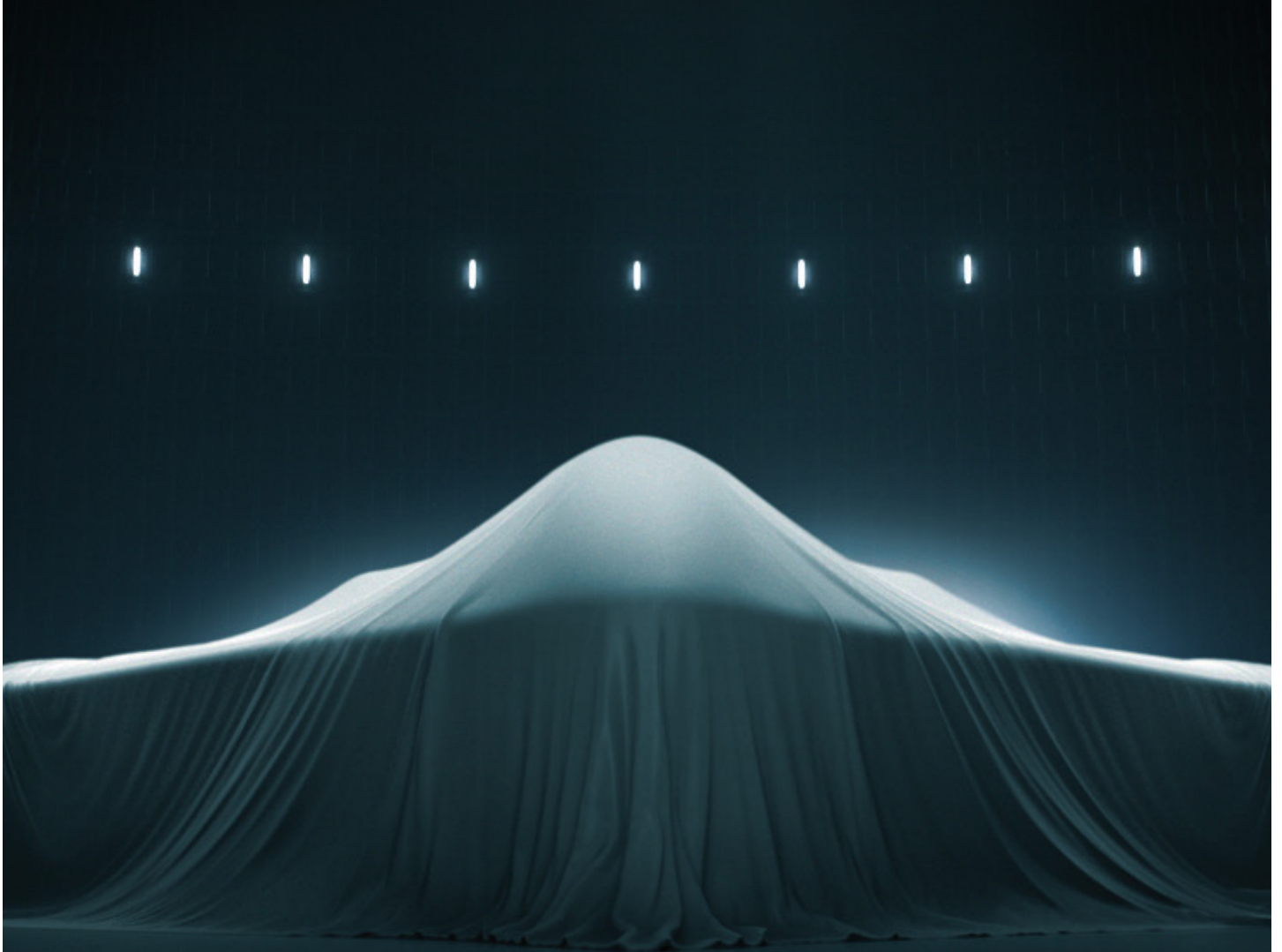


STRATEGY

A S P I

‘Impactful projection’

Long-range strike options for Australia



Marcus Hellyer
and Andrew Nicholls

A S P I

AUSTRALIAN
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December 2022



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Acknowledgements

The authors would like to thank the external reviewer and many colleagues at ASPI and in the Department of Defence who have provided constructive feedback on previous drafts that has helped to shape this report. They don't necessarily agree with everything in it, so all views expressed here are the authors' alone. The development of this report also benefitted from Marcus Hellyer spending a two-week residency at ASPI's Washington DC office and engaging with think tanks there.

No specific sponsorship
was received to fund
production of this report.

Cover image: Northrop Grumman, [online](#).

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First published December 2022

Published in Australia by the Australian Strategic Policy Institute

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Executive summary

The Australian Government has stated that the ADF requires greater long-range strike capability. This was first stated by the previous government in its 2020 Defence Strategic Update (DSU), which emphasised the need for ‘self-reliant deterrent effects’. The present government has endorsed that assessment: Deputy Prime Minister and Defence Minister Richard Marles has stated that ‘the ADF must augment its self-reliance to deploy and deliver combat power through impactful materiel and enhanced strike capability—including over longer distances.’ He’s coined the term ‘impactful projection’ to describe the intended effect of this capability, which is to place ‘a very large question mark in the adversary’s mind.’

The term may be new, but the concept is not. To us, it’s a restating of the concept of deterrence by denial; that is, having sufficiently robust capabilities to convince an adversary that the cost of acting militarily against us isn’t worth any gains that might be made.

But the need for the ADF to have those kinds of capabilities has become much more urgent. As the 2020 DSU noted, we no longer have 10 years of warning time of conventional conflict involving Australia. Moreover, this is not just the prospect of conflict far from Australia’s shores. People’s Liberation Army (PLA) force-projection capabilities have grown dramatically in the past two decades and include long-range conventional ballistic missiles, bombers and advanced surface combatants that have already transited through Australian waters.

The ‘worst case’ scenario for Australia’s military strategy has always been the prospect of an adversary establishing a presence in our near region from which it can target Australia or isolate us from our partners and allies. PLA strike capabilities in the archipelago to our north or the Southwest Pacific, whether on ships and submarines or land-based missiles and aircraft, would be that worst case. That could occur as China sought to ‘horizontally escalate’ a conflict with the US to stretch its military resources. So, an enhanced ADF long-range strike capability is not primarily about a conflict off Taiwan or in the South China Sea.

Unfortunately, the ADF’s strike cupboard is rather bare. Defence is acquiring more modern maritime strike and land-attack missiles for its existing platforms. But, even if equipped with better weapons, strike systems built around fighter planes or surface combatants are unlikely to have the ‘affordable mass’ or range needed to deter or defeat a major power’s attempts to project force against Australia.

There’s no doubt that the Defence Strategic Review (DSR) commissioned by the Albanese government is considering new strike options. According to the review’s terms of reference, those capabilities need to be delivered by 2032–33. In this report, we consider options to increase the ADF’s strike power in that time frame.

We start with the US Air Force’s B-21 Raider bomber, which was recently rolled out in California. The B-21 has become a topical issue here but so far there’s been little reliable information to inform the public discussion. This report is a first step in investigating the public data that is currently available on the B-21, while also analysing the B-21’s suitability for Australia’s needs.

As an extremely stealthy bomber that can deliver large amounts of ordnance across our near region, the B-21 is the ‘gold standard’ in strike capability. It could potentially be delivered by 2032–33. But that capability comes at great

cost. We estimate the total acquisition cost for a squadron of 12 aircraft to be in the order of \$25–28 billion and have a sustainment cost that would put it among the ADF's most expensive current capabilities (but be significantly less than nuclear-powered submarines).

But that cost is potentially offset by a number of factors. A single B-21 can deliver the same effect as many F-35As. Moreover, B-21s would not require the 'overhead' of supporting capabilities such as air-to-air refuellers when operating in our region. Moreover, the B-21 can prosecute targets from secure air bases in Australia's south, where it has access to workforce, fuel and munitions.

Of course, there are other options for long-range strike. These have their own constellations of cost, capability and risk. Long-range missiles, including hypersonics, have also received much recent attention. But they may be deceptively expensive; the further we want a missile to fly, the more expensive it is, and none of its exquisite components are reusable. Moreover, history suggests that very large numbers of missiles will be needed to defeat an adversary—more than we're ever likely to be able to afford or stockpile.

Any assessment of capability options needs to be informed by robust cost-benefit analysis. The B-21 certainly has a high sticker price, but if, by virtue of its stealth, it can employ cheaper, short-range weapons, then in the long run it may be more affordable and deliver greater effects than long-range missiles alone. It was analysis of this kind that persuaded the USAF to go down the path of a new bomber. Of course, such exercises are assumption-rich activities, and all assumptions need to be rigorously tested; what's valid for the US might not be for Australia.

Then there are several options that fall under the heading of the 'Goldilocks' bomber: a strike system that doesn't have the eye-watering cost of the B-21 but still delivers a meaningful capability enhancement. One option is provided by 'palletised munitions' dropped from military cargo aircraft. There are two attributes of this approach that have appeal in Australia's circumstances. The first is that many of the components, such as the missiles and aircraft, are already in ADF inventory or are being acquired. The second is that airlifters can operate from the short and unprepared airfields found in our region. More strike aircraft operating from more locations enhances the survivability of our strike system and complicates the adversary's operating picture.

Another Goldilocks approach is potentially provided by autonomous, uncrewed systems. They will still need to be large to provide the range needed for impactful projection. However, it's possible to discern what the solution could look like; for example, a larger version of the Ghost Bat that can deliver ordnance across our near region. At some point, the future of strike will involve larger crewed and uncrewed systems supported by large numbers of 'the small, the smart and the many'—cheap, disposable systems that Australian industry can responsively produce in mass. The key question is: can that be done within the DSR's 2032–33 target time frame?

There is potentially a way for Australia to have its cake and eat it too: by hosting USAF B-21s. Under the Enhanced Air Cooperation stream of the US Force Posture Initiative, USAF B-1, B-2 and B-52 aircraft visit northern Australia. In future, having our major ally rotate B-21s through northern Australia could obviate the requirement for Australia to have this kind of long-range strike capability in its own order of battle. Ultimately, the issue comes down to how much independent, sovereign strike capability the Australian Government requires. And any sovereign Australian capability adds to the overall alliance pool, which is the core concept underpinning AUKUS.

This report also examines some of the main arguments against the B-21. While all of them need to be considered seriously, we would also note that the world has changed. The September 2021 AUKUS announcement under which Australia will acquire a nuclear-powered submarine capability demonstrates that. Things that were previously inconceivable are now happening, so we shouldn't dismiss the B-21 out of hand. Our recommendation is that the Australian Government should engage with the US Government to gain access to the information on the B-21 program so they can make an informed decision on its viability for Australia.

This analysis will form part of wider ASPI program of work looking at the strategic and capability questions that Australia is grappling with, including deterrence and long-range strike.

Chapter 1: The strike problem

The Australian Government has reinforced the assessment first made in the previous government's 2020 Defence Strategic Review (DSR) that the ADF needs more long-range strike power to deter or impose great cost on a major power operating against Australia. Deputy Prime Minister and Minister for Defence Richard Marles has spoken about the need for 'impactful projection' to shape an adversary's operations against us. It's clear he understands that to mean strike. There's no doubt that the Defence Strategic Review commissioned by the Albanese government is examining strike options.

But any new capability will require either new funding or for existing parts of the Department of Defence's acquisition plan to be shrunk or cancelled so the resources can be redirected, so any strike capability will require a compelling business case.

This report starts by examining Australia's strike requirements, focusing on our near region. We then examine options to address those requirements, beginning with an assessment of the viability of the B-21 Raider stealth bomber. The B-21 has become a topical issue, and not just because the first aircraft was recently publicly unveiled. Before then, Marles stated that the B-21 bomber is being considered by the DSR.¹ The opposition has pushed for its acquisition.² A senior representative of the US Government has said that it would consider providing them if Australia asked.³ The concept already has supporters and detractors.⁴

It's quite a remarkable situation, considering that the aircraft hasn't flown yet and only a year ago had barely been raised as a possibility for Australia. But, as the September 2021 AUKUS announcement shows, the Indo-Pacific security situation has changed dramatically and things that were inconceivable, such as an Australian nuclear-powered submarine (SSN) capability, are now being actively pursued.

We also start with the B-21 because in some ways it's the 'gold standard' for strike. We'll look at the capability that the aircraft provides (Chapter 2) and the cost and schedule involved in delivering it (Chapter 3). Overall, the B-21 offers a very high level of capability. Not surprisingly, that comes at significant cost—around \$25–28 billion for its acquisition alone. There are other arguments against the B-21 which we consider (Chapter 4).

Of course, there are other options for long-range strike. These have their own constellations of cost, capability and risk. Long-range missiles, including hypersonics, have also received much recent attention. But they may be deceptively expensive; the further we want a missile to fly, the more expensive it is, and none of its exquisite components are reusable. So any assessment of capability options needs to be informed by robust cost-benefit analysis. Depending on your assumptions, the B-21 may be more affordable than a strike system built solely around long-range missiles (Chapter 5).

Finally, we review (Chapter 6) several options that fall under the heading of the 'Goldilocks' bomber: a strike system that doesn't have the eye-watering cost of the B-21 but still delivers a meaningful capability enhancement. These include 'palletised munitions' dropped from military cargo aircraft, which could have advantages for Australia's particular circumstances. And no review of alternatives would be complete without an examination of the potential offered by autonomous, uncrewed systems. At some point, the future of strike will involve larger crewed and

uncrewed systems supported by large numbers of ‘the small, the smart and the many’—cheap, disposable systems that Australian industry can responsively produce in mass. The key question is: can that be done within the DSR’s 2032–33 target time frame?

What does the government want from a strike capability?

The Australian Government wants the ADF to have greater long-range strike capability. The current government has endorsed the assessments in its predecessor’s 2020 Defence Strategic Update (DSU), which stated:

Given Australia’s limited resource base, we must improve our ability to deliver these effects without seeking to match the capability of major powers. This includes developing capabilities to hold adversary forces and infrastructure at risk further from Australia, such as longer-range strike weapons, cyber capabilities and area denial systems.⁵

Richard Marles has recently used the term ‘impactful projection’. He first defined the term on 8 November this way:

I think increasingly we’re going to need to think about our defence force in terms of being able to provide the country with impactful projection, impactful projection, meaning an ability to hold an adversary at risk, much further from our shores, across kind of the full spectrum of proportionate response. Now, that is actually a different mindset to what we’ve probably had before ...⁶

His later remarks on 14 November expanded on this, stating: ‘The ADF must augment its self-reliance to deploy and deliver combat power through impactful materiel and enhanced strike capability—including over longer distances.’⁷

The timing of Marles’s remarks is, of course, not random. In his second address, Marles told us: ‘Earlier this month, I received the interim advice on the Defence Strategic Review from Professor Stephen Smith and Sir Angus Houston.’ That comes on the back of Prime Minister Anthony Albanese revealing that the National Security Committee of Cabinet has had frequent updates from the review’s leads.⁸ So we can safely assume that Marles is giving us a foretaste of what they’ll deliver.

Moreover, there’s broad political bipartisanship on the kinds of capabilities the ADF needs. One of those capabilities is nuclear-propelled submarines—a capability to be acquired under the AUKUS partnership announced by the previous government. Marles noted that ‘a long-range-capable submarine does impactful projection more than any other platform that we have within our defence force right now.’⁹ But with an SSN force unlikely to be established until well into the 2040s, we’re looking at 20-year strike gap, even if we assume that a fleet of ‘up to eight’ SSNs will eventually meet our strike requirements.¹⁰

Before we can answer the question about what system or system of systems will meet Australia’s strike requirements, we need to have some idea of what those requirements are. That’s a surprisingly hard issue to address. Australian governments have traditionally issued defence policy documents such as white papers that outline strategy at the broadest level. Those are supported by investment plans that set out a shopping list of capabilities with some high-level information about budgets and schedules. However, while there may be classified military planning occurring within the Department of Defence, any discussion of how the force will be used, where it will be used, or the kinds of contingencies and operations that the government envisages it will be engaged in (and, conversely, ones that the government thinks are unlikely or can be ‘risk managed’) is largely absent from public documents.¹¹ That leaves interested observers to reverse-engineer operating concepts from the force set out in the investment plan. Public versions of operating concepts generally tend to be very conceptual and situated in an abstract space, again revealing little about where and how the force would be used. This generally leads to a lot of unconstructive debate about particular capabilities, as the debaters come with very different assumptions about what the force is meant to achieve and often argue past each other.

Impactful projection: deterrence by denial

Debates about military capability generally start by defining the effects that the capability is meant to deliver. Effects lie on a spectrum from the very technical (such as, 'penetrate x mm of armour at y metres') to the very high level (such as, 'complicate the adversary's planning'), but, when we don't have a good understanding of what operations the government wants the ADF to conduct, it's hard to talk precisely about effects.

Governments necessarily operate at the high level, and we can see this in Marles's comments about impactful projection and SSNs:

The point [a submarine commander] made to me was that submarines, by virtue of their stealth and the unique capabilities, unlike any other platform we have, can place the single biggest question mark in our adversary's mind. That's in a sense what we're buying with the capability. We are buying a large question mark in our adversary's mind. More than anything else that we have. And if our strategic setting going forward needs to be more like a porcupine, then in fact question marks in our adversary's mind are going to be really, really important and the size of them is going to matter.

Marles continued:

That's what submarines do, and I think being able to explain that to the Australian public so that people can understand why we are spending an enormous amount of money, on a comparatively small number of platforms. If it stops being about the platform, but it starts being about the question mark and the pause for thought we give in respect of any adversary, suddenly, every cent associated with this is worth it and I think being able to give that message to Australian people is profoundly important.¹²

If we apply the terminology of deterrence theory to Marles's comments—and indeed to the earlier DSU assessment—he appears to be talking about deterrence by denial. He's not talking about deterrence by punishment; that is, striking the adversary's homeland. Rather deterrence by denial creates uncertainty in the mind of an adversary about the cost they would have to absorb to successfully act against us, to the point that they would have to consider that the cost was too great to bear in return for any gains to be won.¹³

In our view, this is the correct approach to deterrence for Australia. Deterrence by denial is more direct—if you seek to attack my territory, I'll put more troops and weapons there. Deterrence by punishment involves a more indirect response so it can be harder to understand how you are or aren't shaping an adversary's calculus. For this reason, deterrence theorist Michael J. Mazarr notes, 'most classic studies suggest that denial strategies are inherently more reliable than punishment strategies' (although other theorists may disagree).¹⁴ A potential adversary can see that I am taking direct steps to bolster the defence of my territory. But they may not be convinced that I am going to launch a nuclear strike on their homeland if it could prompt a retaliatory nuclear strike on mine.¹⁵

The next question is: where does the government want to impactfully project to? How far out does it want to place that deterrence question mark? The porcupine metaphor is telling. Ever since federation, Australian thinking about the role of the defence force has sat along a spectrum. At one end are those who believe that the ADF's primary purpose is to defend Australia—that is, the continent of Australia. At the other end are those who think the best way to defend Australia is to work with our great and powerful allies to defeat significant threats wherever they may arise in the world. Porcupines might suggest the former philosophy, while impactful projection might imply the latter. Generally, in practice Australia has taken a hybrid approach: we prioritise the defence of Australia as a force design principle, but deploy further afield when the government assesses that it's in our interests to do so. So strike capabilities acquired for the former could still do the latter.

Regardless of the view of policy elites, the Australian people believe the primary role of the defence force is to defend Australia. That means that any argument for increased defence funding—and the Prime Minister has said that the government will spend whatever it takes to keep Australia secure—will likely need to be couched in terms that the Australian public finds compelling. Ultimately, that comes down to an ADF designed to defend Australia.

Tellingly, Marles didn't refer to Taiwan or the South China Sea in either of the forums in which he talked about impactful projection.

So that explains the porcupine, but how is that consistent with impactful projection? It's probably an expression of a fundamental recognition of the changing nature of military technology and the threat that presents. Fighter planes with a combat radius of 1,000 kilometres might have been able to defend the 'air-sea gap' against conceivable threats in the era of Paul Dibb's defence-of-Australia doctrine in the 1980s and 1990s. But now that a potential adversary has capabilities that can kinetically strike Australia from more than 3,000 kilometres away, the ADF's capabilities are outmatched. We certainly won't be imposing cost on an adversary, but simply paying it if we don't increase the range of our own strike capabilities. This isn't primarily about the South China Sea or Taiwan. To expand on Marles's own metaphor, impactful projection seems to be a porcupine with very long quills.

Time is of the essence

The key difference between current considerations of ADF strike capability and previous discussions is that there's now a sense of urgency. That's for two reasons. The first is that there's now a threat that can operate in our near region and reach Australia with long-range strike systems (as we discuss below). The second is that there are some questions about the ability of our great and powerful ally, the US, to address all threats on our behalf. That's not because the Australian Government believes that the US lacks intent or commitment. It's simply because the US may lack the capacity to meet all possible military contingencies in the Indo-Pacific due to its global commitments and the challenge presented by autocracies in multiple theatres. That's created a new sense of urgency.

In a clear break with previous strategic planning parameters, the 2020 DSU stated:

Previous Defence planning has assumed a ten-year strategic warning time for a major conventional attack against Australia. This is no longer an appropriate basis for defence planning ... Australia can no longer rely on a timely warning ahead of conflict occurring. Reduced warning times mean defence plans can no longer assume Australia will have time to gradually adjust military capability and preparedness in response to emerging challenges.¹⁶

The current government shares that assessment. In contrast to previous strategic planning documents, which tended to have a 20–25-year time horizon, the DSR terms of reference emphasise the period to 2032–33, for example by stating that:

the Review must consider all elements of the Integrated Investment Program and provide recommendations for the Program's reprioritisation, particularly in light of recently announced large-scale projects, to provide Australia with the force structure required by 2032–33.¹⁷

The two factors driving our sense of strategic urgency are the same ones that drove AUKUS. Ultimately, what's behind AUKUS is the mutual acceptance that the US's partners must do more for their security within the framework of their alliances with the US. The nuclear-powered submarines may well place Marles's question mark in potential adversaries' minds—but they won't do it by 2032–33. As noted above, the schedule under which they'll be able to impactfully project and shape an adversary's calculus sits outside the DSR's window. So any consideration of strike options needs to foreground schedule, in particular whether they can deliver capability by 2032–33—and preferably sooner—and whether they can help bridge the gap to the establishment of an effective SSN capability.

Figure 1: Prime Minister Anthony Albanese and Deputy Prime Minister Richard Marles announcing the Defence Strategic Review, 3 August 2022



Source: Anthony Albanese via [Twitter](#).

What do we mean by ‘strike’?

Readers might reasonably ask what we mean by ‘strike’. It’s easy to get bogged down in theoretical debates about it. It’s one of those fields of defence and strategic studies in which commentators take delight in lecturing others on their doctrinal inconsistency and incorrectness. In fact, the authors of this study have somewhat different views from each other, so we aren’t going to try to develop a perfect definition when a utilitarian one will do.¹⁸

Let’s start with what the 2020 DSU states, namely that Australia needs to develop ‘capabilities to hold adversary forces and infrastructure at risk further from Australia, such as longer-range strike weapons, cyber capabilities and area denial systems’.¹⁹

That could be read as stating a need for strategic strike, which can be defined as follows:²⁰

- ‘Strategic’ refers to the highest level of an opponent’s system, capability or capacity to operate against Australian interests.
- ‘Strike’ entails offensive action, proactive and aggressively directed against an opponent’s strategic core.

That suggests targeting key systems and critical infrastructure in the adversary’s homeland, or deterrence by punishment. But the government’s strike porcupine seems to imply operational or theatre-level effects, for example against an adversary’s supply lines, logistics hubs, forward operating bases, air bases, deployed air defence networks and command and control systems in Australia’s nearer region and approaches. That is, degrading an adversary’s ability to conduct operations that directly threaten Australia, our friends and neighbours in the region

and our sea lanes. That's deterrence by denial. Moreover, there's a tactical or battlefield element to strike: targeting troop concentrations and warships on the front line with great precision. Maritime strike, after all, is about sinking or disabling ships.

But whether we call that tactical, operational or strategic is somewhat irrelevant. In some ways, the distinctions between the three are being effaced by the growing range, precision and lethality of modern strike weapons.²¹ Legacy anti-ship missiles have a range of around 100 kilometres. The Long Range Anti-Ship Missile (LRASM) is likely to have a range of close to 1,000 kilometres, but it's still performing the same function. In short, we shouldn't confuse longer range with 'more strategic'.

The DSU defines our near region as 'ranging from the north-eastern Indian Ocean, through maritime and mainland South East Asia to Papua New Guinea and the South West Pacific'; that's still extremely large.²² Ideally, we should seek a strike system—whatever that ultimately looks like—that's flexible enough to deliver sufficient kinetic effects across that geographical expanse to present a credible deterrent and response option to adversary forces operating against us and our partners.

Of course, like many ADF capabilities, a long-range strike capability could also be used in accordance with the second school of strategic thought outlined above; that is, outside Australia's near region to address threats further afield in coalition with our allies. Indeed, it could be the most useful and 'impactful' contribution Australia could make to such a coalition. But we'll focus on our strike requirements closer to home.

What does the ADF need to be able to strike?

It's vital that we get out of the habit of assessing People's Liberation Army (PLA) capabilities as they are today and start assessing where they'll be in 10 or 20 years' time. Repeatedly, the Western intelligence community has accurately reported on the capabilities the PLA didn't have, the techniques or operations it couldn't perform, and the locations it didn't have a presence in. Then, five or so years later, it has accurately reported that the PLA now had those capabilities, could employ them operationally and was regularly operating in those locations. In the meantime, we've done little to develop the capabilities needed to match what the PLA has achieved. In essence, we didn't use whatever warning time we had. Now we've realised we have none.

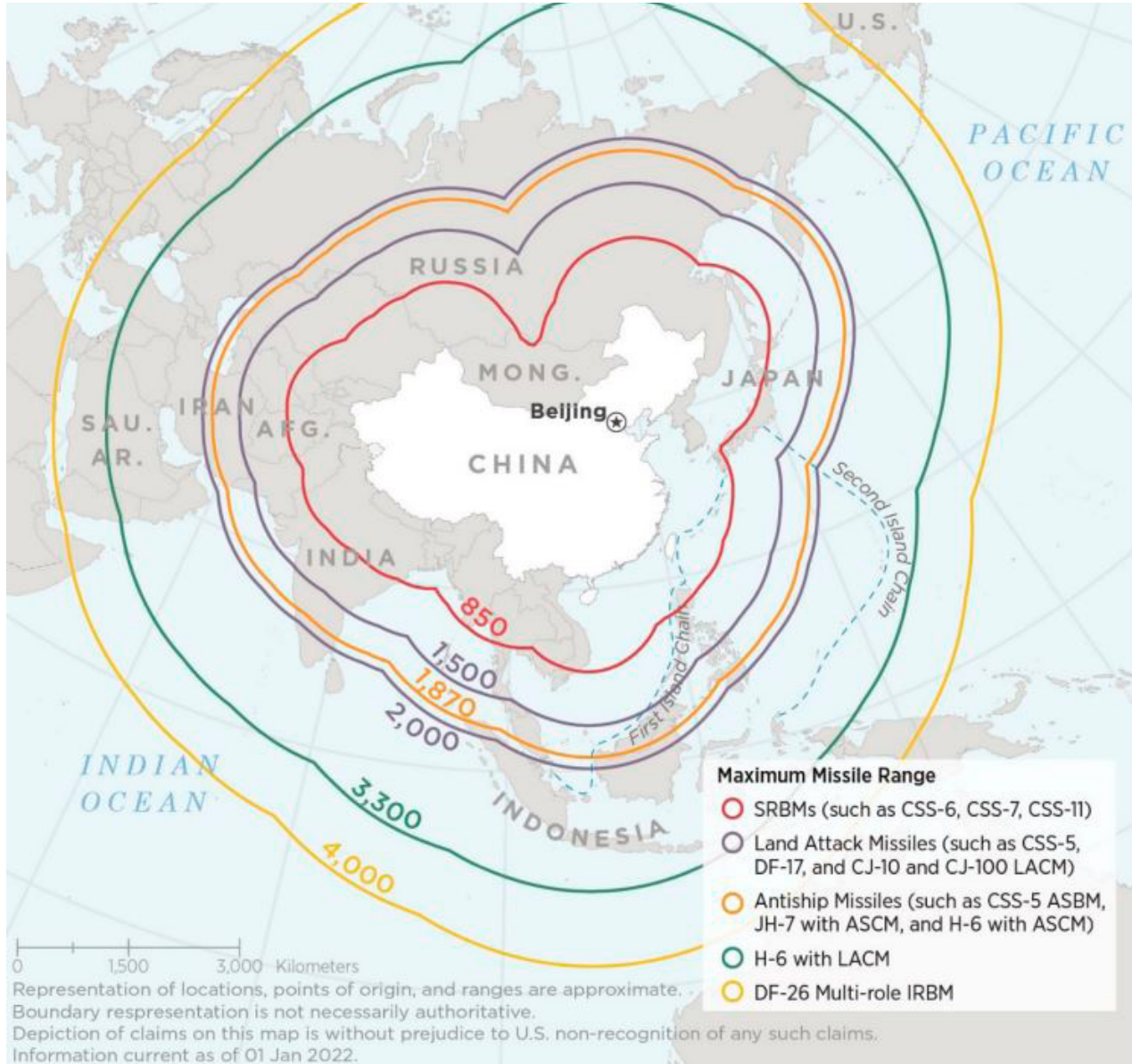
So we need to be looking forward and not focusing solely on what the PLA can do today. When the intelligence community assesses what the PLA can do today, it produces graphics like the one in Figure 2. They show that, operating from mainland China, the PLA's longest range conventional strike weapons, such as the H-6 bomber armed with land-attack cruise missiles, can cover most of the Indonesian archipelago and that the DF-26 intermediate-range ballistic missile can just reach northern Australia.

Should those systems be deployed to the bases and airfields that the PLA has established on reclaimed features in the South China Sea, that would place them around 1,000 kilometres closer to us, bringing them within range of northern Australia.

The closer to Australia the PLA can establish forward operating bases, the greater the number of PLA strike systems can reach Australia's population centres, critical infrastructure and military assets. A forward operating base in the archipelago to our north or in the Southwest Pacific would allow the PLA to target Sydney, Canberra and Melbourne. That would expose Australia to the prospect of coercion, interdiction of trade and isolation from the US, even before we consider the prospect of civilian casualties.

This is a key point, and it is one of the many reasons why we need to plan for the future. The range of those systems means that the quills on the porcupine (or echidna) need to be long. Without striking range, we're simply adopting a defensive posture and absorbing punishment.²³

Figure 2: Range of PLA conventional strike system based in mainland China



Source: US Department of Defense, *Military and security developments involving the People's Republic of China 2022: annual report to Congress*, US Government, 2022, 67, [online](#).

While the prospect of PLA strike systems in Australia's near region may seem like a remote prospect, they're already appearing off Australia's coast. We like to speak of the 'air-sea gap' to our north, but the seas are roads for navies, not gaps. The PLA Navy is now the world's largest navy and has been demonstrating its ability to deploy its ships across the region. Figure 3 shows a PLA Navy Luyang-class destroyer transiting through the Torres Strait earlier this year. PLA Navy vessels carry very large numbers of missile cells; the Luyang class has 64 cells, and the larger Renhai-class cruisers have 112. The cells can carry anti-ship and air-defence missiles and will likely carry land-attack cruise missiles in the near future.²⁴ But they don't need to be operating right off our coast for their weapons to be able to reach northern Australian towns, infrastructure and bases.

Figure 3: A PLA Navy Luyang-class guided missile destroyer leaves the Torres Strait and enters the Coral Sea on 18 February 2022



Source: Defence image library, [online](#).

The ‘worst case’ scenario for Australia’s military strategy has always been the prospect of an adversary establishing a presence in our near region from which it can target Australia or isolate us from allies. PLA strike capabilities in the archipelago or Southwest Pacific, whether on ships and submarines or land-based missiles and aircraft, would be that worst case. The ADF will need to have the ability to prevent PLA forces establishing themselves in our near region and to destroy or degrade them if they do.

But doing so is a non-trivial task. Modern PLA Navy vessels are essentially large strike platforms that are heavily defended by advanced active phased-array radar systems and deep magazines of air-defence missiles. Similarly, any forward operating base established in our near region will be heavily defended by capable integrated air defence systems, including low-frequency radars that can provide some early warning of stealth aircraft, and long-range air-defence missiles.

While this worst-case scenario may seem a remote prospect, the 2020 DSU assessed that the likelihood of contingencies such as these is increasing. It isn’t difficult to forecast scenarios that involve the PLA projecting advanced strike capabilities into our near region. They could include scenarios in which the PLA Navy tries to establish a second, southern front in the event of a US–China conflict over Taiwan in order to ‘horizontally escalate’ the conflict and stretch US resources. This could include strikes on US forces in northern Australia. Another form of escalation would be to send naval forces into the Indian Ocean. Again, we need to be thinking about where PLA capabilities could be in 10 or 20 years. It’s worth comparing where PLA capabilities are today with where they were 20 years ago. The growth in size, capability and ability to project force has been remarkable.

It’s also worth remembering that the US Navy’s demonstration of resolve and support for Taiwan by sending two aircraft carriers through the Taiwan Strait in 1996 prompted China to develop its own anti-access/area-denial capabilities. It’s time for Australia to do the same.²⁵

The strike problem

Currently, the ADF doesn’t have a strike system that can pose a credible deterrent. That’s because it faces key limitations in both mass and range. This is the strike problem.

The RAAF’s longest ranged weapon, the ‘classic’ Joint Air-to-Surface Standoff Missile (JASSM) with a range of 370 kilometres, was by default retired when the only aircraft in the RAAF that could launch it, the ‘classic’ F/A-18A/B Hornet, was retired in 2020. Arguably, the ADF currently has no long-range land-strike capability.

Defence currently has other missiles with greater range on order. It has ordered the land-strike JASSM-ER (that is, extended range) with a range of around 925 kilometres.²⁶ The missile will be carried by the F/A-18 Super Hornet. It will probably also be carried by the F-35A at some point, but it will have to be carried externally as the missile is too large to be carried in the aircraft’s payload bay, and that will reduce the Super Hornet’s stealth. Defence is also acquiring the LRASM, which is a maritime strike weapon with significantly greater range and survivability than the current weapon in inventory, the Harpoon.

The previous government announced that it was acquiring the Naval Strike Missile (NSM) with a range of around 185 kilometres for the Hobart-class destroyers and Anzac-class frigates. The NSM is primarily a maritime strike weapon, but it also has a land-attack capability. There also appears to be some consideration within Defence for acquiring the Tomahawk Land Attack Missile (TLAM) for the Collins-class submarines.²⁷

These weapons represent a significant step up in capability from current weapons in terms of range.²⁸ But while long-range strike weapons, whether air-launched (such as the JASSM-ER) or sea-launched (such as the TLAM) have utility against a small number of high-value targets, it’s unlikely they can ever be delivered in sufficient mass to defeat an adversary.

The historical record indicates that long-range missiles have achieved little by themselves in air campaigns. When they have been used effectively in previous conflicts, such weapons have provided a first-day-of-the-war capability to ‘kick in the door’ by degrading air defence networks, but they need to be followed up by very large numbers—potentially thousands—of aircraft sorties which deliver shorter range—and therefore considerably cheaper and more numerous—guided weapons such the Joint Direct Attack Munition (JDAM) or the Small Diameter Bomb (SDB).

For example, in 1999, in an effort to persuade Serbia to stop ethnic cleansing in Kosovo and remove its forces from there, NATO bombed Serbia. During the campaign, NATO launched 218 Tomahawks, which was less than 1% of the 28,108 munitions delivered. TLAM strikes were followed up by 38,004 aircraft sorties, of which 10,484 were strike sorties. Ultimately, it took something like old-fashioned bombing with dumb munitions by heavy bombers (along with the threat of NATO ground operations) to induce the Serbs to leave Kosovo.²⁹

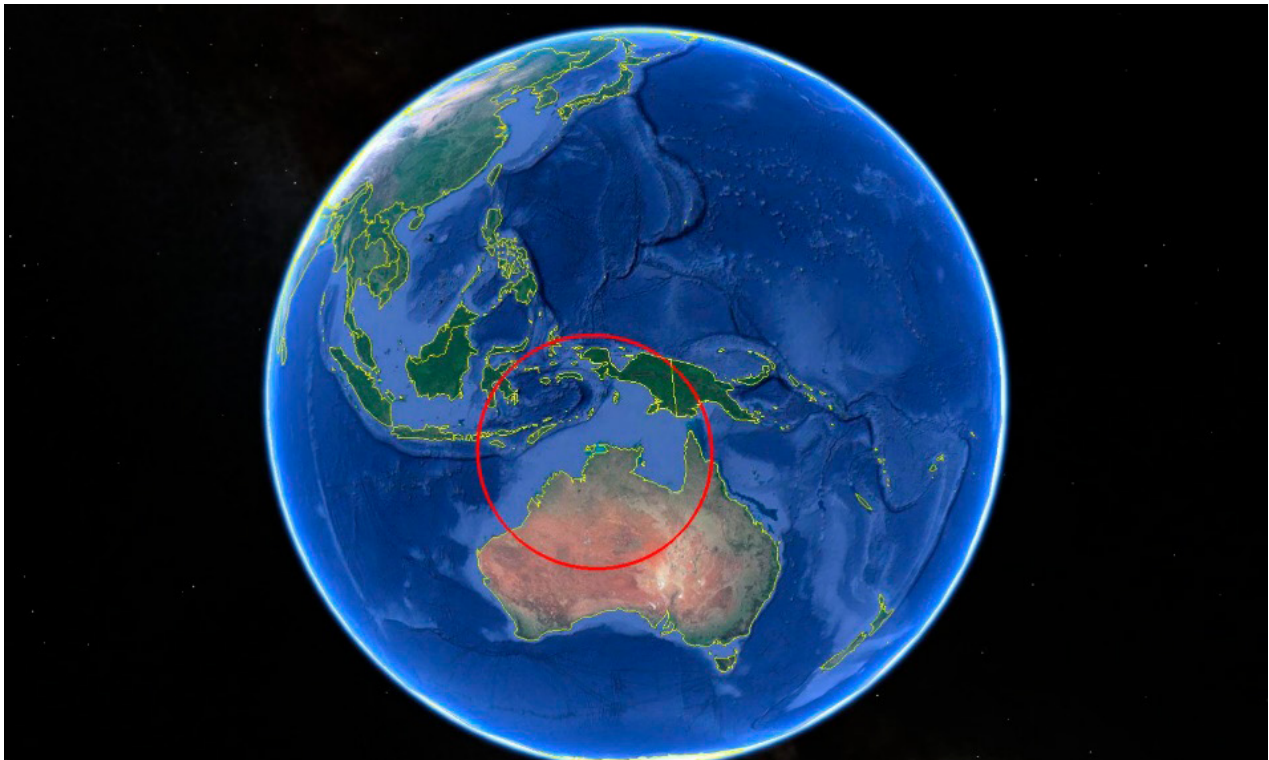
Four years later, in Operation Iraqi Freedom in 2003, the US and its allies expended 29,199 munitions, of which two-thirds were guided. That included 802 sea-launched Tomahawks. Put another way, a huge number of long-range missiles still only made up only 2.7% of the total number of weapons used.³⁰

Russia has already used thousands of precision guided weapons in an attempt to degrade Ukrainian civilian infrastructure. While it has had a serious effect on Ukraine’s power grid, Ukraine is still fighting.

Granted, striking an adversary’s forward operating bases in the archipelagos to Australia’s north and degrading their ability to support offensive operations against Australia is a different task from compelling a nation to surrender. But missiles’ ability to achieve even the former is questionable. When used by themselves, missiles are limited in the effects they can achieve. The US has used them to send a message to al-Qaeda and the Syrian regime, but the message delivered wasn’t sufficient to deter or defeat them.³¹ The US fired 59 Tomahawk missiles against the Shayrat air base in response to Syria’s use of chemical weapons. Syria resumed aircraft sorties from Shayrat within hours of the Tomahawk strikes.³²

So strike operations until now have relied on crewed aircraft, but the essence of the strike problem is that the RAAF doesn't have the ability to follow up missile strikes with sufficient numbers of crewed aircraft. First, even with refuelling, the maximum range of a strike package built around the F-35A with short-range weapons such as the JDAM is around 1,500 kilometres (Figure 4). That doesn't encompass our first island chain, let alone areas in our broader region from which an adversary can operate against Australia.³³

Figure 4: The effective range of a F-35A strike package from RAAF Base Darwin (1,500 kilometres)



Source: The authors, using Google Earth.

Second, strike packages delivering short-range weapons are vulnerable to air-defence systems. Therefore, they need a range of enabling capabilities to support them, such as Growler electronic attack aircraft, Wedgetail airborne early warning and control aircraft, and potentially other fighter aircraft focusing on counter-air operations or the suppression of enemy air defences. In short, large numbers of aircraft will be needed.

Even if the weapons are delivered by a stealthy aircraft such as the F-35A, the rest of the package won't be stealthy, meaning that it will be easily detected by an adversary with reasonably sophisticated surveillance systems—or even an observer sitting outside an Australian air base watching aircraft take off. An adversary is likely to be prepared.

Third, those supporting aircraft will themselves need to be refuelled, with the result that the RAAF's air-to-air refuelling fleet (currently seven KC-30A tankers) will be insufficient to meet demand. A small number of tankers will be a single point of failure for the campaign.

Ongoing operations will quickly exhaust fuel reserves in northern Australia. Those reserves will need to be replenished through long supply chains back to southern Australia and ultimately overseas, as Australia has extremely limited refining capacity. The rate of effort needed to sustain operations will exhaust aircrew, particularly those operating enabling capabilities such as air-to-air refuelling.

Long-range weapons will always face a serious shortcoming: their extreme cost. JASSM-ER currently has a unit price of US\$1.427 million, but, once all the elements needed to support the weapon are taken into account, it's closer to US\$3 million.³⁴ So we are unlikely to have a lot of them. We discuss this in more detail in Chapter 5.

Strike delivered by naval assets fares no better. In some senses, a modern surface warship is the analogy of the strike package described above, but with many different capabilities integrated into one platform. Because surface warships face so many threats, they're optimised to protect themselves and their human crew against those threats, leaving little capacity for offensive weapons—particularly in the RAN's vessels. The eight Anzac-class frigates only have eight vertical launch cells each, and those are all needed for air defence. The three Hobart-class air warfare destroyers have 48 cells, but that's far short of the US Navy's Arleigh Burke-class destroyers with 96, or PLA Navy destroyers with around 100. Since they're the RAN's primary air-defence assets (and for now also its most capable antisubmarine warfare vessel), those cells are likely to be needed for air-defence missiles too. With only one air warfare destroyer likely to be available for operations on a sustained basis (under the 3 for 1 rule of thumb), it's hard to see the surface fleet generating any useful number of missile shots.

The first Hunter-class frigate is scheduled to enter service around 2033–34, but it will be the late 2030s before they're available in useful numbers. With only 32 cells in a world of rapidly increasing anti-ship threats, their 32 cells will be dedicated to air-defence, leaving little capacity for land-strike weapons.

The case for arming the Collins-class submarines with a long-range strike weapon such as the TLAM is even less compelling. The Collins is our primary maritime strike capability. While it's large for a conventional submarine, it still can carry only 20 or so weapons. Every strike missile reduces the number of weapons it can carry for its antisubmarine or anti-ship role. Even if strike missiles made up 50% of its load out, it's still such a small number that it's unlikely to be able to deliver a decisive blow against a major adversary. And, at the Collins transit speed, it would take weeks for the boat to return to Australia, reload and return to the fray.

Once the naval taskforce has delivered its small number of long-range strike weapons, what then? We still need to follow up with large numbers of shorter range weapons to degrade an adversary. Closing to use a 5-inch gun brings the ship well within the range of many different kinds of weapons, so the ADF would need to follow up with crewed aircraft sorties—the limitations of which we've already discussed.

The ADF rates somewhat better in a maritime strike role; that is, targeting an adversary's ships. That's because far fewer missiles are needed to disable a maritime target (although advanced air-defence systems such as those on PLA Navy ships will stop a lot of missiles getting through) compared to a land-based system. But that calculus works both ways. Using our surface ships to strike the adversary's ships brings them within range of the adversary's missiles. In fact, the PLA has anti-ship ballistic missiles with ranges far beyond even the new anti-ship missiles that Australia has on order.

The answer might seem to be, then, acquiring large numbers of land-based missiles. There are both advantages and disadvantages to that approach, which we discuss in a separate chapter.

Bombers in Australia's military history

The strike option that we start with in this paper is a crewed bomber. But before we assess that option, we'll briefly review how the RAAF has used bombers in our region in the past, as that still holds relevant lessons for our present and future.

The RAAF has a long history of operating bombers. Due to the Lancaster bomber G for George's prominent place in the Australian War Memorial, many Australians are familiar with Australians' role in the strategic bombing campaign against Nazi Germany. But it's the historical role of bombers in our near region, particularly during World War II, that provides a better analogy for our current circumstances.

A key element of the war in the Pacific was a struggle to secure air bases to support the projection of air power over the vast distances that characterise the region's geography. Long range and the ability to carry sufficient ordnance to destroy enemy ships and aircraft on the ground and the infrastructure that supported their operations were essential attributes of strike aircraft.

For much of the war, the RAAF was limited to light and medium bombers. While those aircraft played an important, and at times essential, role in operations in the Southwest Pacific theatre, Australia persistently sought heavy bombers as Japanese aircraft operating from the archipelago continued to threaten Australia itself. Those efforts culminated in the establishment in the last year of the war of squadrons equipped with American Liberator bombers, which operated out of northern Australia to bomb Japanese targets in New Guinea and the Dutch East Indies (Figure 5). As the focus of the war moved north, those aircraft operated not just over the archipelago but in the Philippines campaign and even as far north as China.

Figure 5: Consolidated B-24 Liberator aircraft of No. 82 (Heavy Bomber) Wing RAAF lined up on the airstrip at their base in the northwest of Australia, March 1945



Source: Australian War Memorial, [online](#).

The demonstrated utility of heavy bombers in the Pacific theatre led Australia to acquire a bomber with even greater range and payload—the British Avro Lincoln, which was essentially a ‘stretched’ version of the Lancaster (Figure 6). This was the largest aircraft ever built in Australia. The Lincoln missed World War II but operated out of Singapore conducting operations against communist insurgents in the Malayan Emergency.

Figure 6: A RAAF No. 1 bomber squadron crew in front of their Avro Lincoln bomber after returning from a mission over Malaya, Singapore, late 1950s



Source: Australian War Memorial, [online](#).

Australia continued to operate bombers. The Lincoln was replaced by the Canberra bomber, which served in Vietnam, which in turn was replaced by the F-111 (Figure 7). In the long period since World War II, it's only been for the past decade or so since the retirement of the F-111 at the end of 2010 that Australia has been without a long-range strike aircraft.

Long-range or heavy bombers are often associated with ‘strategic strike’; that is, operations targeting the adversary’s key infrastructure, systems and even will to fight. Often, this involves operations against the enemy’s homeland, as in the bombing campaign that the Australian War Memorial’s iconic G for George Lancaster bomber participated in. However, we aren’t arguing for the acquisition of a long-range bomber to perform strategic strike in this sense. There are several reasons for this. The first is that, in an age of instantaneous media coverage, tactical events can have strategic implications. Second, long range isn’t just about targeting the enemy’s homeland; it has become an essential requirement to successfully conduct operations against an adversary’s military assets in the field. For example, the PLA’s DF-26 anti-ship ballistic missiles are designed to sink warships, but they have a range of 3,000–4,000 kilometres. Moreover, a dramatic operational success (such as the sinking of an aircraft carrier) could have strategic impact in terms of degrading a country’s will to fight—or escalating the conflict dramatically. In short, distinctions between tactical, operational and strategic have always been subjective but are increasingly blurred, and any automatic association between strategic and long-range can be misleading. For this reason, we don’t use the term ‘strategic strike’.

Figure 7: An F-111 based at Royal Australian Air Force Base Amberley for exercise Talisman Sabre, landing as part of a mission within the exercise



Source: Defence image library, [online](#).

The third reason is perhaps the most important. As our brief historical survey suggests, long-range strike aircraft such as bombers are inherently flexible weapons. Their key attributes of long range and large payload can be put to many purposes. In the war in the Pacific, Australia used heavy bombers for maritime strike, in offensive counter-air missions (destroying enemy aircraft on the ground and degrading their bases), for offensive mine-laying interdicting enemy ports and key straits, and for battlefield air support. In Malaya, Australia used heavy bombers in a counterinsurgency campaign. More recently, the US has used its bombers, including the B-2 stealth bomber, to strike insurgents in Afghanistan in what could be considered a ‘tactical’ or battlefield role.³⁵

The fundamental questions are: Is there a case to re-establish a capability with the attributes of long range and large payload in ADF service? If so, which system would most effectively provide that capability? We argue that there’s an urgent need for that capability, and the business case for delivering that capability by the B-21 bomber is worthy of further examination.

Chapter 2: The B-21

What is it?

The B-21 Raider is a stealth bomber aircraft currently being developed by Northrop Grumman for the USAF to meet the force's long-range strike bomber requirements. Much information about the program is classified, but the open-source information is broadly consistent about the following features:³⁶

- Northrop Grumman was selected for the contract in 2015.
- Northrop Grumman is assembling the aircraft in Palmdale, California.
- Six aircraft are currently in production.³⁷
- The first aircraft was publicly rolled out on 2 December 2022.
- The aircraft has not yet flown.
- The aircraft will perform both conventional and nuclear roles.
- Like its predecessor the B-2 bomber, the aircraft uses a 'flying wing' design that doesn't require vertical control surfaces.
- The aircraft is being designed with a very high level of stealth to allow it to penetrate into well-defended airspace. Therefore, it's referred to as a penetrating bomber rather than a 'stand-off' aircraft.
- The USAF is seeking at least 100 aircraft, which will allow it to retire its B-1 and B-2 bomber fleets in the 2030s (with some of its B-52 fleet remaining in service).

We discuss cost in detail below, but the target average procurement cost is US\$550 million in FY2010 dollars. The USAF has stated that the program remains on budget; in 2021, it said that the average procurement cost was still US\$550 million, which is US\$639 million in 2019 dollars.

What can it do?

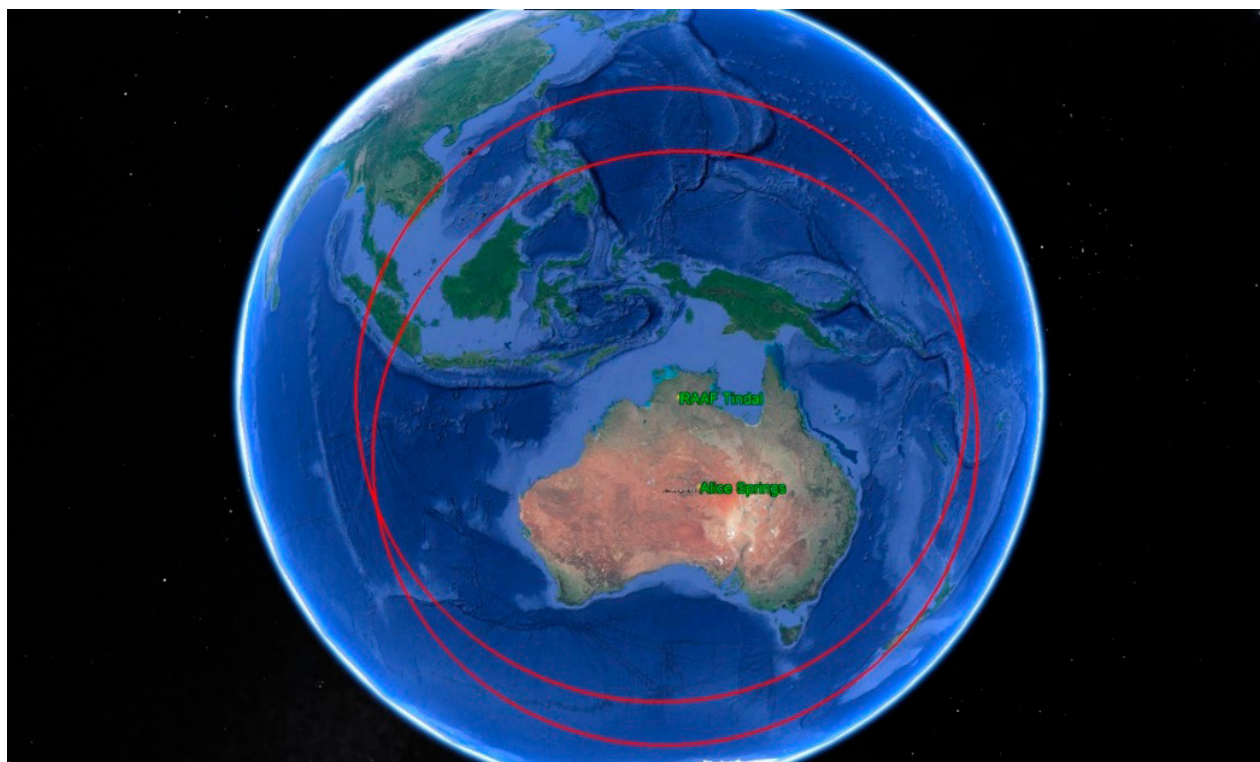
There's little definitive open-source information on the aircraft's technical performance. There's general consensus that it will have significantly better stealth performance than the B-2. That's in part due to the development of stealth technologies over the past three decades as well as the B-21 not suffering from the compromises made to the B-2 design to allow it to conduct low-level operations, which affected its radar signature.

It was broadly anticipated that the B-21 would be smaller than the B-2, although how much smaller is still not clear, even after the initial roll out.³⁸ Since the USAF is seeking a similar range to the B-2's, the compromise needed to achieve that range with a smaller aircraft is likely to be payload. Again, how much payload the B-21 will have isn't yet public. Below, we've assumed 75%–80% of the B-2's payload. That's still a very large amount of ordnance.

Range

We've illustrated two 4,000-kilometre range rings in Figure 8, based on RAAF Tindal and a hypothetical central Australian base representing a 'real world' combat radius for the B-21. That's based on a very conservative reading of open-source information on the unrefuelled range of the B-2 (circa 11,000 kilometres). That extends far beyond the range of the F-35A, even with refuelling. It allows the ADF to 'impactfully project' beyond the archipelagos to our north. That combat radius doesn't take into account refuelling or the range of the aircraft's munitions, which would expand the size of the rings.³⁹ But a key advantage of the B-21 for Australia is that the aircraft can cover a substantial part of our region of strategic interest without requiring enabling capabilities that we'll only ever have in relatively small quantities, such as tankers.⁴⁰

Figure 8: 4,000-kilometre range rings from RAAF Tindal and a hypothetical central Australian base



Source: The authors, using Google Earth.

Payload

As well as being able to reach places that fighter aircraft can't reach from Australian mainland bases, the B-21 can carry significantly more munitions than the F-35A. While there's no authoritative open-source information on the B-21's payload, assuming around 75%–80% of the B-2's, a single aircraft could carry around 12 anti-ship strike missiles compared to the F-35A's two carried internally. Or it could carry around 50–60 direct attack weapons such as 500-pound JDAMs, compared to eight for the F-35A. That is, the B-21 can probably carry as much ordnance as six F-35As, as well as reach places the F-35A can't, regardless of the number of fighters or tankers employed.

A small number of B-21s can carry as many stand-off land-strike weapons as an entire RAN taskforce, with the advantage that the B-21 can return to base and reload in hours, while ships and submarines require transits to facilities in southern Australia that can take weeks.

Working alone—a key cost–benefit

The key advantage of the B-21 is that it can operate alone. Tyler Rogoway compared a B-2 mission with a 'standard' strike package this way:

For most missions the jet is better off going it alone than being part of a massive strike package. This means the normal armada of suppression of enemy air defenses, counter-air, and in some cases electronic warfare aircraft, along with an array of standoff support assets like tankers, combat search and rescue packages, airborne early warning aircraft, and other assets, are not needed or are needed in far smaller numbers. Were fighters were used instead of heavy bombers, the strike package might include dozens of strike aircraft alone, not counting all their support assets. In essence, using the B-2 means less assets and lives put at risk against an objective. It also means the whole battle plan can be simplified, executed faster, and with fewer avenues for disruption.⁴¹

For Australia, with an air force that has limited numbers of support assets, this is a key advantage. A strike package of six F-35As operating at the limits of their refuelled range would require several tankers (out of a total RAAF fleet of seven). As the package would no longer be stealthy, it would be likely to require EA-18G Growler aircraft to suppress the adversary's air-defence system (also requiring tankers) and E-7A Wedgetail aircraft to manage the battle (which may require their own fighter escorts and refuellers).

Moreover, to reach the target, the package would need to operate from a northern air base where fuel is limited and has to be resupplied from southern Australia, either along a single railway or by fleets of trucks (Figure 9). Depending on the actual range that the aircraft can achieve and operational range requirements, the B-21 could potentially operate out of air bases in southern Australia that are more easily supplied with fuel and munitions, and that are outside of the range of virtually all adversary threat systems.

Whether you call it elegance or cost-effectiveness, the B-21 can complete missions with fewer resources and less risk than strike packages built around the F-35A. It can also complete missions that the F-35A cannot complete in any circumstances.

Figure 9: Two USAF B-2 Spirit stealth bombers fly a bomber taskforce mission alongside two RAAF F-35A Lightning II aircraft over RAAF Base Curtin during Exercise Koolendong 2022



Source: Defence image library, [online](#).

Roles

Long-range bombers are commonly associated with ‘strategic strike’; that is, attacking strategic systems in the adversary’s homeland. However, that isn’t the role we envisage for it. We certainly don’t see it as a delivery system for nuclear weapons (we discuss nuclear issues in Chapter 4). Rather, a long-range bomber is a flexible platform that can be adapted over time to perform many roles. This has been demonstrated by the history of the B-1, B-2 and B-52, the missions and capabilities of which have evolved over their long service lives. This section examines the ‘air power contributions’, as defined by the RAAF’s *Air power manual*, that the B-21 could make.⁴²

Offensive counter-air

The B-21 won’t shoot down enemy aircraft, but it can destroy them on the ground or destroy their support systems and infrastructure such as runways, fuel farms and munitions storage. With its high level of stealth, the B-21 can also target the adversary’s ground-based air-defence networks to allow other coalition aircraft to operate more safely. That would degrade an adversary’s ability to project air power against Australia or our regional partners.

Land strike

Land strike is, of course, an obvious role for the B-21. Bombers have a disproportionate impact in land-strike missions. For example, B-2 bombers flew less than 1% of missions yet accounted for around 33% of targets destroyed in Operation Allied Force in the former Yugoslavia in 1999. Again, land strike doesn’t automatically imply strategic strike against an adversary’s homeland. It could be against any forward operating bases established in the archipelago, as we discussed in Chapter 1.

The benefit of the B-21’s stealth is that it can potentially conduct this role using cheaper munitions than non-stealthy aircraft that are forced to use expensive stand-off munitions in order to survive or long-range missiles. We discuss this further in Chapter 5.

Close air support

According to the RAAF’s *Air power manual*, the aim of close air support is ‘to neutralise or disrupt an adversary who is engaged with, or about to engage with, friendly ground or amphibious forces’. While it may appear to be overkill, heavy bombers have performed this role many times. Their greater range allows them to operate with more persistence and responsiveness. Their large payload allows them to prosecute a large number of battlefield targets, whether planned or targets of opportunity. Despite having thousands of fighters in its inventory, the US frequently used bombers in that role in the war in Afghanistan. Of course, the capabilities of the adversary’s air defence system would influence whether or how a bomber would perform this mission.

It will be particularly difficult for the ADF to provide close air support for deployed troops in our region with its current and planned air combat assets. There are very few air bases in our region that are capable of supporting F-35A operations, and Defence has no plans to acquire a maritime fixed-wing capability (that is, aircraft carriers). Even with refuelling, the F-35A will have little or no time on station supporting deployed land forces in our near region when operating from mainland Australian bases.

Anti-surface warfare

Long-range bombers have always been used to strike enemy ships. This role is likely to become even more important, as the number of ships in the PLA Navy has grown to exceed the US Navy’s. In response to this, the B-1 bomber has been equipped with the LRASM, turning it into a ship killer. New developments in weapons are creating very cheap but effective air-launched anti-ship weapons such as the Quick Sink bomb.⁴³ The B-21 could also potentially lay smart sea mines, in particular offensively in the approaches to an adversary’s ports or forward operating bases in the region.

Antisubmarine warfare

A B-21 bomber isn’t going to detect enemy submarines, but it can contribute to an antisubmarine warfare campaign in other ways. It can, for example, strike submarines in port or the facilities that support submarine operations. As with anti-surface operations, it can also lay mines.

Counterstrike

Counterstrike isn’t a separate air-power contribution *per se* in the RAAF’s *Air power manual*, but it’s likely to become an increasingly important requirement as the PLA’s capability to directly strike Australia and our regional partners grows. Defence’s acquisition program includes a substantial planned investment of \$15.8–23.7 billion in deployed ballistic and high-speed missile defence. But defensive measures are only one part of a system that can defeat an adversary’s strike capability. The ADF and its allies require the ability to interrupt the adversary’s strike chain before the last resort of shooting down its missiles. This can involve striking the adversary’s command and control system, intelligence, surveillance and reconnaissance (ISR) nodes and launchers well before launch. This is a task that the B-21 (supported by robust ISR assets) can perform.⁴⁴

The B-21 as Australia’s interim submarine

We’ve written elsewhere about the potential schedule and risks associated with Australia’s nuclear-powered submarine program.⁴⁵ Other observers have raised concerns about the schedule and risks. Consequently, they’ve argued for the acquisition of a new conventional submarine to bridge a potential submarine capability gap between the Collins-class submarine and a future SSN capability. Opinions vary on which submarine we should choose and how it should be acquired.

The B-21 isn’t a submarine, but it can potentially do some of the things a submarine can do, albeit in a different way. There are also some effects that we want submarines to deliver that a bomber could perform by working with other capabilities, and there are some of those things it can’t do at all. But what it definitely can do is deliver a strategic effect, creating the big question mark in an adversary’s mind that Richard Marles has spoken of.

So, is it an option to fill a possible submarine capability gap? That depends on how you view the risks in the SSN enterprise and in a new conventional submarine program. If you assess the greatest risk to be the ability of the Navy to grow its uniformed workforce from around 800 to more than 2,000 submariners with an ageing Collins fleet, then the B-21 doesn’t help to address that risk at all. If you think the biggest risk is Australia’s ability to present a credible long-range conventional deterrent as the Collins ages, then the B-21 could be a way to manage that risk. The question is: does it do it better and with less risk than a new conventional submarine?

If introducing a third class of submarine into the long transition simply exacerbates risks, then the B-21 allows us to avoid that. The RAN has stated that it doesn’t have the capacity to operate three classes of submarines. In addition, it will be challenging for Australian industry to manage three very large submarine programs simultaneously: the Collins life-of-type-extension, the build of a new conventional submarine, and the ramp-up of the SSN enterprise. The B-21 would allow Australian industry to focus on maintaining the Collins as a viable capability throughout its life while it ramps up for the SSN enterprise.⁴⁶

A system-of-systems approach could deliver many of the effects we want from submarines. Rather than using submarines to monitor key choke-points and prosecute adversary surface ships transiting them, extra-large uncrewed undersea vessels (XLUUVs), such as those being developed by Anduril, could conduct the surveillance, while B-21s respond to strike the vessels. The Collins could focus on tasks that only submarines can perform, or Australia could rely on its major ally to supplement our submarine capability. It appears that this is already being ‘baked in’ to the submarine transition: forward basing of US Navy SSNs in Western Australia is looking increasingly like a necessary part of the transition.

There are many potential paths forward in the wicked problem space of submarines. However, we shouldn’t automatically default to the acquisition of a new conventional submarine without considering all options that can mitigate risk and ensure that the ADF can deliver the effects the government requires.

Chapter 3: Delivering a B-21 strike capability

The fundamental inputs to capability

While discussion tends to focus on the platform itself, many elements are needed to deliver an effective military capability. In the Australian Department of Defence, those elements are referred to as ‘fundamental inputs to capability’ (FICs).⁴⁷ There are nine FICs:

- Major systems
- Personnel
- Organisation
- Facilities and training ranges
- Collective training
- Supplies
- Support
- Command and management
- Industry.

All new capabilities require new FICs. Generally, when a capability that’s similar to the one it’s replacing is acquired, much of the FICs can be re-used. Personnel can be retrained on the new system, for example. In the case of the B-21, which would be a fundamentally new capability, virtually all of the FICs would be new and come at significant cost. We’re assuming that there’ll be no personnel offsets from any retired capabilities, for example. We won’t discuss all of the FICs in detail, but have taken them into account in the cost estimate presented below. Rather, we’ll highlight some of the more significant issues.

Our overall assessment is that an Australian B-21 capability would need to be closely integrated with the USAF in order for it to achieve its potential as a strike capability and for the costs to be manageable. An analogy would be the RAAF’s EA-18G Growler electronic attack capability. The RAAF’s squadron is essentially sustained as the US Navy’s 13th Growler squadron, and much of the RAAF personnel’s training is conducted in the US.

Major systems

We assume an acquisition of 12 B-21 aircraft. This would allow around six sorties per day for combat operations. Our cost analysis is based on that number of aircraft, but the exact size of the force would of course require more robust analysis.

Personnel

There are no personnel offsets; the F-111’s workforce was reassigned long ago. We understand that the operation of the B-21 would require a large squadron of at least 300 personnel. Since a single B-21 could potentially carry as many weapons as the RAAF has loaded for any mission in its recent history, a substantial number of aircraft armaments technicians will be required.

Facilities and training ranges

USAF bombers are now frequent visitors to Australia, so it's reasonable to assume that we have adequate training ranges. Australia also has one of the world's best test ranges at Woomera. But one of the biggest questions and challenges in the introduction of a B-21 capability is its base. All ADF basing decisions raise complex issues. While the question of the B-21 base might not be as difficult as the choice of an east coast nuclear submarine base, there's no doubt that it would be more difficult than most.

A base would have to address the following requirements:

- a runway of the necessary length and structural integrity
- capacity to accommodate other necessary infrastructure, including hangars, aprons, weapons storage, accommodation and adequate security to address cyber and physical security threats
- the environmental conditions to ease the impact of weather on the aircraft, including its stealth coating and structures
- a suitable balance between being sufficiently far from threat weapons yet close enough to potential theatres of operation to not require refuelling when conducting missions
- availability of workforce.

While we don't know exactly how long a runway the B-21 will require, USAF B-1B, B-2 and B-52 bombers have operated from RAAF Tindal.⁴⁸ However we don't know whether they have taken off with a full payload of fuel and weapons. The runways of their home bases are around 3,600 to 4,000 metres long, which is longer than any RAAF air base runway. It's likely that an existing air base would need to have its runway lengthened. In addition, there would be a requirement for significant new facilities. This would include substantial weapons storage and loading facilities.

An existing airbase in southern Australia would have some benefits, including proximity to workforce and more desirable posting destinations as well as the ability to leverage existing infrastructure and, importantly, fuel infrastructure. But, in the light of the urban encroachment occurring at all of Defence's major bases in the south of Australia (Williamstown, NSW; Edinburgh, South Australia; and Amberley, Queensland) the development of any of those facilities would probably be prevented by lack of access to land, concerns about proximity to munitions and noise impacts.

A better existing option could be RAAF Tindal near Katherine in the Northern Territory. It's currently being developed to host USAF B-52s, which indicates that it ticks a lot of the boxes for bomber operations, although hosting short-term deployments is a different matter from being the home base for a very sophisticated bomber fleet. It's reasonably far from potential adversary threat systems while still allowing the B-21 to cover much of Australia's northern approaches without requiring air-to-air refuelling. However, recruiting and retaining workforce could be challenging in a remote location.

A third option would be to develop a new base in the south, close enough to large population centres to be able to draw on their workers, but far enough to assuage concerns about noise and proximity to munitions. While it can sometimes be easier, faster and cheaper to develop a greenfield site than to redevelop an existing one, this is likely to be an expensive approach.

Australian industry

There's unlikely to be substantial direct involvement by Australian industry in production. Initial production has begun, so the prime contractor has probably already identified its suppliers, making it difficult for Australian companies to enter the production supply chain.

But there are significant opportunities in the sustainment system. One approach to consider would be an F-35 Joint Strike Fighter-type model that would build on the regional maintenance hub already established here not just for the RAAF but for the other countries acquiring that aircraft. Under this approach, Australia could be a maintenance

hub for USAF B-21s that are forward-deployed to the western Pacific and Indian oceans. This approach would be strengthened if the B-21 uses the same engines as the F-35 (as appears to be the case, although that hasn't been confirmed by the USAF) since Australian industry already conducts maintenance on F-35 engines.

Targeting and intelligence, surveillance and reconnaissance support

Targeting and ISR aren't a FIC category *per se*, but they're a fundamental input into any long-range strike capability. Without them, a B-21 fleet would provide little if any capability. We can make several points about these inputs.

First, the B-21 isn't unique: any ADF long-range strike capability will be heavily dependent on ISR and targeting systems to deliver an effect. Without understanding the value of a target to the adversary's broader capabilities, there may be little point in attacking it even if you can find it.

Second, some targets are harder to target than others. Large static targets are relatively easy to identify and prosecute. Relocatable targets are more difficult, because you need to ensure that the target hasn't relocated. Moving targets are harder still, as they not only need to be identified but must be tracked until the weapon hits the target.

Third, the ADF is developing its self-reliant targeting capability. It has significant expertise developed in the Middle East to build upon. But, as is the case with many military capabilities, you're never going to have as much of it as you want.

Fourth, in the same vein, the ADF is making substantial investments to increase its ISR assets, including Triton high-altitude, long-endurance uncrewed aerial vehicles (UAVs), Peregrine ISR electronic warfare aircraft, and surveillance satellites, and systems to store, analyse and disseminate ISR information. However, being able to identify and track targets 3,000–4,000 kilometres from Australia will be challenging. Getting the most out of the B-21 (or any long-range strike capability) will require sufficient integration with the rest of the ADF in order to full exploit those ISR assets.

Overall, by itself, the ADF may always have difficulty in achieving the full potential of any strike system that has a nominal range in the thousands of kilometres. It may be able to strike fixed targets in an adversary's forward operating bases (fuel farms, ordnance depots, headquarters, etc) but relocatable or moving targets will be challenging. Considering that those are likely to be the kinds of targets involved in a counterstrike role, that's another reason why an Australian B-21 capability would need to be closely integrated with the USAF and its vastly larger targeting capabilities.

Acquisition cost

The total acquisition cost is estimated at \$25–28 billion (out-turned dollars). This doesn't include weapons, which we consider in Chapter 5.

Aircraft cost

The cost of 12 B-21 aircraft is estimated at \$15 billion to \$17 billion (out-turned). This is essentially a unit flyaway cost (that is, just for the aircraft).

The cost of the aircraft is based on the US Government's budgeted cost of US\$692 million per aircraft on average (base year 2022 dollars). While the US Defense Department's history is replete with examples of cost overruns, there are some grounds for optimism that the current costs are reasonably reflective—within about 10%—of final costs. First, it appears that the USAF has accepted the use of existing systems (with some evolution and customisation) rather than attempting to introduce a raft of new and untested technical systems.⁴⁹ Future capability growth is being managed through a more open architecture approach.⁵⁰ Moreover, production has started on the initial six aircraft, and the cost estimate appears to be holding. This conclusion is also supported by the fact that the independent cost estimates required by US legislation are actually lower than the current budget.

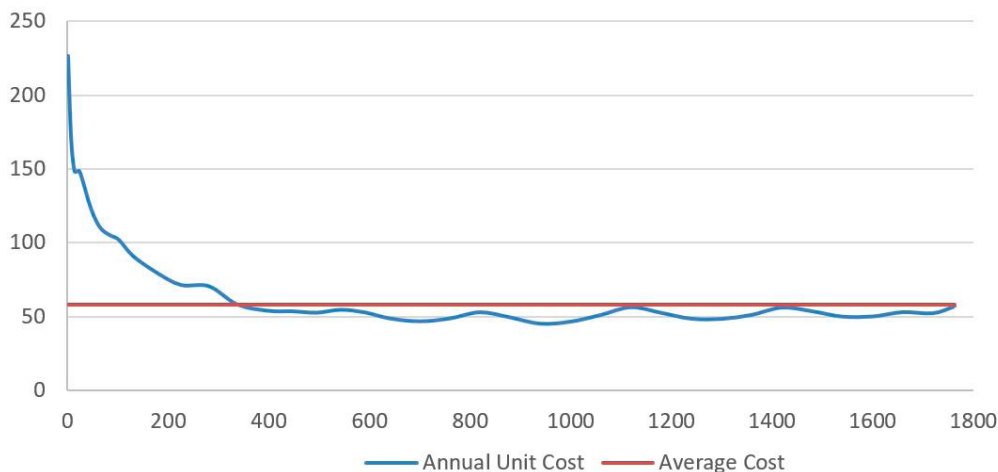
An average unit cost of US\$692 million translates into an average Australian unit cost of between \$1.2 billion and \$1.4 billion (out-turned). To show how we get there, we start in constant dollars and then:

1. convert to Australian dollars
2. update to 2022 dollars
3. establish a learning curve that we can apply to Australia's likely acquisition schedule.

We've used an exchange rate of 76 cents based on the long-term average exchange rate, so the average unit cost becomes \$910 million per aircraft.⁵¹

Getting from there to the \$1.2–1.4 billion results from different assumptions about learning curves and understanding of how the US foreign military sales system works. Neither the US nor its customers pay the 'average unit cost' for individual aircraft. Rather, they pay the contracted annual price of the aircraft.⁵² Simply put, earlier aircraft will cost more, whereas aircraft further along the learning curve will cost less. Figure 10 demonstrates the average annual flyaway cost of the F-35A to illustrate the impact of learning on aircraft cost (and price) and the program average cost.

Figure 10: Evolution of F-35A average unit cost (US\$ million 2012 constant)—horizontal axis is cumulative aircraft production



Source: Authors' analysis based on Office of the Secretary of Defense, *F-35 Lightning II Joint Strike Fighter (JSF) Program (F-35)*, December 2019, [online](#).

In sum, the later in the queue you are, the cheaper the aircraft are likely to be. Therefore, seeking to get capability faster is likely to result in a higher cost for Australia. Aiming for a 2030 initial operating capability will result in higher cost than aiming for 2032; hence, the range of \$15–17 billion for aircraft costs.

Other costs (excluding facilities)

In addition, we estimate project management to cost in the order of \$1.5 billion, other equipment to be in the order of \$2 billion, and all other acquisition costs (other than facilities) to be in the order of \$2.5 billion.

Facilities and training ranges

Facilities costs are very difficult to estimate because there are so many unknowns. Aside from the location, uncertainties include ground conditions, availability of land, availability of work force and competing priorities. The cost estimate includes \$4–5 billion (out-turned) based on the expansion of an existing base. As we've discussed, the establishment of a new base may be a better capability option, but that would be likely to increase the facilities cost.

In total, we estimate the cost of major systems and support systems without weapons to be between \$25 billion and \$28 billion (out-turned).

Sustainment cost

To allow a comparison with the cost of existing ADF capabilities, we're presenting the sustainment costs of the B-21 as an annual figure in current dollars.⁵³ This estimate is based on US Government Accountability Office data for the B-2 bomber with a 20% uncertainty factor applied to it.⁵⁴ Based on analogy with the B-2, our estimate for the total annual operations and support cost of a fleet of 12 B-21 aircraft is around \$850-900 million.⁵⁵

However, US operations and support costs include several major cost elements that are not included in the sustainment cost information published in the Defence Portfolio Budget Statements for ADF capabilities. For example, the US costs include the personnel operating the capability, who are not included in Australian sustainment cost. Once we strip out those costs to get a figure that is analogous to Australian sustainment costs, the estimate is around \$500 million per year.⁵⁶

This estimate would put the B-21 among the most expensive ADF capabilities, behind the Collins-class submarine and comparable to the Super Hornet/Growler fleet. For comparison, based on the October 2022–23 Portfolio Budget Statements,⁵⁷ the current top six are:

- Collins-class submarine: \$740 million (six boats)
- F/A-18F Super Hornet and Growler weapons system: \$550 million (36 aircraft)
- Anzac-class frigate: \$372 million (eight ships)
- F-35A Joint Strike Fighter: \$367 million (50 aircraft so far of 72 ordered)
- E-7A Wedgetail airborne early warning and control system: \$296 million (six aircraft)
- MRH-90 multi-role helicopter: \$296 million (47 aircraft).

As another point of comparison, we estimated the annual sustainment cost of the future fleet of eight SSNs to be around \$3 billion in current day constant dollars, although that figure doesn't include the broader nuclear safety and regulatory system or the 2,000-2,500 operators.

Factors affecting the sustainment cost estimate

It's wise to adopt a conservative approach to estimating sustainment costs for new capabilities. Historical experience indicates that new platforms almost always cost more than the ones they're replacing, so it would also be wise to apply caution to any claims that new systems will be cheaper to operate, even if their manufacturers claim that they're designed with sustainment in mind.

That said, there are several reasons to suggest that the B-21 will be less expensive to operate than the B-2, or at least that any cost growth will be moderate.

The first is that the B-21 is smaller than the B-2. Size and cost tend to be directly related in military equipment. The B-21 will likely have two engines compared to the B-2's four. Overall, it appears that the USAF has adopted an '80% solution' approach to the B-21 to prioritise achieving a larger number of 'good enough' aircraft.

The second is that many of the technologies used in the B-2, such as stealth coatings, have reportedly matured. Northrop Grumman has claimed that:

Stealth aircraft have always had challenges related to maintainability due to the need for specialized personnel, equipment, materials and facilities. The B-21 Raider will not demand the same level of resources. It sports more durable low-observable (LO) treatments and coatings, and maintenance facilities that are less expensive to build and maintain. Additionally, early use of digital design and modelling/simulation capabilities for B-21 systems and structures were applied to sustainment and maintainability, leading to a sturdier aircraft that's ready to fly every day.⁵⁸

One of the reported benefits of more robust stealth coatings is that the aircraft won’t need to be stored in specialised, climate-control hangars, but in open shelters (Figure 11). According to a USAF spokesman:

These shelters also help us generate sorties more quickly by eliminating the need to always have to move aircraft in and out of hangars. Major maintenance activities will still be performed indoors in hangars, but the B-21 Raider design will also provide us the flexibility to perform routine maintenance right on the flightline.⁵⁹

Whether that would hold true for the harsh environmental conditions of central and northern Australia will require careful evaluation.

Figure 11: B-21 prototype environmental protection shelter

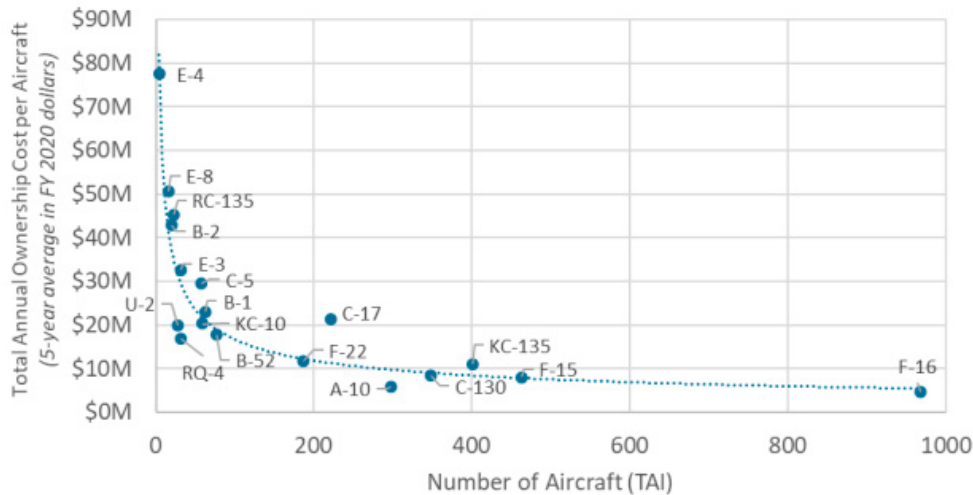


Source: Secretary of the Air Force Public Affairs, [online](#).

Third, a much larger B-21 fleet will drive unit costs down. While it’s unsurprising that there’s a clear correlation between the size and cost of aircraft, there’s also a striking inverse correlation between the size of a fleet and individual aircraft cost. The C-130 and KC-135 are much larger aircraft than the F-15 but have a similar total ownership cost per aircraft. Figure 12 suggests that one reason for that is that they have similar fleet sizes.

The cost falls dramatically even with small increases in fleet size, and the curve flattens out at around 100 aircraft. With only 20 aircraft in the B-2 fleet, operating costs are very high, since fixed costs are amortised over a small number of aircraft. This suggests that, if the USAF can achieve its target B-21 fleet size of least 100 aircraft, that will make a significant difference to the operating cost. It also suggests that an Australian B-21 ‘subfleet’ will need to be integrated as closely as possible into the overall fleet in order to realise operating cost savings.

Figure 12: Annual total ownership cost per aircraft (US\$)



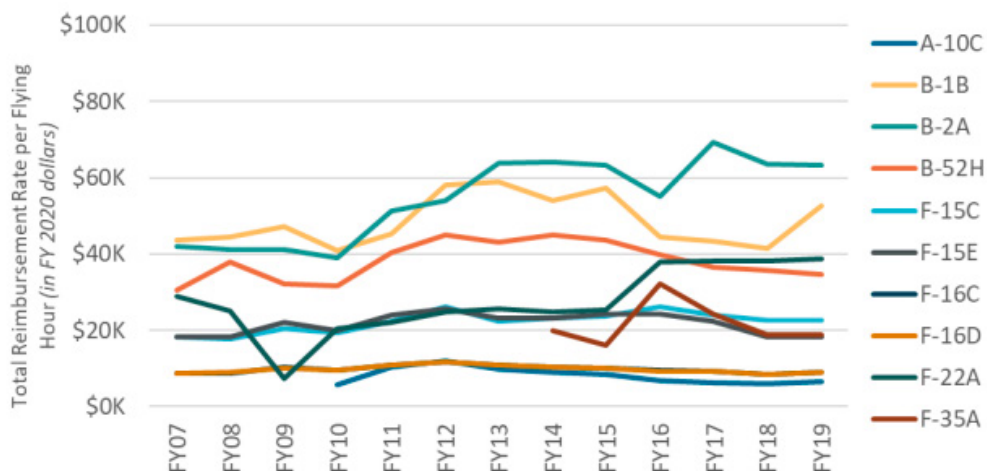
Source: Reproduced from Todd Harrison, *The Air Force of the future: a comparison of alternative force structures*, Center for Strategic and International Studies (CSIS), Washington DC, 2019, 10, [online](#).

If we look at hourly flying costs, the situation is similar but not identical to annual ownership costs. Figure 13 presents hourly flying costs but also includes the F-35A. The B-2 costs a little over US\$60,000 per hour, while the F-35A costs slightly under US\$20,000.

The fundamental question is: does the B-2 deliver three times as much capability per hour than an F-35? Certainly, there are F-35A roles that a bomber can't perform at all. Conversely, to conduct the same kinds of missions as a B-2, the F-35A needs the support of other aircraft, such as tankers, electronic warfare aircraft, and early warning and control aircraft. Plus, the bomber can carry far more than three times the amount of ordnance of the fighter. Finally, there are strike missions that the F-35A simply can't perform due to its range limitations, regardless of the number of enabling aircraft supporting it.

Of course, Australia already has the F-35A. The acquisition costs are largely spent already and the sustainment costs locked in. But if the DSR were considering acquisitions of additional F-35As, the B-21 could be a more capable alternative in the strike role.

Figure 13: Reimbursement rate per flying hour for selected combat aircraft (US\$)



Source: Reproduced from Todd Harrison, *The Air Force of the future: a comparison of alternative force structures*, CSIS, Washington DC, 2019, 8, [online](#).

Schedule

Our current understanding is that the US will build six initial aircraft, with a further five annual low-rate initial production runs of a total of 21 aircraft, followed by full-rate production for a minimum total of 100 aircraft.⁶⁰ Based on this analysis, we’ve developed an indicative US production program with two Australian production supplements based on achieving an initial operating capability (IOC) in either 2030 or 2032 (Table 1).⁶¹ Of those two options, we believe that 2032 is the lower risk path. However, because time is of the essence, an alternative risk assessment may prioritise getting the capability into service sooner and managing the higher implementation risk.

Table 1: Indicative aircraft delivery schedules to achieve IOC in 2030 and 2032

Year	Production stage	US aircraft	Australian aircraft – 2030 IOC	Australian aircraft – 2032 IOC
2023	Test aircraft	1		
2024	Test aircraft	1		
2025	Test aircraft	1		
2026	LRIP1	4	1	
2027	LRIP2	4	1	
2028	LRIP3	4	1	
2029	LRIP4	4	1	1
2030	LRIP5	5	1	
2031	Full production	10	3	3
2032	Full production	10	2	3
2033	Full production	10	2	3
2034	Full production	10		2
2035	Full production	10		
2036	Full production	10		
2037	Full production	10		
2038	Full production	6		
Total		100	12	12

Source: Authors’ estimate based on open-source information on the B-21.

High-level schedule to achieve 2032 initial operating capability

To achieve an IOC in 2032, we envisage the following high-level schedule:

- 2024: First-pass consideration. Training commences in the US on existing bomber classes
- 2026: Second-pass consideration. Training transfers to USAF B-21 aircraft
- 2029: First RAAF aircraft delivered in the US
- 2031: First two aircraft transferred to Australia; maintenance stood up in Australia
- 2032: Aircraft three and four transfer to Australia and IOC declared
- 2034: All aircraft delivered
- 2036: Full operational capability declared.

This path would achieve IOC within the DSR’s 2032–33 time frame. It may be possible to achieve a 2030 IOC, but, as discussed above, that would require purchasing aircraft earlier in the learning curve. That would be likely to result in a cost at the high end of our estimate band as well as potentially accepting more technical risk and therefore capability risk should some technologies in the aircraft take longer to mature.

Chapter 4: The case against the B-21

One commentator described a potential Australian acquisition of the B-21 as fantasy several years ago, and the subject is a fertile topic for the twitterati.⁶² However, the AUKUS announcement on 16 September last year has to be factored into any discussion. Put simply, things that were once inconceivable are now not only possible, but are happening. That doesn't mean we should rush out and buy B-21s; there are arguments against Australia acquiring the B-21 that need to be considered. Here, briefly, are some of those counterarguments.

The opportunity cost

We've outlined the estimated cost above. Acquiring the B-21 naturally represents an opportunity cost in that the funds couldn't be spent on other programs. And, since Defence doesn't have \$24–28 billion sitting around in its financial plan doing nothing, the government would either need to provide Defence with significantly more money, representing an opportunity cost to other government programs and priorities, or the government would have to cancel or significantly reduce other defence capabilities.⁶³

How much 'new money' would be required?

Let's consider the first option. If we project out the 2020 DSU's funding line beyond 2029–30 to, say, 2033–34, when the B-21 capability would have largely been delivered, total Defence funding from 2023–24 to 2033–34 is \$867 billion. That means that the acquisition cost of the B-21 would be around 3.2% of Defence's budget over that period. Since acquisition funding is projected to be around 35%–40% of Defence's total budget, the B-21 would require around 8.5% of Defence's acquisition budget over that period. As a point of comparison, annual spending on the domestic Naval Shipbuilding Program has averaged around 14.6% of Defence's total acquisition budget in recent years (a percentage that will increase substantially as construction on the Hunter and SSN programs ramps up).⁶⁴

Since the average annual acquisition spend would be around \$2.5–3 billion and Australia's GDP will probably reach \$3 trillion before the end of this decade, supplementing Defence's funding by this amount would represent an increase of roughly 0.1% of GDP. While predictions of defence spending as percentages of GDP can change dramatically as GDP predictions rise and fall, broadly speaking that acquisition alone would increase defence spending from around 2.2% to 2.3% of GDP.⁶⁵ In contrast to the shipbuilding spend, however, the B-21 acquisition cash flow would be bounded and not continuous—it would have a finish date.

Sustainment and operating costs would be ongoing. While they could exceed the cost of any current capability, they would be significantly less than the annual acquisition spend on the B-21, based on our analysis in Chapter 4. That is, the annual cost would moderate once the capability entered service.

What would need to be offset?

If the government chose the second path, namely finding offsets, it would have a significant impact on Defence's existing investment program. The funding required far exceeds Defence's ability to realise it simply through

efficiencies. Other capabilities would have to go. Developing coherent options would require the government to set out clear priorities for the ADF and accept more risk around Defence’s ability to perform lower priority tasks.

To provide some context on the scale of the impact, here are the budgets of some other major projects in the 2020 Force Structure Plan that have funding in the relevant time frame of roughly 2025–35 (noting that not all of the funding is necessarily in the window in which B-21 acquisition would occur):

- Hunter-class frigates: \$45.6 billion
- infantry fighting vehicles: \$18.1–27.1 billion
- high-speed long-range strike, including hypersonic research: \$6.2–9.3 billion
- teaming air vehicles: \$7.4–11 billion
- additional air combat capability: \$4.5–6.7 billion
- deployed ballistic and high-speed missile defence: \$15.8–23.7 billion
- weapons inventory surety: \$20.3–30.4 billion.

It’s not within the scope of this study to assess which of those is a higher priority than the B-21. A strong capability case can be made for all of them, which is why they’re in the investment program in the first place. Some could become even more necessary should the B-21 be acquired (for example, the weapons inventory surety), but we should be cautious about automatically privileging capabilities that are already in the program over new additions, particularly when our strategic circumstances have changed since they were first added to the acquisition program.

Does Defence really need more megaprojects?

Acquiring the B-21 would add another megaproject to an acquisition program that already contains several megaprojects: SSNs, Hunter-class frigates, infantry fighting vehicles—with other ones further down the pipeline such as ballistic missile defence and various aircraft replacement programs. Megaprojects can take years, indeed decades, to mature before they deliver capability. In the meantime, they consume billions in cash flow. This limits the government’s and Defence’s ability to react to changing strategic circumstances and emerging threats. The sunk cost can make it politically difficult to cancel the project and reassign resources to new priorities. Granted, the cancellation of the Attack-class submarine at a sunk cost of \$4 billion shows how much money can be lost if we realise that a megaproject isn’t delivering the capability we need and we have to change course.⁶⁶

Noting that Defence’s financial and human resources are finite, it may be that the government would need to cancel another megaproject to free up space for the B-21, with associated capability impacts. That said, the B-21 could probably be acquired in a relatively short time frame compared to other megaprojects, meaning it would deliver a capability return on the substantial investment much faster than projects such as the Hunter-class frigate and the SSNs. But the bulk of the B-21s acquisition funding would be in the crucial decade out to 2022-23.

The people problem

ASPI has written previously about the difficulty Defence has encountered in growing its ADF workforce.⁶⁷ Over six years in what’s essentially been a financially unconstrained environment, the ADF has grown by only 300 personnel per year. It still needs to grow by around 3,000 to fill the positions created by the *2016 Defence White Paper* and the 2020 DSU before it can begin to address the roughly 14,000 new positions announced by the previous government earlier this year. Any new requirement for skilled workforce adds to that pressure.

We could consider two ways to address this. The first is a reasonably traditional approach; as discussed, an Australian B-21 capability would need to be implemented as part of a large coalition enterprise. Therefore, under arrangements similar to AUKUS’s SSN program, the training of Australian aircrew and maintainers could begin almost immediately on other classes of USAF bombers. They could then transition to US B-21s as those aircraft enter service and ultimately to Australian B-21s. The situation would be similar for other trades that would require new skill sets, such as air battle managers, targeteers, munitions technicians, and so on.

The second is a more radical approach and involves fundamentally rethinking Defence's capability development philosophy. At the moment, Defence has an 'if you build it, they will come' approach. Granted, Defence carefully assesses how many people each new capability needs, but it assumes that its recruitment and retention tools will be sufficient to develop the necessary workforce. But, despite its best efforts, those tools aren't working.

A more radical approach would be to flip the process around and design a force that can deliver the maximum effect with the number of people that Defence might reasonably expect to have. Under that approach, we would seek 'more bang for the person'. Seen through this lens, the B-21 becomes considerably more attractive. Of course, the B-21 will still require very skilled operators, but it will be a relatively small number compared to some other high value capabilities, such as the 2,000–2,500 required for a fleet of SSNs. Moreover, when our people are extremely valuable, the fact that each B-21 has a crew of only two becomes a very significant feature.

How long will stealth endure for?

The B-2 is harder to detect than stealth fighters. In particular, its flying wing shape means it has no vertical control surfaces, so its form can be optimised to minimise radar reflections in particular wavelengths. The B-21 is likely to be even stealthier. Since the key advantage of the B-21 over 'bomb trucks' of various kinds is its highly developed stealth, it's reasonable to ask whether its stealth will endure. It's been suggested that quantum radars could render stealth technologies irrelevant.⁶⁸ For example, in 2021 it was reported that Chinese researchers from Tsinghua University were working on developing quantum radar technologies that could detect stealth aircraft.⁶⁹ If a B-21 can be detected as easily as a B-52 or a C-130J, the huge investment in acquiring it would be largely nugatory.

We should note that there's nothing particularly new about claims of radars being able to detect stealth aircraft. It's no secret that lower frequency, longer wavelength radars already have some ability to detect stealth aircraft. The problem for air-defence systems is that those radars can't provide fire-control solutions—you can't use the information to fire a missile at the aircraft. Still, having some ability to detect the aircraft is better than nothing for air-defence systems. Mission planners already plan air combat operations for stealth aircraft around this. It's a factor to be taken into account, but it doesn't eliminate the benefits of stealth by any means. So, even if quantum radars could detect stealth aircraft, the question is: what additional useful information would that provide to an air-defence system?

Moreover, there's considerable scepticism about the feasibility of quantum radar systems, particularly in real-world applications. For example, they may only work at very low temperatures and may only provide an advantage over classical radar technology at extremely low levels of power that are too low to provide any real-world utility.⁷⁰ At best, they seem to offer the potential for 'trip-wire' detection, but probably not tracking.⁷¹ So it seems unlikely that the B-21 will become as visible as B-52s and C-130Js any time soon. Nevertheless, it's important to perform due diligence before embarking on a \$28 billion investment.

Will the US let us have it?

Two years ago, it may have seemed unlikely that the US would provide us with the B-21. The AUKUS announcement has changed everything. That doesn't mean we should assume access would be automatic, but with the US now seeking greater contributions from its allies in the Indo-Pacific to contribute to the collective deterrence of the Chinese Communist Party's coercion and aggression, the pendulum appears to have swung in Australia's favour. In August this year, USAF Secretary Frank Kendall responded to a question regarding Australian access to the B-21 by stating:

... I don't think that there's any fundamental limitation on the areas in which we can cooperate. If Australia had a requirement for long-range strike, and I think I'd turn it over to the chief of air staff to talk about that, then we'd be willing to have a conversation with them about that.⁷²

There are a range of steps between expressing interest and actually seeking to acquire the capability. The Australian Government should, as a first step, seek access to sufficient information to understand the cost and FICs involved in operating the capability.

Nuclear issues

The B-21 is being designed to be part of the US’s nuclear forces. This raises issues for a potential Australian acquisition. The first issue is whether the US would let us have a nuclear-capable bomber. History would suggest that the answer is ‘yes’.

The F-35A is being certified to carry nuclear weapons. Five US allies in NATO already participate in nuclear sharing to the extent of having aircraft that are able to carry nuclear weapons; four of them are acquiring the F-35A and are likely to use it in that role.⁷³ So the US can and does provide nuclear-capable aircraft to its allies.

But a long-range bomber that’s potentially capable of reaching mainland China from Australia (with refuelling) is a different matter from a fighter. The USAF’s B-21 will be able to carry not only free-fall bombs, but nuclear-tipped cruise missiles. However, the US can remove and has removed the nuclear capability from aircraft, for example to comply with arms-control measures. Its B-1 fleet is no longer nuclear capable, and only around half of its B-52 fleet retains a nuclear capability. The F-111 was nuclear capable in US service, but Australia’s aircraft had that capability removed. Therefore, it would appear that it would be possible for the US to provide a non-nuclear-capable version of the B-21. It’s likely that decommissioning any RAAF B-21’s nuclear capabilities would be more complex than simply removing a black box, but an assessment of the cost and technical risk involved would be another part of the due diligence process.

The second issue is an adversary’s threat perception, particularly for a nuclear-armed adversary. It may still see Australian B-21s as a threat—one potentially to be placed on its nuclear targeting list. This can be addressed in two ways. The first is to reaffirm Australia’s longstanding commitment to not seek nuclear weapons. Australia’s policy of not acquiring or using nuclear weapons is clear and unambiguous. This was one of the current government’s conditions when it was in opposition for supporting the acquisition of nuclear submarines under AUKUS. It has vigorously restated this after AUKUS. It would be no different with the B-21. This declaratory approach would also include reaffirming Australia’s commitment to the Treaty of Rarotonga (the South Pacific Nuclear Free Zone Treaty), under which it won’t permit the stationing of any nuclear explosive device on its territory.⁷⁴

The second mitigation is to establish a verification process under which it could be demonstrated that Australia’s aircraft had been denuclearised. There are clear analogies with the SSNs to be acquired under AUKUS; Australia and its partners have stated that they’ll implement a rigorous safeguards regime in cooperation with the International Atomic Energy Agency. An inspections regime is also consistent with precedents set by USAF aircraft such as the B-1B, which has been denuclearised.

International responses

An Australian acquisition of the B-21—indeed, of any long-range strike capability—would need to be conducted through careful engagement with key regional partners. In this regard, the initial AUKUS announcement isn’t a good template to follow. Any public announcement should be preceded by confidential discussions about Australia’s intent and the enhancement to regional stability and security that a strengthened conventional deterrent will bring.

Of course, there’ll be countries that won’t be happy. We can already draft China’s response, which will be the usual mix of chestnuts such as that the acquisition represents Cold War thinking, arms racing, zero-sum thinking, and so on. Since the intent of a B-21 acquisition is to bolster regional deterrence against Chinese coercion and aggression, we can hardly expect any other response. Australia’s only reply should be to remind the international community that China already has long-range bombers (and is developing its own stealth bomber), other conventional

long-range strike assets such as intermediate range ballistic missiles, a rapidly expanding fleet of submarines (including nuclear-armed and nuclear-powered boats) and a large and growing nuclear arsenal, including intercontinental ballistic missiles. China also continues to reject or deflect any proposals for transparency about those capabilities.

The concerns of other regional nations should be taken seriously. Australia's motivation for the acquisition and its contribution to regional stability and deterrence should be explained in advance of a public announcement. Once the capability enters service, Australia should make neighbours familiar with it and explain how it can contribute to collective security. For example, we should provide regional partners with the opportunity to exercise with the capability at Exercise Pitch Black in the Northern Territory. But if some countries privately accept Australia's motivations and the benefits to regional security that an effective strike capability would deliver, they may still choose to appease various domestic and international audiences, so we'll need to accept some criticism.

Chapter 5: Bombers versus missiles

We've seen that there are arguments against the B-21. And \$28 billion could buy a lot of missiles. Those missiles could make Australia look like a very prickly porcupine (or echidna). Does that mean they're a better option than a long-range bomber? Like everything in the force design space, the answer is that it depends on what you want to achieve.

Missiles aren't cheap either

The first point to make is that if you want to impactfully project at long range, Western countries don't currently have a land-based missile that has comparable range to a bomber. The Tomahawk land-attack missile has a range of around 1,600 kilometres. There currently isn't a land-based version in service, but, with the end of the Intermediate-Range Nuclear Forces Treaty, it's likely that the US will re-establish the capability. But that's still only between one-third and one-half of the likely range of the B-21. Moreover, that range is about the same as our current air combat force's strike range so, while it may require less overhead to launch TLAMs from northern Australia than to employ strike packages built around F-35As, it doesn't actually increase the length of the echidna's spines.

A key factor is that, the further you want a missile to go, the more expensive it will be.⁷⁵ The larger the warhead you want it to carry, the more expensive it will be. Moreover, none of the missile delivering the warhead is reusable. That delivery system, which comprises a very sophisticated motor and guidance system consisting of hundreds of components (including many microchips), which may well be in very short supply in a conflict, and that may have taken years to build, is destroyed in the process.

The US and some of its allies are developing hypersonic missiles, some of which will have greater range than existing missiles.⁷⁶ But hypersonic missiles aren't going to change that calculus. They may reach the target faster and be harder to defeat, but they'll still be a very expensive way to deliver a relatively small amount of high explosive. The US Army's Long Range Hypersonic Missile will have a range of around 2,750 kilometres (still less than a bomber), but also a hefty price tag—potentially US\$100 million each according to some reports and US\$40 million according to others.⁷⁷ No doubt the US Department of Defense will be seeking to reduce the cost as the technology matures, but hypersonics will always be very expensive.

Cost-benefit analysis

If the claim is that missiles will achieve the same effects more cheaply than bombers, that's a cost-benefit argument that we can test. But we'd need to do a lot of tests, because, like many areas of force design, we're in an assumption-rich environment and different assumptions will produce very different results. However, the analysis will be some version of the following example.

Let's say that we want to prosecute 25 targets at a range of 3,000 kilometres. We'll assume each target will require two munitions to ensure an acceptably high probability of successfully destroying it. If we prosecute the targets with a long-range penetrating bomber with very high levels of stealth that can get relatively close to them, we could use

one bomber carrying 50 small munitions each costing \$100,000, for a total cost of \$5 million in ordnance. But we also have the \$1 billion sunk cost of the bomber to consider. However, if we use ground-launched missiles, a missile that can fly 3,000 kilometres will be very expensive, as we've noted. Let's assume that their cost has come down to \$20 million each. The cost of 50 weapons is then \$1 billion, so it's basically the same. Except, to have that bomber available, we needed to buy a fleet of 12 for around \$28 billion. So how many times are we going to need to conduct that mission? Is 28 times a reasonable assumption?

Changing the assumptions will change the comparison in favour of one side of the bomber versus missile balance. The fundamental question is: what's a reasonable set of assumptions?

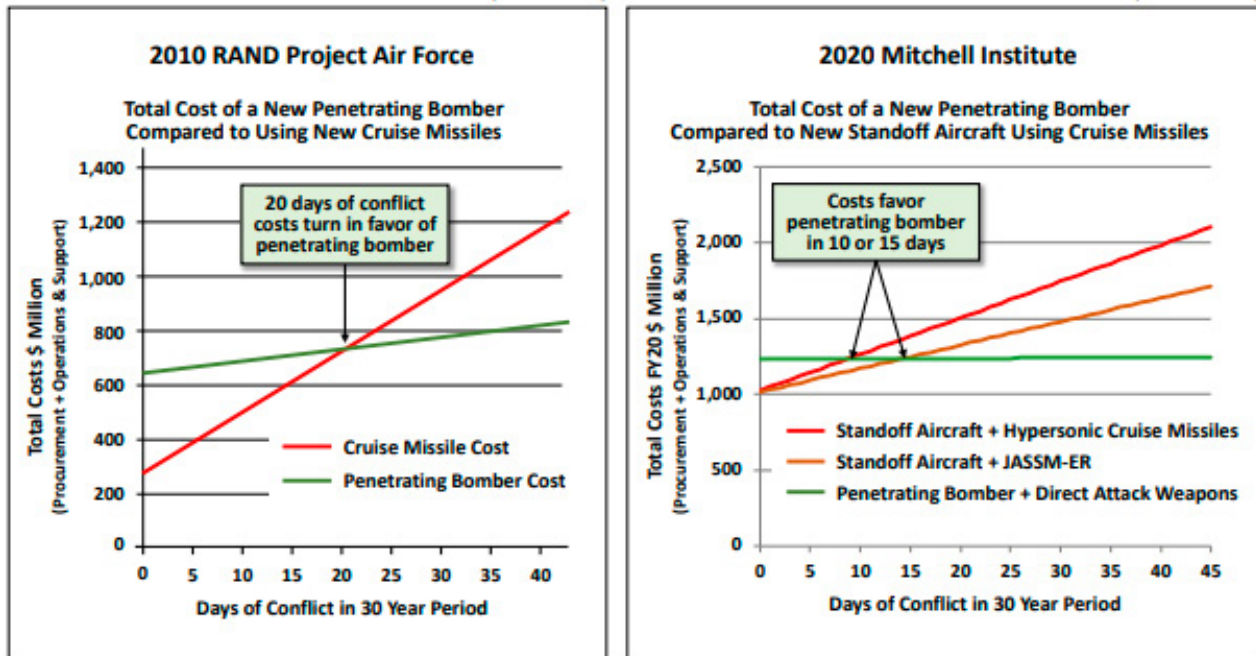
Some of the variables to consider include:

- *Range.* A range of up to 4,000–5,000 kilometres makes little difference to the bomber, but increasing the range has a major impact on the price of the missile. If you only want to prosecute targets up to a range of 1,600 kilometres, the Tomahawk is a relatively inexpensive option, but a missile with a 4,000–5,000-kilometre range is a very expensive prospect.
- *Effectiveness of stealth.* If the bomber's stealth 'overmatches' the adversary's air-defence capabilities, that moves the needle in favour of bombers, as they can use shorter range and therefore cheaper weapons. If the bomber needs to stand off and launch a weapon such as the JASSM-ER, which cost \$3 million each, it might not provide significantly better capability than some of the 'bomb truck' options we discuss below.
- *Attrition.* The flip side of the previous point is that, in a prolonged conflict with a peer adversary, you're likely to lose bombers, even stealthy ones. That will not only affect the cost-benefit assessment, but potentially at some point prevent you from delivering effects at all. Defence virtually never factors combat attrition into its acquisitions, but, as we enter an era in which combat with a technologically advanced adversary could occur, that needs to change.
- *The multiplier effect on FICs.* We've considered the FICs needed for the B-21 and their cost. But long-range missiles are big. That means big launchers, big support vehicles to reload them, large infrastructure to store them and the missiles, and lots of people to operate them.
- *Flexibility.* A bomber can carry a range of weapons optimised for the target. But a long-range missile could be overkill for a small, tactical target. Moreover, a bomber can deploy weapons than can't be delivered by long-range missiles, such as smart sea mines.
- *The number of targets.* More targets essentially means more opportunity to amortise the cost of the bombers. If you're mainly interested in sinking ships, that's a relatively limited number of targets and a small number of very capable missiles could suffice. If you're trying to degrade a dug-in land force, that's potentially thousands of targets.
- *The length and frequency of the conflict.* Again, longer conflict means more missions to amortise the cost of the bombers. Moreover, in prolonged conflict with disrupted supply chains, it will be more viable to produce short-range, less sophisticated weapons than to rely on the capability of the bomber to get them to the target, rather than long-range stand-off weapons.

So there are many variables affecting the calculus, and, without a military strategy and operating concept, it's hard to assess which are reasonable assumptions.

Some US institutions have attempted to conduct this kind of analysis. Figure 14 compares the results of studies conducted by the RAND Corporation and the Mitchell Institute (both of which are funded by the USAF). We should note that both studies considered air-launched weapons rather than ground-based missiles.

Figure 14: RAND and Mitchell Institute cost comparisons of bombers versus missiles

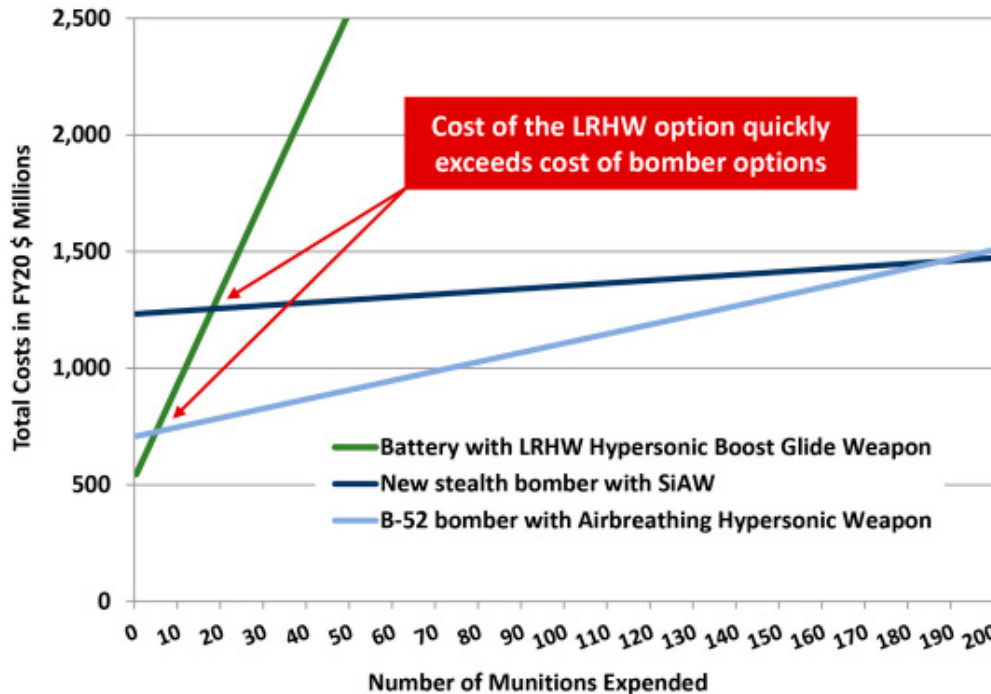


Source: Mark Gunzinger, *Long-range strike: resetting the balance of stand-in and stand-off forces*, Mitchell Institute, Arlington, 2020, 6, [online](#).

The RAND study compared the cost of bombers to the cost of cruise missiles, while the Mitchell Institute compared the cost of bombers using direct attack weapons with stand-off aircraft using long-range weapons (JASSM-ER and a hypersonic cruise missile). Both studies analysed at what point the cost comparison turned in favour of bombers. In the RAND study, the costs favoured bombers after 20 days of conflict over a 30-year period; Mitchell put it at between 10 and 15 days. According to the Mitchell Institute, the analysis in the RAND study was crucial in the US Department of Defense's decision to begin the B-21 program.⁷⁸

The Mitchell Institute also conducted a cost comparison of the B-21 using a new generation of 'stand-in attack weapons' with the Long-Range Hypersonic Weapon (LRHW) as well as with the legacy B-52 employing a new air-breathing hypersonic weapon (see Figure 15). Considering that the exercise assumed a cost of US\$40 million for the LRHW, the cost of that option exceeded the B-21-based option after less than 20 weapons were expended. Since the cost of the new air-breathing hypersonic weapon was assumed to be US\$4–5 million, the cross-over point was at around 190 munitions.

Figure 15: Cost comparison of B-21 with LRHW and B-52 with new stand-in weapon



Source: Mark Gunzinger, Lukas Autenried, Bryan Clark, *Understanding the long-range strike debate*, policy paper 26, Mitchell Institute, April 2021, 7, [online](#).

Every comparative cost-benefit analysis will be assumption dependent. The Mitchell Institute's assumptions might not be valid for Australia. For example, as a superpower with global security commitments, the US is likely to participate in conflicts in which long-range strike capabilities are employed more often than is Australia.

Numbers matter

Whichever long-range strike option the government pursues, we'll need significantly more guided weapons than the ADF has previously held. This is one of the major lessons from modern warfare. In July, President Zelenskyy stated on social media that Russia had already fired 3,000 cruise missiles at Ukraine.⁷⁹ US air campaigns since 1991 have used thousands of weapons. Even the US was able to sustain those campaigns only by relying on affordable direct-attack munitions rather than expensive long-range stand-off weapons. Some 97% of the air-to-ground munitions used by the US in its major air campaigns in the 1990s and 2000s were direct-attack munitions. The Mitchell Institute estimated that the USAF would exhaust its inventory of around 6,500 long-range weapons (JASSM, JASSM-ER and LRASM) in less than nine days of conflict with a peer adversary.⁸⁰

Whatever long-range weapons Australia acquires, it's hard to see us holding enough to sustain air operations in anything other than the most narrow set of missions (for example, prosecuting a small number of maritime targets) if we are relying on them exclusively for long-range strike. Australia is acquiring 80 JASSM-ER land-attack missiles at a cost of US\$235 million; that's unlikely to be enough for any conceivable strike operation against a peer adversary. As we've noted, the US launched 59 Tomahawk missiles at a single Syrian air base with only temporary effect.

The B-21 may allow us to solve this problem. To tilt the cost-benefit calculus in its favour, there are signs that the USAF is exploring new weapons that offer a better balance of range against cost. By exploiting the B-21s range and stealth, it can trade off the ordnance's range to reduce cost allowing the B-21 to deliver 'affordable mass' while still surviving.⁸¹ Such weapons could be acquired in much greater quantities than JASSM-ER or LRASM for the same outlay.

The key point is that an aircraft such as the B-21 allows you to make such trade-offs—long-range missiles alone do not. Since the cost of a missile is directly related to its range, Australia will never be able to generate mass from missiles that have to be launched at great range from the target, whether those are land-based or launched from non-stealthy aircraft. The same is true for ship- or submarine-launched missiles due to those vessels’ very limited magazine depth. Moreover, if the ADF is reliant solely on long-range missiles, it has limited ability to match the weapon to the target—you’re using a scarce multimillion-dollar weapon regardless of the nature of the target.

Chapter 6: Other strike options

The USAF conducted an analysis of alternatives that considered many different solutions to its long-range strike requirements. The fact that it identified a penetrating bomber as the best solution doesn't automatically mean that it's the best solution to Australia's requirements—after all, the USAF has always had the infrastructure, trained personnel and support capabilities required to operate a fleet of long-range bombers. The cost of entry for Australia is substantially higher. Plus, some of the options considered have undergone further development; uncrewed and autonomous systems continue to make significant strides. Nevertheless, all options come with their own mix of cost and risk, advantages and disadvantages.⁸²

Cyber

As one of the means to impose greater cost on an adversary, the DSU explicitly refers to cyber. We won't discuss cyber in detail here, simply because it's something Australia is investing in heavily already. Australia has a declared offensive cyber capability, managed by the Australian Signals Directorate (ASD). And, while few details about the scope of ASD's \$9.9 billion REDSPICE program that was announced in the March 2022–23 budget have been revealed—other than that it will rapidly double the size of the organisation—it's reasonable to assume that it will boost ASD's offensive cyber capabilities even further.

Cyber won't be the only solution to our strike requirements. Many targets won't be connected to the internet. Russia is one of the most accomplished cyber actors, and offensive cyber operations are part of its toolbox. While cyber has had an impact in the war in Ukraine, Russia hasn't been able to shut down Ukraine's power grid through cyber means and it has still expended thousands of kinetic strike munitions.

But we shouldn't ignore the potential synergies between cyber and kinetic strike. Cyber is a crucial ISR asset and therefore can play a vital role in our own targeting system by collecting information on adversary systems. This includes helping us to understand an adversary's command and control networks and identifying key nodes that can be kinetically prosecuted. Cyber can potentially provide real-time information on the status of an adversary's assets, which is essential for mission planning, as well as battle damage assessment.

The Goldilocks bomber

A fundamental disadvantage of the B-21 is its price. It provides very substantial capability, but that comes at a high price. The problem is that there aren't any off-the-shelf options for a 'Goldilocks' bomber—something with greater range and payload than a fighter, but at less cost than the B-21. We briefly review several here.

Converted 'bomb trucks'

Several options involve a 'bomb truck'; that is, some kind of transport aircraft with relatively large payload that's modified to deliver munitions. Like all strike options, the bomb-truck concept has advantages and disadvantages.

One variant that's been proposed but not developed envisages converting a civilian jet airliner such as a Boeing 747. While the range and payload of a 747 may sound like an attractive starting point, converting an aircraft that doesn't have a bomb bay or hard points on its wings is a significant engineering challenge and hasn't been seriously pursued by any nation.

Palletised munitions

Another variant on the theme that also uses military airlifters is showing much more promise. Under this concept, munitions are air-dropped from the back of an airlifter such as a C-17 or C-130 Hercules and then ignite their motors once in the air. The 'palletised munitions' concept is approaching maturity. The USAF Research Laboratory recently successfully demonstrated the launch of the JASSM-ER long range strike missile from a MC-130J Hercules (Figure 16).⁸³

Figure 16: A palletised 'effects system' containing JASSM-ER missiles falls from the cargo hold of a USAF MC-130J during a live-fire demonstration on 9 November 2022



Source: USAF Research Laboratory, [online](#).

This approach has several advantages. Key elements are already in or planned to be in ADF inventory. The RAAF already has eight C-17A and 12 C-130J aircraft in its inventory, and, according to a recent Defence media release, the current C-130J will be replaced with a larger number of the same aircraft.⁸⁴ The JASSM-ER is also being acquired by the ADF. Both the C-17A and the C-130J have longer range than the F-35A and can carry significantly more weapons of the class of JASSM-ER. Should a weapon such as the LRASM or the Joint Strike Missile be integrated into the system, it would also give the C-130J a maritime strike capability (noting that striking moving targets adds a layer of difficulty to the task and the weapon would need to be delivered well outside the adversary's air-defence system).

Just as importantly, this approach can enable the dispersed or 'mosaic' operating concepts that are likely to be required in a future conflict with a major-power adversary that has significant strike assets of its own. Sustaining combat operations is likely to require the dispersal of assets both to complicate an adversary's targeting challenge and to allow strike operations to continue should the runways and aprons needed to support fighter aircraft be damaged by the adversary's offensive operations. The C-130J can operate off relatively short and primitive runways, meaning that a larger number of airfields can be used, including many throughout our near region outside of Australia.

The use of palletised munitions from relatively unprepared air bases could be supported by hub-and-spokes concepts in which pallets are prepared in safe areas in Australia's south and delivered to forward operating bases, minimising the amount of infrastructure and stored munitions exposed to the adversary's strikes. Since the weapons are loaded on standard cargo pallets, no specialised equipment is needed, enhancing the flexibility of this approach.⁸⁵

Of course, there are disadvantages to this concept. Transport aircraft aren't survivable in contested environments; they have a massive radar signature and can't outrun enemy fighters or evade air-defence missiles. Therefore, they would need to operate outside the adversary's air-defence envelope. While the use of long-range stand-off weapons allows them to do this (for now at least), it does mean that a transport aircraft in this role can only use weapons that are, as we've noted, expensive and in very short supply. While a C-130J can in effect extend the range of a JASSM-ER, it's still delivering a very expensive JASSM-ER. It can't extend the range of an affordable direct-attack munition because the C-130J would most likely be destroyed in the process of delivering it.

A separate disadvantage is that, as soon as a conflict starts, all airlift assets will be in high demand and the bomb trucks may be assigned to other tasks.

P-8A

The RAAF already has another fleet of potential bomb trucks in its inventory: its 14 P-8A maritime patrol aircraft. The previous government announced that the P-8A would be equipped with the LRASM. This is a significant increase in maritime strike capability over the Harpoon anti-ship missile. But a weapon such as the related JASSM-ER could also be integrated onto the aircraft, giving it a land-strike capability, although that would probably have to be done at Australia's expense, since the US Navy doesn't appear to have expressed an interest in that path. But, if Australia did explore that concept, there are other weapons that could be integrated on the platform, such as the Naval Strike Missile, which has a land-strike mode.

Nevertheless, all of the disadvantages of the palletised munitions approach outlined above apply to the P-8A as a bomb truck: it's not stealthy, it needs to rely on expensive long-range stand-off weapons, and in time of conflict it will probably have its hands full dealing with its primary missions of antisubmarine warfare and maritime strike.⁸⁶

B-1B Lancer

One strike option for Australia that has circulated for some time among commentators is the acquisition of former USAF B-1B Lancer bombers.⁸⁷ The B-1B is a supersonic, long-range, heavy bomber that entered service in 1986. A hundred were built, but only around 45 are still in service, as aircraft have been retired as cost-saving measures. While it could originally carry nuclear weapons, that capability was disabled in the 1990s and it now carries only conventional weapons. However, the range of weapons it can carry has been progressively expanded and demonstrates the flexibility of a large, long-range bomber.

It can, for example, carry 96 Small Diameter Bombs (SDBs; precision-guided 250-pound class weapons) or 24 of the larger JDAMs. It can also be used in the maritime strike role using the LRASM, and it can lay sea mines. The USAF is also planning to launch its future hypersonic weapon from the B1-B.

The B-1B could provide a strike boost to the ADF. In fact, the B-1B probably has a greater combat radius and payload capacity than the B-21. But it's not stealthy. It's not going to be able drop those 96 SDBs in a contested environment in which it will need to rely on stand-off weapons, so it's a different cost-benefit case from the B-21. In some ways, it's a bigger, faster and probably more expensive version of the C-130 bomb truck that we've discussed.

Another negative factor in the cost-benefit calculus is that the USAF will replace its B-1B fleet with B-21s in the 2030s. While Australia might get B-1Bs for a nominal acquisition cost, there would be major risks to our ability to successfully sustain the capability. Australia would start by being an operator of a subfleet of a small overall fleet and then transition to become the sole operator. As we've seen, small fleet sizes result in very high unit costs.

Moreover, it’s very difficult to be the sole operator when we don’t have the industrial base needed to support the capability. Australia had that experience previously after the USAF retired its F-111s, leaving Australia as the aircraft’s only operator.

One approach could be to operate the B-1B as a transition step to the B-21, but that path to re-establish a bomber capability comes at significant cost and churn, duplicating the transition effort. A better transition path could be deeper participation in the Enhanced Air Cooperation initiative, which is discussed below.

Uncrewed and autonomous systems

The small, the smart and the many

ASPI authors have questioned the acquisition of exquisitely capable yet extremely expensive larger crewed platforms that can be acquired only in small numbers and have encouraged the ADF to take up uncrewed and autonomous systems, particularly those that can be produced quickly, cheaply and in mass. We’ve laid out the benefits of ‘the small, the smart and the many’ in previous publications and have advocated for the government and the Defence Department to support Australian companies that already have the ability to produce uncrewed autonomous systems and loitering munitions,⁸⁸ so it may appear inconsistent that we’re examining the feasibility of the B-21, which is the epitome of exquisite and expensive. Why not pursue the small, the smart and the many to deliver long-range strike?

The challenge is in the requirement for long range. Currently, long range requires relatively large systems. That applies to both crewed and uncrewed systems—and missiles are essentially uncrewed kamikazes. But, as we’ve noted, that long range comes at a cost, so the small won’t have the range and acquiring lots of the systems that do have range will come at great cost.

But it’s not an either/or situation. It’s highly likely that the strike system of the future will be a combination of both; that is, a large mothership will carry and deploy many small, potentially disposable, systems. We’ve already examined the cost–benefit ratio of being able to use smaller, cheaper, short-range munitions. The mothership, whether an exquisite one like the B-21 or a utilitarian one like an airlifter, could be armed with munitions as well as small UAVs. The UAVs could provide electronic warfare effects, such as jamming or being decoys, or they could be loitering munitions that target air-defence radars when those radars turn on to detect the mothership. The precise mix could be tailored for the individual mission.

An uncrewed Goldilocks bomber

It’s possible that the Goldilocks bomber could be an uncrewed aircraft. It would need to be large enough to have sufficient range to cover our near region, but small enough to be affordable. An uncrewed aircraft changes the calculus. First of all, it doesn’t need systems to keep the crew alive, so that space and weight can be assigned to fuel and payload. Moreover, since we aren’t protecting very valuable aircrew, we can probably accept higher losses. Those factors drive cost down and potentially deliver more payload. If one of the key risks for the B-21 (or any crewed aircraft) is the ability of a small fleet to absorb attrition, an uncrewed aircraft potentially offers a better alternative. It’s likely to be cheaper, smaller and simpler, allowing it to be produced in greater numbers.

There are potentially other benefits to this kind of aircraft.

There are *industrial* advantages: if they can be produced quickly, they can be produced responsively (that is, when we need them), rather than being acquired in one batch to last for 30 years. They could also be assembled in Australia with fewer and simpler components—a key advantage in wars (which are essentially exercises in supply-chain disruption).

There are *operational* benefits: they could be pre-positioned in containers at bare bases in northern Australia. They could self-deploy to forward operating bases with short runways. Large numbers of UAVs operating from large numbers of airfields contribute to the mosaic warfare effect that we've discussed. Dispersal aids survivability and resilience, while complicating the adversary's defensive operating picture. More aircraft operating from more locations deliver a greater operational tempo, wearing the adversary down.

There are *personnel* benefits, and as we've seen, the availability of people with the right skills will be one of Defence's biggest challenges. UAVs may need as many people as crewed aircraft overall, but they require different skill sets. While modern combat aircraft are exquisite systems, the skills required of their operators are equally exquisite, requiring years to develop. It's often been said that the hardest parts of an air-combat system to develop and replace are the pilots. Anything that can be done to mitigate that risk should be pursued.

Unfortunately, something like this doesn't exist—yet—but one can imagine what it could look like, and it's not necessarily an unobtainable unicorn. It could be, indicatively, something like a larger, twin-engine version of the MQ-28A Ghost Bat currently being developed by Boeing Australia for the RAAF. An aircraft in that class could have a combat radius of several thousand kilometres with a payload of two to four large weapons such as stand-off missiles, or 12–16 weapons in the class of the Small Diameter Bomb.

The modular nature of the Ghost Bat means that strike packages as well as individual aircraft could be tailored to the particular missions, with armed Ghost Bats being accompanied by electronic warfare versions or communication node versions. And Ghost Bats could themselves be motherships for smaller, disposable UAVs or loitering munitions.

It's highly likely that a combination of a long-range strike UAVs working with smaller, disposable systems like this will be part of the future of strike aircraft. The question is: when will this kind of capability be mature? If it's feasible by the end of this decade, then it's an option that warrants further consideration and potentially accelerated investment.

The US Force Posture Initiative / Enhanced Air Cooperation

There is potentially a way for Australia to have its cake and eat it too: by hosting USAF B-21s. The Enhanced Air Cooperation (EAC) stream of the US Force Posture Initiative has continued to develop over the past five years. The EAC supports the US strategy of dispersal of assets throughout the Indo-Pacific, complicating the PLA's targeting and creating greater resilience in the face of PLA long-range strike.

Under the EAC, USAF B-1, B-2 and B-52 aircraft have visited northern Australia for relatively short deployments. The cooperation took a major step forward earlier this year when four B-2 bombers—a not inconsiderable part of the USAF's total fleet of 20—operated for around two months out of northern Australia. Another significant step forward is the development of the infrastructure at RAAF Base Tindal to support extended rotations of up to six B-52 bombers.

Should the USAF reach its target of at least 100 B-21s, it's reasonable to assume that some will deploy regularly to northern Australia, particularly if the aircraft's maintenance requirements are less demanding than the B-2's. Having our major ally rotate B-21s through northern Australia could obviate the requirement for Australia to have this kind of long-range strike capability in its own order of battle. Strong alliances allow a nation to accept more sovereign risk in particular areas than it would if it were not in the alliances. Australia and other US allies rely on the US's extended nuclear deterrence and don't pursue their own nuclear forces. The Australian Government could continue its current approach to conventionally armed bombers and rely on the EAC program.

Of course, one could respond to this proposition by noting that rotations of US marines through Darwin under the US Force Posture Initiative haven't made the Australian Army redundant. Nor has the government sought to meet its future submarine capability needs solely by basing US Navy SSNs in Australia (although that would make sense as

part of the transition to an Australian SSN capability). Ultimately, the issue comes down to how much independent, sovereign strike capability the Australian Government requires. And any sovereign Australian capability adds to the overall alliance pool, which is the core concept underpinning the AUKUS SSN enterprise.

Should the Australian Government choose to re-establish a bomber capability, a potential pathway forward would be to use the EAC as a springboard; for example, by using USAF bomber rotations to train Australian aircrew and maintainers and by expanding the EAC facilities currently under construction at RAAF Base Tindal, such as fuel and munitions storage. Furthermore, in future, just as Tindal serves as a forward operating base for USAF bombers, it could also perform the same function for RAAF bombers, which could have their home base further south, closer to workforce and away from PLA threats.

Notes

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- 3 Brendan Nicholson, 'Senior US official says Washington would consider supplying B-21 bombers to Australia', *The Strategist*, 23 August 2022, [online](#).
- 4 Detractors include Hugh White, 'Australia and B-21 bombers: less bang for the buck', *The Interpreter*, 7 November 2022. Supporters, or at least those who have suggested it's worthy of further investigation before being dismissed out of hand, include Marcus Hellyer, 'B-21 bomber could be Australia's best long-range strike option', *The Strategist*, 24 May 2021, [online](#); Robert Haddick, 'Save the AUKUS partnership—share the B-21 bomber', *The Hill*, 2 November 2022, [online](#).
- 5 Department of Defence (DoD), *2020 Defence Strategic Update*, Australian Government, 2020, paragraphs 2.23, 3.3, [online](#).
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- 7 Richard Marles, 'Address to the Sydney Institute Annual Dinner lecture', 14 November 2022, [online](#).
- 8 Greg Sheridan, "'It's not optional": PM's strategic ambitions laid bare', *The Australian*, 4 November 2022, [online](#).
- 9 Richard Marles, 'Submarine Institute of Australia—Conversations with Michael Fitzgerald'.
- 10 On viable submarine transition timelines, see Marcus Hellyer, Andrew Nicholls, 'Australia's transition to nuclear-powered submarines could run into the 2060s', *The Strategist*, 7 July 2022; Marcus Hellyer, 'Australia's "damn the torpedoes" path to nuclear-powered submarines', *The Strategist*, 4 October 2022, [online](#).
- 11 In fact, it's hard to find any public information on operating concepts on Defence's website at the moment.
- 12 Marles, 'Submarine Institute of Australia—Conversations with Michael Fitzgerald'.
- 13 On the distinction between deterrence by denial and deterrence by punishment, see Michael J Mazarr, *Understanding deterrence*, RAND Corporation, Santa Monica, 2018, [online](#); on the application of the concept of deterrence by denial to strike capabilities in the Australian context, see Marcus Hellyer, 'Deterrence and a long-range strike capability for Australia (part 1)', *The Strategist*, 4 March 2020, [online](#); Marcus Hellyer, 'Deterrence and a long-range strike capability for Australia (part 2)', *The Strategist*, 5 March 2020, [online](#).
- 14 Mazarr, *Understanding deterrence*, 2.
- 15 This is not to say that Australia working with its allies can't conduct deterrence by punishment in certain circumstances. Calling out a state's bad behaviour in international forums is a form of deterrence by punishment: if you undermine international norms, we will hurt your reputation. Economic sanctions are also a form of deterrence by punishment. Moreover, Australia supports the US's extended nuclear deterrent, which is the ultimate form of deterrence by punishment. But kinetic, conventional deterrence by punishment against a nuclear-armed great power is a dangerous and most likely futile path for a medium-sized power to go down alone. Ultimately, all Australian approaches to deterrence of a major power need to be coordinated with our partners and allies; see Rebecca Shrimpton and Iain MacGillivray, 'Integrated deterrence' in John Coyne and Grace Stanhope (eds), 'With a little help from my friends': *Capitalising on opportunity at AUSMIN 2022*, ASPI, Canberra, 2022, [online](#).
- 16 DoD, *2020 Defence Strategic Update*, paragraph 1.13.
- 17 'Defence Strategic Review: Terms of reference for the independent leads of the review', Australian Government, 3 August 2022, [online](#).
- 18 We've often argued that the perfect is the enemy of the good when pursuing military capability. Why should it be any different when pursuing definitions of military concepts?
- 19 DoD, *2020 Defence Strategic Update*, paragraph 2.23.
- 20 Adapted from USAF doctrine publication 3-70, *Strategic attack*, 22 November 2021.

- 21 Take, for example, the PLA targeting a US Navy aircraft carrier with a DF-26 anti-ship ballistic missile as part of a Taiwan contingency. The 4,000-kilometre range of the DF-26 exceeds the range of World War II bombers that were conducting strategic strike against the adversary's homeland. But striking adversary platforms is generally a tactical effect and, by preventing US Navy carriers from operating close to China and Taiwan, the DF-26 is achieving a crucial operational effect. Moreover, if a DF-26 strike did sink a US carrier and cause the deaths of some of its 5,000 crew, it would probably have a strategic effect by causing the US public to question the ability of the US to win a war with China at acceptable cost.
- 22 DoD, *2020 Defence Strategic Update*, paragraph 1.2.
- 23 While passive defensive measures can be cost-effective, it's hard to envisage an Australian Government whose military strategy is to rely solely on the resilience of the Australian people to absorb attacks with no ability to respond.
- 24 Department of Defense, *Military and security developments involving the People's Republic of China 2022: annual report to Congress*, US Government, 2022, 53, [online](#).
- 25 We aren't suggesting that strike capabilities alone will be sufficient to deter, deny, degrade or defeat an adversary. It may well be necessary to evict an adversary from a forward operating base, which will require ground forces. However, our amphibious forces won't be able operate with acceptable levels of risk with the ADF and its partners without establishing air and sea control. That will require strike capabilities.
- 26 Defense Security Cooperation Agency, 'Australia—Joint Air-to-Surface Standoff Missiles—Extended Range (JASSM ER)', media release, US Government, 21 July 2022, [online](#).
- 27 Anthony Albanese, 'An address by Opposition Leader Anthony Albanese', Lowy Institute, 4 March 2022, [online](#).
- 28 As well as survivability. In the face of increasingly sophisticated air defence networks, enhancing weapon survivability is crucial, since all militaries have limited war stocks.
- 29 Benjamin S Lambeth, *NATO's air war for Kosovo*, RAND Corporation, 2001, [online](#).
- 30 T Michael Moseley, *Operation Iraqi Freedom—by the numbers*, Assessment and Analysis Division, Department of Defense, US Government, 30 April 2003, [online](#).
- 31 Marcus Hellyer, 'Does the Royal Australian Navy need Tomahawk missiles?' *The Strategist*, 16 February 2021, [online](#).
- 32 Wikipedia, '2017 Shayrat missile strike', [online](#). This does raise the question of whether strike capabilities (or air and missile defence capabilities) are the most cost-effective way to deal with an adversary's long-range strike capabilities that are targeting Australia's military assets. When the adversary is relying on very expensive long-range weapons, which they, too, will hold only in finite quantities, passive defences such as hardening of shelters, dispersal, decoys, or simply having the ability to rapidly repair runways could prove to be very effective. However, it may be politically unacceptable to simply 'sit and take it', particularly if the adversary also chooses to target civilian infrastructure or population centres. The bottom line is that Australia will need all three: counterstrike, hard-kill air defence and passive defences. The only question is: what's the most effective mix in return for the level of investment we're willing to make?
- 33 For an analysis of the limitations of the RAAF's strike capability, see Marcus Hellyer, 'Projecting power with the F-35 (part 1): How far can it go?' *The Strategist*, 27 September 2019, [online](#); Marcus Hellyer, 'Projecting power with the F-35 (part 2): going further', *The Strategist*, 3 October 2019, [online](#); Marcus Hellyer, 'Projecting power with the F-35 (part 3): operational implications', *The Strategist*, 10 October 2019, [online](#). While those pieces were written before the government announced the acquisition of the LRASM and JASSM-ER, they assumed that those weapons would become part of the ADF's inventory.
- 34 US Department of Defense budget papers list the cost of JASSM-ER at \$1.427 million in FY 2023 (Department of Defense, *Fiscal Year (FY) 2023 budget estimates. Air Force. Justification book volume 1 of 1. Missile Procurement, Air Force*, April 2022, 31, [online](#)). However, the US Defense Security Cooperation Agency states the cost of 80 JASSM-ER missiles approved for purchase by Australia at US\$235 million, which includes a much broader range of elements than simply the missiles themselves; Defense Security Cooperation Agency, 'Australia—Joint Air-to-Surface Standoff Missiles—Extended Range (JASSM ER)', media release, 21 July 2022, [online](#).
- 35 Granted, it would probably be a great value-for-money proposition to acquire them primarily for this role, but it illustrates the flexibility of the platform.
- 36 For an overview of the program from a reliable source, see Jeremiah Gertler, 'Air Force B-21 Raider long-range strike bomber', Congressional Research Service, Washington DC, 22 September 2021, [online](#). Because the program is being conducted outside the US Department of Defense's usual acquisition processes, it doesn't appear (yet, at least) in the US Government Accountability Office's *Weapon systems annual assessment*.
- 37 Greg Hadley, 'Six B-21s in production, fuel control software already tested', *Air & Space Forces Magazine*, 9 February 2022, [online](#).
- 38 A preliminary assessment of the differences between the two aircraft is provided in John A. Tirpak, 'Eight features that show the new Raider is not the B-2.1', *Air & Space Forces Magazine*, 5 December 2022, [online](#).
- 39 With refuelling, Australian-based B-21s could reach far into the South China Sea and probably to mainland China. This will not go unnoticed by China. We discuss this further in Chapter 4.
- 40 Of course, we can't assume direct overflight rights, so real-world range is a different thing from a range ring on a map. But this applies to any air-delivered strike system. It also applies to missiles.

- 41 Tyler Rogoway, 'Why the B-2 stealth bomber was used to strike ISIS camps in Libya', *The Warzone*, 3 July 2020, [online](#).
- 42 On 'air power contributions' as defined by the RAAF, see *The Air Power Manual*, 7th edition, March 2022, [online](#).
- 43 Joseph Trevithick, 'New look at air force's ship-killing smart bomb in action, Seeker details revealed', *The Warzone*, 22 September 2022, [online](#). The Quick Sink bomb uses a modified JDAM to deliver the same effect as a heavyweight torpedo by detonating beneath a ship, breaking its back.
- 44 On the role of counterstrike in enhancing the survivability of US and allied forces in the Indo-Pacific, see Carl Rehberg, Josh Chang, *Moving pieces: near-term changes to Pacific air posture*, Center for Strategic and Budgetary Assessments.
- 45 Andrew Nicholls, Jackson Dowie, Marcus Hellyer, *Implementing Australia's nuclear submarine program*, ASPI, Canberra, 2021, [online](#).
- 46 Of course, the scale of these enterprises isn't fixed. The Collins life-of-type extension could be shortened so it doesn't include all six boats; a new conventional submarine could be acquired overseas, although few of its supporters advocate this path; and what local construction of the SSNs looks like in practice could take a wide range of paths. The capacity risk in running three submarine enterprises depends to a large extent on the degree to which they complement or compete with each other. For example, does building a new conventional submarine here build industrial capacity and capability in preparation for the SSN build or simply compete for resources with it? It's difficult to answer these questions without knowing what an achievable schedule for the introduction of the SSN capability is.
- 47 Australian Defence Force, *Capability life cycle manual (Version 2.1)*, Australian Government, 2020, 2, [online](#).
- 48 As with all aircraft, the B-21 could operate off shorter runways by sacrificing fuel and ordnance.
- 49 Jeremiah Gertler, 'Air Force B-21 Raider long-range strike bomber', Congressional Research Service, Washington DC, 22 September 2021, [online](#).
- 50 Although, for those who have been in the game for a while, open doesn't always mean non-proprietary.
- 51 This is based on the 10-year average exchange rate, not the current exchange rate, which is at a 20-year low. Should the Australian dollar remain at this level, that would of course increase the acquisition cost.
- 52 There are some exceptions depending on how contracts are developed, but the statement is fundamentally true for military aircraft.
- 53 The problem with generating a whole-of-life sustainment cost is that it's hard to know how long the capability will be in service. Moreover, once out-turning is applied over what could be a 30–40 year service life, the result is a number that's very different from the constant estimate. This makes it very difficult to compare with the sustainment costs of existing capabilities.
- 54 Government Accountability Office, *Weapon system sustainment: aircraft mission capable rates generally did not meet goals and cost of sustaining selected weapon systems varied widely*, GAO-21-101SP, US Government, Washington DC, 19 November 2020, 53–56, [online](#).
- 55 The main elements of this cost are unit level personnel, unit operations (e.g., fuel), maintenance, and continuous improvement. This doesn't include munitions.
- 56 This figure still includes around \$155 million per year for continuous improvement since the through-life sustainment philosophy for the B-21 is based around continuous improvement rather than large mid-life upgrades. This is consistent with Australia's Super Hornet/Growler fleet.
- 57 DoD, *Portfolio Budget Statements 2022–23: Defence portfolio*, Australian Government, 2022, 117–123, [online](#).
- 58 Barry Rosenberg, 'The B-21 Raider: infused with stealthy lessons learned for maintenance and support', *Breaking Defense*, 20 October 2021, [online](#). See also interview with Steve Sullivan, VP of Northrop Grumman's Strike Division: 'The B-21 Raider: a bomber that's both low observable and easier to maintain', *Breaking Defense*, 3 August 2021, [online](#). These pieces were sponsored by Northrop Grumman.
- 59 Secretary of the Air Force Public Affairs, 'B-21 prototype environmental protection shelters construction, test underway', *Air Force*, 3 March 2021, [online](#).
- 60 This extrapolates data presented in Gertler, 'Air Force B-21 Raider long-range strike bomber'.
- 61 We define IOC as four aircraft delivered and flying in Australia.
- 62 Tyler Rogoway, 'Australia buying B-21 Raider stealth bombers is a fantasy but other options exist', *The Warzone*, 26 November 2019, [online](#).
- 63 ASPI has discussed the pressures on the defence budget in Marcus Hellyer, *The cost of Defence: ASPI defence budget brief 2022–23*, ASPI, Canberra, 2022, Chapter 5, [online](#) and Marcus Hellyer, *The cost of Defence: ASPI defence budget brief October 2022–23*, ASPI, Canberra, 2022, 18–19, [online](#).
- 64 See the shipbuilding spreadsheet in ASPI's Cost of Defence public database, [online](#).
- 65 Predicting defence spending as a percentage of GDP is a fraught activity, even when Defence funding doesn't change. As GDP predictions have changed over time, the estimates of 2022–23's defence funding as a percentage of GDP have fluctuated between 1.96% and 2.35%, even though the funding has essentially remained the same. See Hellyer, *The cost of Defence: ASPI defence budget brief October 2022–23*, 18–19.

- 66 On the sunk cost of the Attack class, see Hellyer, *The cost of Defence: ASPI defence budget brief October 2022–23*, 22–23.
- 67 For example, Marcus Hellyer, 'Where will Defence find 18,500 more people?' *The Strategist*, 17 March 2022, [online](#).
- 68 Heidi Vella, 'Could quantum radars expose stealth planes?' *Engineering and Technology*, 18 April 2019, [online](#).
- 69 Stephen Chen, 'Chinese teams says quantum physics project moves radar closer to detecting stealth aircraft', *South China Morning Post*, 3 September 2021, [online](#).
- 70 Adrian Cho, 'The short weird life—and potential afterlife—of quantum radar', *Science*, 23 September 2020, [online](#).
- 71 Andrew Davis, Patrick Kennedy, *From little things: quantum technologies and their application to defence*, ASPI, Canberra, 2017, [online](#), in particular the chapter on quantum radar.
- 72 Brendan Nicholson, 'Senior US official says Washington would consider supplying B-21 bombers to Australia', *The Strategist*, 23 August 2022, [online](#).
- 73 'Fact sheet: US nuclear weapons in Europe', Center for Arms Control and Non-Proliferation, 18 August 2021, [online](#).
- 74 'South Pacific Nuclear Free Zone Treaty (with annexes) concluded at Rarotonga on 6 August 1985', articles 3 and 5, [online](#).
- 75 Mark Gunzinger, *Long-range strike: resetting the balance of stand-in and stand-off forces*, Mitchell Institute, Arlington, 2020, 31–33, [online](#).
- 76 Kelley M Saylor, 'Hypersonic weapons: background and issues for Congress', Congressional Research Service, 27 October 2022, [online](#).
- 77 Saylor, 'Hypersonic weapons', [online](#).
- 78 Gunzinger, *Long-range strike: resetting the balance of stand-in and stand-off forces*, 6.
- 79 Volodymyr Zelenskyy, *Telegram*, 18 July 2022, [online](#).
- 80 Mark A. Gunzinger, 'Affordable mass: The need for a cost-effective PGM mix for great power conflict', Mitchell Institute Policy Paper Vol.31, November 2021, 19, [online](#).
- 81 John A Tirpak, 'Air Force looking for new stand-off attack weapon', *Air & Space Forces Magazine*, 1 September 2022, [online](#).
- 82 Many have been discussed and compared previously, for example in Rogoway, 'Australia buying B-21 Raider stealth bombers is a fantasy but other options exist'.
- 83 Stephen Losey, 'Watch this US Air Force cargo plane launch a cruise missile in Norway', *DefenceNews*, 11 November 2022, [online](#);
- 84 DoD, 'Project AIR 7404 Phase 1—medium air mobility replacement', media release, Australian Government, 1 November 2022, [online](#); Defense Security Cooperation Agency (DSCA), 'Australia—C-130J-30 Aircraft', media release, US Government, 2 November 2022, [online](#); DSCA, 'Australia—Joint Air-to Surface Standoff Missiles—Extended Range (JASSM ER)', media release, US Government, 21 July 2022, [online](#).
- 85 In some ways, this concept is analogous to the US Marine Corps' expeditionary advanced based operations concept
- 86 For a slightly different take on this, which proposes a dedicated bomb-truck version of the P-8, see Tyler Rogoway, 'The case for stripping the P-8 Poseidon down into an RB-8 multi-role arsenal ship', *The Warzone*, 22 July 2021, [online](#).
- 87 For example in Rogoway, 'Australia buying B-21 stealth bombers is a fantasy'.
- 88 For example, Marcus Hellyer, *Accelerating autonomy: autonomous systems and the Tiger helicopter replacement*, ASPI, Canberra, 2019, [online](#); Malcolm Davis, *Autonomous military and naval logic gains life of its own*, ASPI, Canberra, 8 October 2019, [online](#).

Acronyms and abbreviations

ADF	Australian Defence Force
ASD	Australian Signals Directorate
DSR	Defence Strategic Review
DSU	Defence Strategic Update
EAC	Enhanced Air Cooperation
FIC	fundamental input to capability
GDP	gross domestic product
IOC	initial operating capability
ISR	intelligence, surveillance and reconnaissance
JASSM	Joint Air-to-Surface Standoff Missile
JASSM-ER	Joint Air-to-Surface Standoff Missile—extended range
JDAM	Joint Direct Attack Munition
LRASM	Long Range Anti-Ship Missile
LRHW	Long-Range Hypersonic Weapon
NATO	North Atlantic Treaty Organization
NSM	Naval Strike Missile
PLA	People's Liberation Army
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
SDB	Small Diameter Bomb
SSN	ship, submersible, nuclear (nuclear-powered fast attack submarine)
TLAM	Tomahawk Land Attack Missile
UAV	uncrewed aerial vehicle
USAF	US Air Force
XLUV	extra-large uncrewed undersea vessel

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