ASPI

SPECIAL REPORT

Understanding the price of military equipment

Dr Marcus Hellyer

May 2022

ASPI
AUSTRALIAN
STRATEGIC
POLICY
INSTITUTE

About the author

Dr Marcus Hellyer is a senior analyst at ASPI, focusing on defence economics and military capability. Previously, he was a senior public servant in the Department of Defence, providing the government and Defence Department leaders with independent advice and analysis on major capital investments.

About ASPI

The Australian Strategic Policy Institute was formed in 2001 as an independent, non-partisan think tank. Its core aim is to provide the Australian Government with fresh ideas on Australia's defence, security and strategic policy choices. ASPI is responsible for informing the public on a range of strategic issues, generating new thinking for government and harnessing strategic thinking internationally. ASPI's sources of funding are identified in our Annual Report, online at www.aspi.org.au and in the acknowledgements section of individual publications. ASPI remains independent in the content of the research and in all editorial judgements. It is incorporated as a company, and is governed by a Council with broad membership. ASPI's core values are collegiality, originality & innovation, quality & excellence and independence.

ASPI's publications—including this paper—are not intended in any way to express or reflect the views of the Australian Government. The opinions and recommendations in this paper are published by ASPI to promote public debate and understanding of strategic and defence issues. They reflect the personal views of the author(s) and should not be seen as representing the formal position of ASPI on any particular issue.

Important disclaimer

This publication is designed to provide accurate and authoritative information in relation to the subject matter covered. It is provided with the understanding that the publisher is not engaged in rendering any form of professional or other advice or services. No person should rely on the contents of this publication without first obtaining advice from a qualified professional.

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

Cover image: ADF's new Australian designed Hawkei protected vehicle at the Thales Protected Vehicles facility in Bendigo, Victoria. Defence image library, online.

Understanding the price of military equipment

Dr Marcus Hellyer

May 2022

ASPI
AUSTRALIAN STRATEGIC POLICY INSTITUTE

© The Australian Strategic Policy Institute Limited 2022

This publication is subject to copyright. Except as permitted under the *Copyright Act 1968*, no part of it may in any form or by any means (electronic, mechanical, microcopying, photocopying, recording or otherwise) be reproduced, stored in a retrieval system or transmitted without prior written permission. Enquiries should be addressed to the publishers. Notwithstanding the above, educational institutions (including schools, independent colleges, universities and TAFEs) are granted permission to make copies of copyrighted works strictly for educational purposes without explicit permission from ASPI and free of charge.

First published May 2022

Published in Australia by the Australian Strategic Policy Institute

ASPI
Level 2
40 Macquarie Street
Barton ACT 2600
Australia

Tel + 61 2 6270 5100
Fax + 61 2 6273 9566
Email enquiries@aspi.org.au
www.aspi.org.au
www.aspistrategist.org.au

Facebook.com/ASPI.org

@ASPI_org

Contents

Executive summary

Confusion reigns in discussions about the cost of the Department of Defence's equipment projects. Whether we're talking about media articles, parliamentary committee hearings, letters to the editor, duelling internet commentators or any other forms of discourse that address Defence acquisitions, the only thing that's clear is that we're almost always talking past each other when it comes to the cost of military equipment. Defence doesn't help when it releases only a bare minimum of information. This sorry state of affairs reached its peak several years ago, when it turned out that when Defence said that the cost of the Attack-class submarine was $50 billion it really meant that the cost was somewhere around $90 billion.

The situation gets even murkier when commentators compare the cost of military acquisition projects here in Australia with ones overseas. It's very rare that we can make a direct, apples-to-apples comparison between local and overseas projects, and very often it's more like apples-to-orangutans. Being completely unaware of the basis of the costs they're comparing doesn't stop some commentators from making strong claims about the rapacity of foreign arms companies or the competence of the Australian Defence Department.

This report attempts to be a guide for the perplexed. It's not a technical manual, but a plain-English discussion that unpacks the cost of Australian defence equipment projects. While it would be useful for those working in the field of defence and strategic studies to read the whole report, it can also be used a reference tool explaining key terms such as 'constant' and 'out-turned' dollars or different cost-estimation methodologies.

It's important up front to acknowledge that the cost of modern military equipment can be eye-wateringly high, and there's always a 'sticker shock' when we compare the costs of military systems with the costs of their civilian counterparts. Those costs are driven by the constant quest for better capability that provides an advantage in a life-and-death business. That striving in turn drives rates of cost escalation that greatly outstrip inflation in the broader economy. No Western country has yet found a way out of that endless cost spiral, and Australia is certainly not an exception.

Anyone discussing cost has to understand what's included in the price. It's here that comparisons of Australian and overseas projects are difficult. Australian defence project costs include all the elements needed to get a capability into service, which are known as the fundamental inputs to capability. They comprise much more than the military equipment itself and can include facilities, training systems, documentation, intellectual property, integration of the new equipment (such as a missile) onto existing systems (such as the aircraft that will launch it), science and technology programs, and so on.

Elements other than the equipment aren't trivial and can sometimes make up half of the total acquisition cost. Australian projects also include significant risk provisions, known as contingency. In contrast, most overseas programs don't include all of those elements, so their cost can appear significantly smaller.

In this report, I provide a hypothetical example that illustrates how the cost grows as we include these factors. If we start with available off-the-shelf equipment costing $1 billion and adjust for price escalation (including inflation and capability enhancements) and factor in all fundamental inputs to capability and contingency, we quickly get to a total acquisition cost of $3.5 billion. That's before we include operating costs.

The report also briefly examines a current, real-world example by comparing the cost of Australia's Hunter-class frigate project with analogous international projects. While we attempt to make some assessments, the exercise confirms that comparisons are difficult when we don't have visibility of what's included in the price tag.

We also attempt to debunk the popular and deeply held view that Defence projects frequently go over budget. Based on the public evidence, the opposite is in fact the case. Once the government considers a business case and gives Defence approval to enter into contracts to acquire a particular system with a set budget, the department rarely goes over budget. However, it must be said that, before that point, Defence's estimates of the funding needed to acquire a capability can grow significantly as its understanding of its requirements and the possible solutions develops. It's here that the infamous 'blowouts' generally occur, not after actual acquisition commences.

Some commentators have suggested that focusing on the cost ignores the value those systems provide—why quibble over a few billion here or there when the security of the country is at stake? I'd argue that it's difficult to assess value for money if you don't understand how much money you're paying. This study aims to help Australians understand how much they're paying. It's only then that we can make informed decisions about military spending.

Chapter 1: Introduction

One of the greatest areas of confusion in public discussions of the cost of defence is the price of military equipment. It's hard to know what Australia is paying for its weapons, which makes it hard to know whether we're paying the right price or getting value for money.

The Defence Department doesn't release information on the price it's paying for particular items, but only high-level project costs—and then only for some projects. Those numbers include a wide range of elements beyond the equipment itself. Public discussion is confused and confusing when commentators take the project-level numbers and crudely reverse-engineer the cost of individual items from them.

To address that shortcoming, commentators look for relevant cost information overseas. But often the issue gets even murkier when Australian costs are compared with overseas numbers. Some national defence agencies, particularly the US Defense Department, publish very detailed information, yet their numbers are generally not amenable to a direct apples-to-apples comparison with Australian data.

The following is an example that illustrates why we need to be cautious even when using numbers from a reliable source. The Defense Security Cooperation Agency (DSCA) manages the US's Foreign Military Sales program which allows partner countries to acquire US-made military equipment at the same price as the US military. The DSCA has to notify the US Congress of potential sales that have been approved by the US State Department. Those notifications are public and are a useful source of information, but they can be misleading when misused.

In April 2020, the DSCA notified Congress of the potential sales of 10 AGM-84L Harpoon Block II air launched anti-ship missiles (Figure 1) to India for US$92 million and of 10 of them to Morocco for US$62 million.[1] It would be wrong to assume that India was being gouged US$9.2 million per missile while Morocco was getting them at a bargain price of US$6.2 million. Both sales also included 'containers, spare and repair parts, support and test equipment, publications and technical documentation, personnel training and training equipment, US Government and contractor representatives' technical assistance, engineering and logistics support services, and other related elements of logistics support'.

In fact, the cost of a Harpoon missile itself is nowhere near US$9.2 million, or even US$6.2 million. At almost the same time as those DSCA announcements, the US Navy awarded a contract to Boeing in May 2020 worth nearly US$657 million for 467 Harpoon Block II missiles and support equipment for various foreign military sales customers.[2] So the price of an individual missile was less than US$1.4 million.

This example shows that we need to be careful even when comparing numbers taken from the same source that seem to have similar scope. But it also shows that the cost of a weapon itself is only one part of the total cost of a project or program and that the weapon is only one part of an effective military capability. Depending on whether you're developing a cost for the weapon or for the capability, you'll come up with dramatically different numbers.

Figure 1: Harpoon anti-ship missile: US$1.4 million, US$6.2 million or US$9.2 million?

Source: Defence image library, online.

Unfortunately, many commentators aren’t careful when using cost figures whether from here or overseas. This results in murky numbers being used to justify strong claims such as that the US’s latest nuclear-powered submarine would cost substantially less than the Attack-class conventional submarine, or that Australia is being taken for a ride by unscrupulous company *X* or country *Y*, and so on.

In this report, I start by looking at why the ‘sticker shock’ for modern weapons is so high to start with. I then look at how different definitions of cost sit along the spectrum from weapon to complete capability resulting in very different scope. I explain key concepts in cost estimation. The report then provides a hypothetical example illustrating how these definitions and concepts increase the cost as we move from weapon to capability. We’ll reinforce that with a real-world example drawn from the Navy’s Hunter-class frigate program. The report ends with a chapter that examines the validity of the popular view that Defence’s projects often go over budget.

Chapter 2: Why does it cost so much?

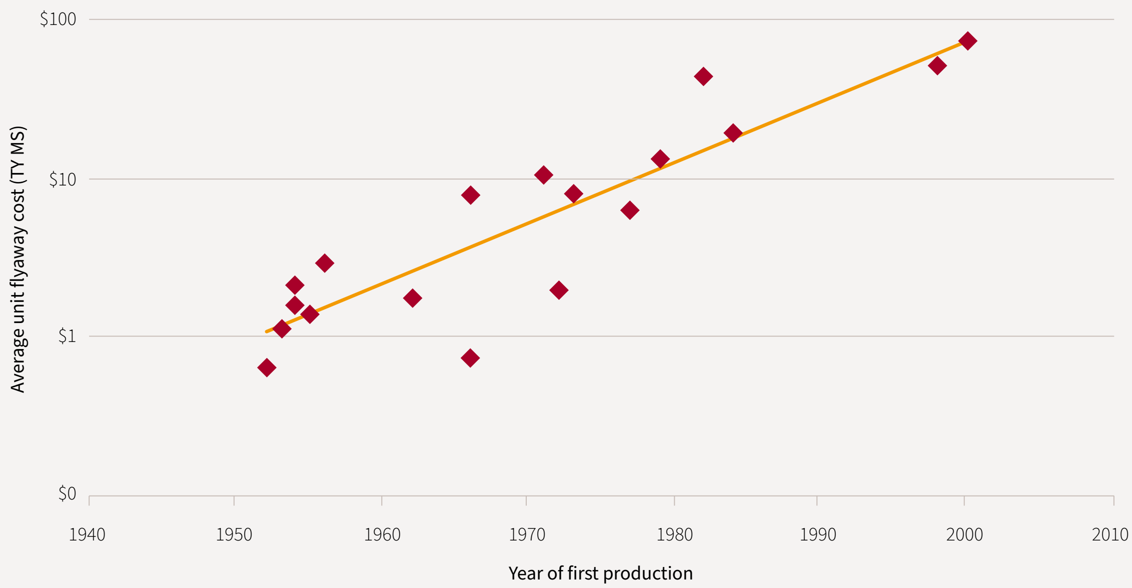
Before we unpack whether Australia is paying more than it should for its military equipment, it's useful to briefly consider why military equipment costs so much in the first place. This will help disabuse us of notions that Australia's situation is significantly different from that of other countries. In fact, all advanced militaries are grappling, largely unsuccessfully, with the upwards spiral in the cost of military equipment. The fundamental concept we need to understand is that requirements drive cost, and those requirements are set by the military so that it can achieve its missions with acceptable risk. Simply blaming the cost of equipment on supposedly unscrupulous foreign arms manufacturers overlooks what's the key cost driver.

The exponential increase in cost

Military equipment is expensive. It tends to be eye-wateringly expensive. And it's always getting more expensive. It's well established that the cost of military equipment is increasing at a faster rate than inflation in the broader economy. For example, the RAND Corporation concluded that the increase in the cost of US amphibious ships, surface combatants and attack submarines averaged around 10% per year between 1950 and 2000, which was twice the rate of inflation.[3]

A few percentage points here, a few decades there, and pretty soon we're talking real money. In fact, the compounding effects are so great that graphs that seek to illustrate those costs have to use logarithmic scales on the y-axis just so they can fit on the page, as the next two graphs illustrate. Figure 2 is the RAND Corporation's illustration of the increase in fighter aircraft costs over the second half of the 20th century.

Figure 2: Fighter aircraft cost escalation, 1950 to 2000

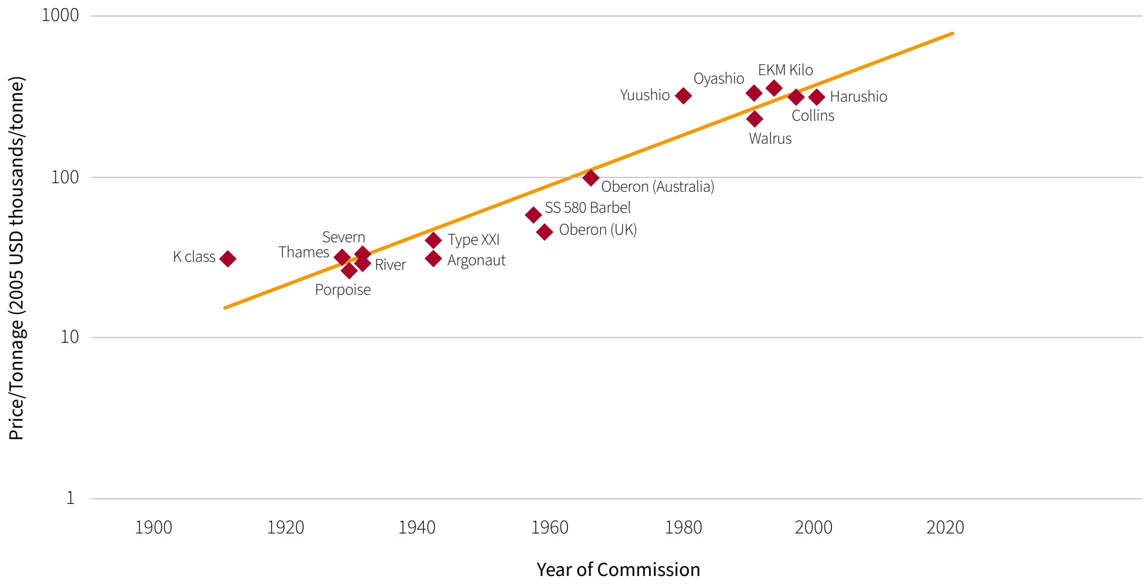


Source: RAND Corporation, online.

While the graph might suggest a steady but straight-line increase in cost, due to the logarithmic scale it's actually a dramatic curve in which the cost of aircraft increased from $1 million each in 1950 to $100 million 50 years later.[4]

This is in part driven by the increasing size of ships and aircraft, but it's mainly driven by the dramatically increasing cost per unit of weight; that is, ships and aircraft aren't just getting more expensive because they're getting bigger but rather each tonne of ship and aircraft is getting much more expensive as well. Figure 3 is reproduced from an earlier ASPI study on the cost of the future submarine and shows the growth in the cost of submarines on a per tonne basis. Again, the straight line obscures a dramatic curve.

Figure 3: Submarine real prices per tonne, 1900 to 2010 and beyond



Source: Defence Material Organisation, cited in Sean Costello, Andrew Davies, *How to buy a submarine: defining and building Australia's future fleet*, ASPI, Canberra, October 2009, online.

From what we currently know about the Hunter-class frigate program, its costs will be consistent with these historical patterns (as the Attack-class submarine probably would have been, had it not been cancelled).

Requirements drive cost

Why have costs consistently grown at such a rate? There are many factors that play a role. It's been argued that consolidation in the defence industry resulting in the dominance of a very small number of prime contractors has reduced or virtually eliminated commercial competition. The intermittent nature of projects, particularly in countries like Australia with relatively small armed forces, also plays a role by reducing economies of scale and the benefits of continuous production.

Those factors certainly play a role, but the main cause of exponential cost increase is the continuing quest for ever greater performance. Performance can take many forms depending on the system in question—speed, endurance, miniaturisation, processing power, sensor range and discrimination, blast protection, stealth, weapons capacity. The list includes all aspects of military systems. We should also add factors that aren't about military performance *per se* but involve meeting broader societal standards for work health and safety, habitability or environmental protection. We can group all of those factors under the heading of 'requirements'.

In order to defeat threats and achieve their mission, weapons systems have increasingly demanding requirements. This takes the form of more sensors, more weapons, more processing power and increasingly massive suites of software to run them. Useful proxies to illustrate the growth in the number of systems on modern weapons platforms are size and power density. The classes of ships examined by the RAND Corporation that increased in cost by an average of 10% per year between 1950 and 2000 showed increases in ship weight of between 81% and 90% over the same period. Surface combatants also increased by 88% in power density.

The burgeoning number of systems need to fit on platforms that still have largely the same form as their World War II ancestors, so high degrees of miniaturisation are needed to allow them to fit. Developments in broader industry, for example in processing power, have assisted in reducing some costs, but the need to fit ever more systems onto traditional platforms is a fundamental cost driver.

Ensuring that those systems fit within the space, weight, power and cooling resources available, and can operate effectively with each other (for example, by sharing data in compatible formats or by not producing electromagnetic emissions that interfere with each other's functions, and so on) creates ever greater complexity.

These requirements generate a vicious cost cycle. Edward N Luttwak elegantly described this vicious cycle in 2007 and his analysis is still correct.[5] Requirements drive increasingly large and complex platforms. That in turn drives huge increases in cost. Due to the cost, only small-scale production is possible. In comparison to car factories that can produce hundreds of thousands of vehicles, production lines for military vehicles might produce only a few thousand per year (and even fewer in Australian programs). Military aircraft production lines produce only a few hundred, if that. Even the US is building fewer than 10 warships per year. That means the economies of scale and the efficiencies that civilian businesses routinely achieve (and indeed have to achieve, if they want to survive) can't be attained in the defence industry. That increases the unit cost, which reduces affordability and consequently the size of production runs, which in turn drives up cost.

We haven't quite reached the point sardonically predicted by the American defence industrialist Norman Augustine in 1984 that 'In the year 2054, the entire defense budget will purchase just one aircraft. This aircraft will have to be shared by the Air Force and Navy 3½ days each per week except for leap year, when it will be made available to the Marines for the extra day.' However, numbers of platforms in Western countries continue to fall.[6] There are clear signs of the 'death spiral' of shrinking force sizes analysed by Franklin Spinney over several decades.[7] Australia is holding the line, but only through record investment; it's sobering to note that the planned $53 billion spend on surface combatants (between $8 billion for three Hobart-class destroyers and $45 billion for nine Hunter-class frigates) won't increase the number of ships in the fleet—although the individual ships will be much larger and more capable than the vessels they're replacing.

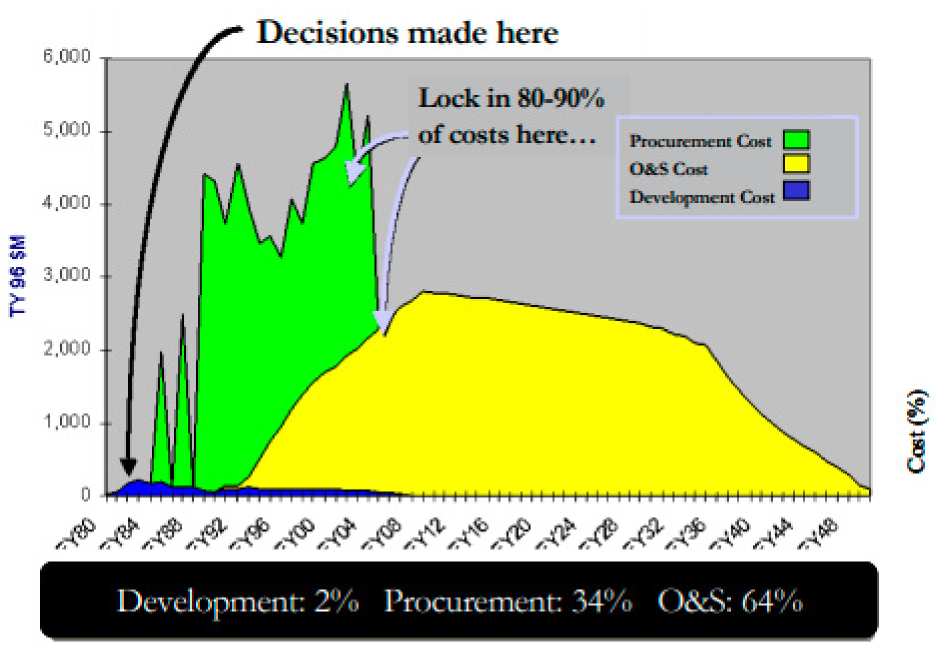
While it may be convenient or emotionally satisfying to blame the eye-watering costs on the defence industry and alleged profiteering, the costs are largely driven by requirements. And it's defence organisations that set requirements and select the equipment solutions that they consider best meet those requirements. The cost of the Attack-class submarine may have seemed exorbitant at nearly $90 billion, but it was Defence that set the requirements that drove the development of the largest (and therefore the most expensive) conventional submarine in history.

Another of Augustine's 'laws' states that 'the last 10% of performance generates one-third of the cost and two-thirds of the problems.' The precise numbers are debatable, but the sentiment is accurate. The desire for the final increment in performance creates a need for new technologies. Much analysis has shown that it's the development of those technologies that drives cost, schedule and risk in projects; linear increases in performance can generate nonlinear increases in all three. So it's vitally important for defence organisations to set real requirements rather than so-called 'desirements' and to rigorously prioritise between the essential and the nice to have.

Costs are locked in early

A corollary of the fact that requirements drive costs is that, once requirements are set, most of the costs are locked in. If you want a crewed, conventionally powered submarine with very long range, extended endurance, large weapons carriage and a highly capable sensor suite, there isn't going to be a large range of engineering solutions that can meet those requirements. Any solution will have a similar cost. Figure 4 shows the whole-of-life cost of a hypothetical US Navy capability, divided into development, acquisition, and operations and support costs. Key decisions early in the development process setting requirements and accepting the engineering solutions to meet those requirements lock in the vast bulk of acquisition and operating costs.

Figure 4: How total cost of ownership is set early on



Source: US Navy, *NAVSEA handbook*, 67, online.

There's of course some wiggle room. Once a capability is in service, the operator can choose to reduce costs by using it less. But there are overheads to the cost of owning and effectively operating a capability that are constant, regardless of the size of a particular fleet. Software upgrades cost the same to develop regardless of the number of platforms they're going on. Efforts to tweak the design to reduce costs once construction has started will at best realise only minor savings (often with major capability implications caused by delivering platforms fitted for but not with key weapons or sensors). At worst, it can result in significant cost increases and delays as design changes to one subsystem create snowballing effects across the entire platform. Changes to the design made once construction has started cost many times more than changes made in the design phase.

Of course, the phenomenon of 'scope creep' (that is, attempts to improve performance by altering the design during construction) will have an even greater impact on cost and schedule. Many projects have foundered on the rocks of scope creep. This is why the programs that are most successful in controlling costs and adhering to schedule are those that set realistic requirements that depend largely on incremental improvements to existing technologies and then stick to the design solution during construction. However, incremental improvements in technology and consequently performance might not deliver the capability advantage often sought by defence forces.

That's why much discussion about the cost of military equipment in Australia fundamentally misses the point. It tends to focus on whether a project has gone over the budget set for it when the government approved it. A more fundamental question is whether the requirements that drove the solution and the budget in the first place were valid ones or simply desirements.

Why does the cost curve matter?

One might ask, 'Why does the exponential cost curve really matter if it's affecting everybody?' There are several answers to this that suggest that Australia and our partners and allies need to escape the cycle sooner rather than later:

- No matter how capable a platform is, it can be in only one place at a time. Presence is important, but with diminishing numbers of platforms it becomes more challenging to have a platform where it's needed.
- Western armed forces have traditionally relied on a technological advantage over adversaries. With the proliferation of advanced technologies, even relatively poor states can acquire highly lethal capabilities. The cost of retaining a clear technological advantage that can reliably defeat those threats is one of the factors driving the cost spiral.
- Moreover, even very low-tech weapons can drive the spiral. For example, roadside bombs made from old artillery rounds or even fertiliser have driven the development of progressively larger and substantially more expensive armoured vehicles that are three to four times heavier than the vehicles they're replacing. We're on the wrong side of the cost–benefit calculus.
- With China becoming the factory of the world, its industrial capabilities are outstripping even the US's. Every year, China is adding new warships to its fleet equivalent in tonnage to major navies. Western militaries are losing both their qualitative and their quantitative advantage.
- When a force has only a small number of platforms, the loss of a small number, or even just one, can be crippling.
- Much of the complexity of platforms is driven by the need to include more systems to defend them and their human crew, resulting in minimal capability to inflict damage on the adversary. Australia's three Hobart-class destroyers cost $8 billion, but each carries only eight anti-ship missiles to sink enemy ships, and, based on the standard 3-for-1 rule-of-thumb, only one of them will be at sea at any one time. Is $8 billion a cost-effective way to get eight anti-ship missiles to sea?

In sum, the return on investment on our current path is looking increasingly questionable.

Breaking out of the cycle

The sticker shock associated with Australian defence acquisition programs isn't unique. All advanced militaries are struggling with the same issues, and some attempts to break out of the cost spiral caused by constantly increasing requirements have been made. Overall, they've had minimal effect to date.

Many attempts focus on processes, such as 'streamlining' defence organisations' bureaucracies and decision-making processes or improving their project-management skills. Others attempt, against the overall trend of the times towards commercial consolidation, to reinject competition into the defence industry. Some attempt to improve the productivity of the industry by building more modern, automated shipyards or production lines. Australia is pursuing 'continuous build' programs to avoid the costs associated with the stop–start nature of small production runs—even though such programs are likely to introduce as many costs as they save when based on small numbers. Even the US Navy, which does have continuous production lines, has declined dramatically in size.

Such efforts can have an effect, but they can only moderate cost growth in defence equipment, not stop or reverse it. That's because they don't get at the fundamental causes of cost growth, which are driven by requirements and the technological solutions needed to meet those requirements. Some attempts have been made to reduce requirements but with only limited success. The issue perhaps isn't so much about requirements *per se*, but the technological solutions to them that militaries are willing to consider.

A key factor that will always drive cost is the human crew. Much of the complexity of modern systems is caused by the need to protect the crew against rapidly proliferating threats. That's resulted in us building $3 billion ships whose capability is optimised to protect themselves. Breaking out of the cost spiral in meaningful ways will probably involve removing the human crews, but that will be at an undetermined time in the future.

Another potential circuit-breaker is to reduce complexity by building systems that aren't multi-role (that is, seeking to perform many tasks in the face of many threats in many different environments) but are optimised for a small number of tasks. A variant of that approach is to build modular systems based on a standard core platform that's capable of accepting different modules depending on the task it needs to perform at the time. Again, such efforts have only had moderate success. The Danish Navy appears to have done well, both in cost and capability terms, with its modular Stanflex payload system, which it's using on several classes of ships. But the US Navy's littoral combat ship concept has, by virtually all accounts, been unsuccessful. That was partly because the modules were either technically immature or didn't provide adequate war-fighting capability, and partly because excessively ambitious requirements for the ships themselves in areas such as speed led to unreliable engineering solutions affecting the viability of the ships.

Any successful approach to breaking out of the vicious cycle is likely to need to draw on some or all of the following elements:

- Removing the human crew, thereby reducing the complexity and cost driven by the need to protect them.
- Physically disaggregating the subsystems on a small number of multirole platforms and instead building larger numbers of smaller systems, each optimised for a small number of roles that can be 'virtually' reaggregated through advanced command, control and communications systems.
- Drawing on the economies of scale provided by the civilian world and wherever possible using commercial technologies. This is likely to become increasingly possible as the capabilities sought by military organisations and broader society converge, for example in autonomous and robotic systems, space assets, processing power and so on.
- Perhaps most importantly, setting requirements in a solution-agnostic way so that new technologies can be explored. For example, instead of stating how many crewed aircraft are needed to conduct surveillance over a certain area of ocean, requirements should simply specify the level of surveillance required and leave the technological solution open so that industry can propose a range of possible solutions that might not even involve aircraft.

Factors such as these may help constrain or even reduce the cost of military equipment, but achieving that outcome will take time and isn't assured. That means we'll need to endure the sticker shock for the foreseeable future. Australia isn't alone in this. Moreover, the sticker price is going to vary greatly depending on what elements of a military capability are included. It's important to do apples-to-apples comparisons of prices.

Price versus value

We can pay the right price for something, but that isn't the same thing as value. We might, for example, accurately cost a fifth-generation stealth aircraft such as the F-35A Joint Strike Fighter and determine that its whole-of-life acquisition cost is more than that of a fourth-generation non-stealthy aircraft such as a F/A-18F Super Hornet. That doesn't mean the Super Hornet is better value. The value of a military capability comes from the effects it can deliver. The stealthy aircraft may be able to prosecute more targets, more successfully, with far lower risk of losses.

Conducting effects-based cost analysis can be challenging. It's easier when the systems being compared are reasonably analogous, such as an F-35A and a Super Hornet. But even there, the systems may conduct a mission quite differently to achieve the same effect, such as destroying a defended ground target. The non-stealthy aircraft might need supporting electronic attack aircraft to suppress enemy air defence radars, or it may need to use more munitions, so a cost analysis should take those other elements into account. Effects-based cost analysis gets harder when the two systems are quite different; for example, aircraft versus ground-based, long-range strike missiles.

Looking at all the options to achieve an effect is termed an ‘analysis of alternatives’. In my experience, Australia isn’t very good at conducting analyses of alternatives. One suspects that rigorous analysis might lead to some quite different solutions to its capability requirement than its traditional approach of replacing ‘like with like’.

In sum, knowing the cost of something isn’t the same as assessing its value. However, it’s difficult to know whether you’re getting value for money if you don’t understand how much money you’re paying.

Chapter 3: What's included in the number?

When comparing numbers, it's very important to know what's included in them. A number that includes only the cost of a particular piece of equipment will be much smaller than a number that includes the cost of everything necessary to design, build and support that equipment, let alone one that includes the cost of operating it over its life (Figure 5). It's hard to know what's included in any particular number quoted in the media. Generally, however, the public costs released for Australian defence projects include more elements than do projects overseas. This can have the apparent effect of inflating the cost of Australian acquisitions.

Figure 5: The cost of an aircraft or any other weapon coming off the production line is only part of the total cost of the capability

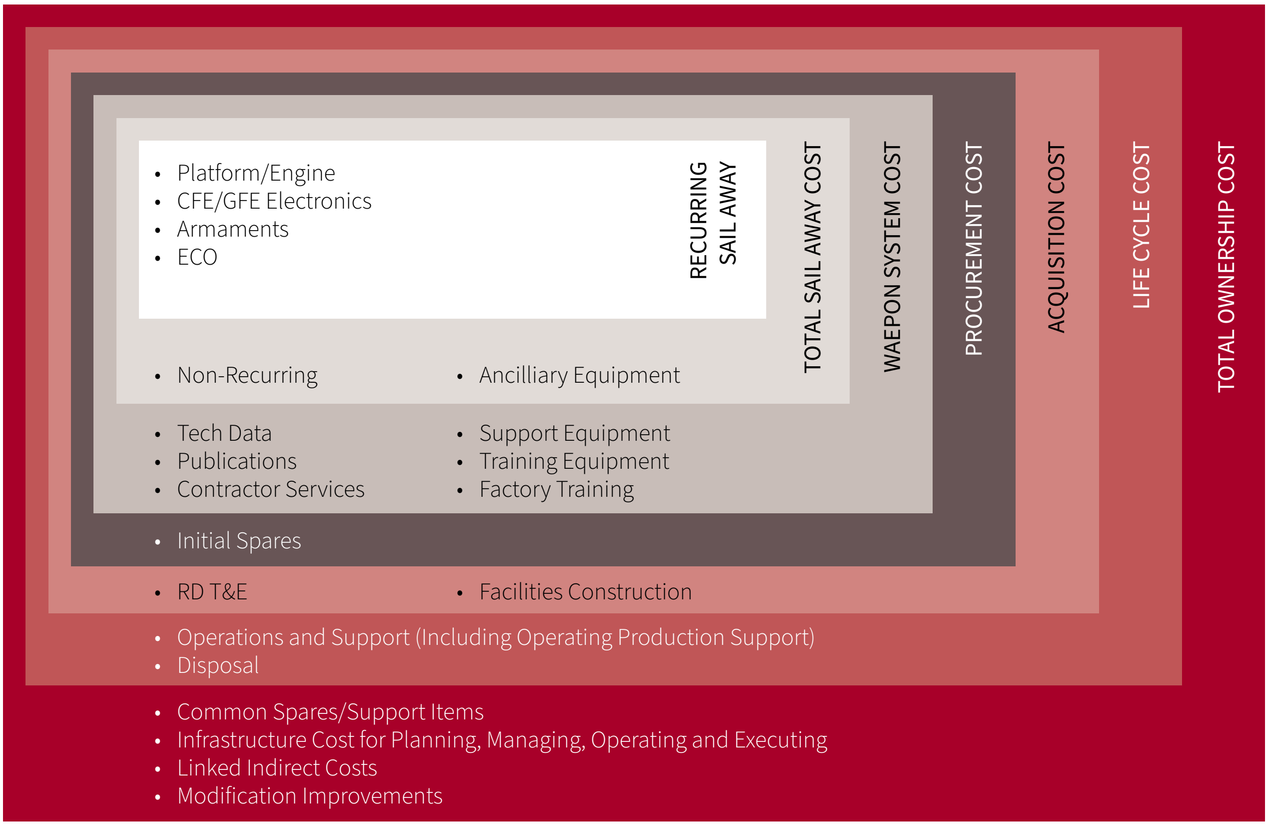
Source: Lockheed Martin.

Components of cost

The US Navy has a useful diagram that shows how different definitions of cost include progressively more elements (Figure 6). Its terminology is different from Australia's, but it shows how the cost of a capability grows as more things are included. There's nothing carved in stone to say how big those costs are, relative to each other:

- *Recurring sail-away cost* (or 'fly-away' for aircraft) is essentially the cost of buying a ship or aircraft or missile off a mature production line.
- *Total sail-away cost* includes non-recurring costs; that is, one-off costs that are the same regardless of the size of the production run. Those include the cost of designing the system.
- *Weapon system cost* adds in elements that are necessary to operate the system, such as training systems and the technical data required for operation and maintenance.
- *Procurement cost* then adds in initial spares. Different organisations will have different rules around how many years' worth of spares need to be acquired up front. Some spares, such as aircraft engines, can cost millions of dollars each.
- *Acquisition cost* includes the facilities necessary to operate the system.
- *Life-cycle cost* adds in the costs involved in operating the system. Depending on the kind of system, these can be much greater than the acquisition cost. For a ship that will serve for 30 years and require a crew, fuel, upgrades and so on, the life-cycle cost could be several times the acquisition cost. For a missile that will sit on a shelf for 20 years, the life-cycle cost adds little to the acquisition cost.
- *Total ownership cost* is the 'sum of all financial resources necessary to organize, equip, train, sustain, and operate military forces', according to the US Navy's definition. Those could include indirect costs that aren't part of the direct cost of operating the system.

Figure 6: Components of cost—US Navy categories



Source: NAVSEA, *2005 cost estimating handbook*, 68, online.

The Australian approach

When the Australian Defence Department seeks the government’s approval to acquire new capability, it’s required to advise the government of the total cost of ownership. That includes everything necessary to acquire, operate and dispose of the system. This is much broader than the equipment itself. In fact, the equipment (termed ‘major systems’) is just one of Defence’s nine fundamental inputs to capability (FICs):

- organisation
- command and management
- personnel
- collective training
- major systems
- facilities and training areas
- supplies
- support
- industry.

This means that both the total acquisition and life-cycle costs are much higher than the fly-away cost of the equipment. However, Defence doesn’t publish either the fly-away cost it pays or the total cost of ownership. In general, the Australian Defence Department publishes much less data that its US counterpart, but it does make some numbers public. Let’s examine what information is available.

Figure 7: Simulators are a key part element of the fundamental inputs to capability

Source: Defence image library, online.

Acquisition cost

Defence's annual Portfolio Budget Statements (PBS) list its 30 military equipment projects with the highest expected expenditure for the coming financial year.[8] The Defence annual report provides the actual achieved spend for those projects for the previous year. The PBS also provides the total approved budget for those projects and their total spend to date. ASPI has collated Defence's Top 30 acquisition project data in its *The cost of Defence* online database.[9]

Until this year, the Top 30 table provided only the planned expenditure of the Capability Acquisition and Sustainment Group (CASG). This is broadly analogous with the US Navy's 'procurement cost' category described above.

However, CASG isn't responsible for delivering all the FICs, and the Top 30 table didn't include funds being spent by other groups in Defence. A separate table in the PBS showed expenditures by Estate and Infrastructure Group on facilities, but any other expenditure, for example by the Defence Science and Technology Group or Chief Information Officer Group, wasn't published. Those other sums could be quite considerable. For example, in 2019, in response to a question about the approved budget for the Future Submarine Program, Defence informed ASPI that 'the total SEA 1000 Government approval is currently $6,364m, which is primarily for CASG-delivered acquisition ($5,959m), with smaller amounts for Estate and Infrastructure business cases ($8m) and DSTG studies/testing/evaluation/etc ($397m).'[10] Similarly, the Offshore Patrol Vessel Project has an equipment budget of $3,670 million but that doesn't include a further $918.5 million in facilities spending that's required because the offshore patrol vessels are much bigger than the patrol boats that they're replacing.

However, starting in the 2021–22 PBS, Defence has included in the Top 30 table an additional line for each project with the cost of what it terms 'Other project inputs to capability', which it states 'could include facilities, information communications technology, and research and development'. The two lines combined broadly coincide with the US Navy's 'acquisition cost' category.

Unit cost

The US Defense Department's budget documents provide a detailed breakdown of the acquisition cost of its equipment in each of the services' 'justification books', even to the level of platforms' subsystems.[11] In contrast, the Australian Defence Department doesn't provide a public breakdown of the elements in the military equipment acquisition line in the Top 30 table (or anywhere else). We shouldn't assume that the recurring sail/fly-away cost element always makes up the bulk of that line. For example, in 2018, Defence informed the Senate that around 50% of the total budget for the F-35A project (AIR 6000 Phase 2A/2B) was for costs beyond the fly-away cost:

> Based on current projections, the average Unit Recurring Flyaway (URF) for an Australian F-35A is expected to be approximately US$90 million (AU$115 million) [that is, making the cost of 72 aircraft around AU$8,280], which remains aligned with projections at Government approval in 2014. URF is the cost of an aircraft delivered from the production line. This cost is reducing with each production lot.
>
> For Australia, around 50 per cent of the total approved budget of $17.26 billion (Out-turned FY2018–19 PBS prices) is for URF costs for 72 aircraft. The remainder is for F-35A support systems and infrastructure including: information technology; training system; weapons; facilities and contingency.[12]

For equipment purchased through the US Foreign Military Sales program, Australia and other US partners pay the same as the US Defense Department, so we can assume that the cost in the US department's justification books is comparable to what we're paying. However, for other Australian acquisitions, the public will never know what fly-away cost Australia is paying.

Sustainment costs

Defence's PBS also provides an estimate for the cost of each of Defence's Top 30 sustainment 'products'; that is, the expected cost of sustaining its 30 most expensive capabilities over the coming year. The PBS doesn't explain what's included in this number; however, Defence has provided this clarification:

> The values in the Top 30 sustainment products table include baseline costs only in sustaining capability, including assets, inventory and operating expenses.
>
> There are no workforce or facilities costs included in the sustainment products. Fuel is managed as a separate sustainment product.[13]

Therefore, the sustainment cost number in the Top 30 table isn't the full operating cost. A key thing missing is the cost of Defence personnel operating or maintaining the capability. Their cost is essentially invisible in Defence's public reporting. That means Defence's sustainment cost numbers aren't directly comparable to US 'operations and support' data because that includes the cost of the operators.

ASPI has collated Defence's Top 30 sustainment costs in its *The cost of Defence* online database.

Chapter 4: Key concepts in cost estimation

In this chapter, we look at some key concepts involved in the development of cost estimates for military equipment. We saw in the previous chapter that different definitions of costs result in very different numbers. Similarly, attempts to unpack costs that don't understand how the following concepts have been applied in the development of those costs can lead to very misleading comparisons.

Constant versus out-turned dollars

A lot of different 'dollars' can be used when discussing public-sector finances, but they broadly fall into two categories. The first category takes real-world factors such as inflation into account. These dollars are termed 'nominal' or 'out-turned'. The Australian Government works in out-turned dollars. That's because out-turned dollars are a better representation of what the government will have to pay for goods and services when the bills are due at some point in the future. The problem with out-turned dollars is that it's hard to compare 2020 dollars directly with 2030 dollars; a 2030 dollar doesn't have the same buying power as a 2020 dollar, so buying the same thing in 2030 will require more dollars than in 2020.

The second category of dollars addresses this by assuming a constant buying power for dollars across time. These are termed 'real', 'current day' or, in Defence terminology, 'constant' dollars. Constant dollars do allow for a more direct comparison of costs at different points in time. Real dollars are, however, no more 'real' than nominal or out-turned dollars, since they essentially involve ignoring time. One way of understanding constant dollars is that they represent what a system would cost if it could be delivered instantaneously. But, since defence projects take time to deliver, constant dollars are in some ways more artificial than out-turned dollars. They certainly don't represent the actual number of dollars that will be paid.

For projects that will take only a short time to deliver, or be subject to low rates of inflation, the difference between the constant and out-turned cost will be small. However, the longer a project goes for, the more time inflation has to compound. That's why Defence's budget for the Future Submarine Program, which was to deliver well into the 2050s, was $50 billion in constant dollars and nearly $90 billion in out-turned dollars. Assuming high rates of inflation can also compound the difference.

Table 1 illustrates the effect of out-turning. The constant budget line assumes a hypothetical project ramp-up and ramp-down in spending as the project matures, enters production, delivers, and closes out. Over the decade, the difference is moderate at a low rate of out-turning. At 10%, however, the difference is extreme.

Table 1: The effect of out-turning at various indices

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Constant budget	50.0	75.0	100.0	125.0	125.0	125.0	125.0	125.0	100.0	50.0	1,000.0
Out-turned at 2.5%	50.0	76.9	105.1	134.6	138.0	141.4	145.0	148.6	121.8	62.4	1,123.8
Out-turned at 5%	50.0	78.8	110.3	144.7	151.9	159.5	167.5	175.9	147.7	77.6	1,263.9
Out-turned at 10%	50.0	82.5	121.0	166.4	183.0	201.3	221.4	243.6	214.4	117.9	1,601.5

Real or constant dollars will still change depending on the base year used; a cost estimate for a project done in constant 2020 dollars will be different from a cost estimate done in constant 2030 dollars. Defence's $50 billion constant budget for the future submarine was in 2016 dollars; if it had been re-baselined in 2021 dollars, it would probably have been around $5 billion higher.

When comparing the cost of military equipment, it's essential to ensure that we aren't comparing costs expressed in real dollars or constant dollars with costs expressed in out-turned dollars.

Escalation

Inflation plays a key role in determining the cost of military equipment. We've noted the difference between cost estimates done in constant dollars and those done in out-turned dollars, which take inflation into account. In Australia, the Consumer Price Index (CPI) measures inflation in the broader economy based on a basket of representative goods. But the CPI is only one measure of price escalation that we need to consider when estimating the cost of military equipment. Military equipment generally increases in price at a greater rate than do products in the broader economy. There are two additional drivers at work here that need to be taken into account in cost estimates.

Labour and materials growth

The first of those drivers derives from the fact that the production of military equipment often requires skills or special materials that are in short supply. For example, all modern military equipment is largely software driven, and demand for programmers far outstrips supply, particularly in Australia. Or it can require special materials such as titanium or rare earths. To address this, cost estimators may apply an escalation factor above the overall rate of inflation in the economy to particular elements of the system.

This is why delaying projects or slowing them down, as Defence appears to be doing with the Hunter-class frigate program to stretch out the build, increases their overall cost in real terms. Time isn't a free good when your costs are increasing at a rate faster than inflation. There's a nexus between cost and schedule that's well understood in industry but not so well in Defence. When Defence has cash-flow pressures, it delays projects; this only increases cost in the longer term.

Capability growth

But there's an even more significant factor to consider in the cost of military equipment: the equipment increases in capability from one generation to the next due to increases in complexity, size and performance—all of which result in cost growth. Compare the performance of a F-35A Joint Strike Fighter with that of a F/A-18 A/B Hornet designed in the late 1970s and procured in the mid-1980s. That performance increase comes with a huge increase in cost. Certainly, the cost of processing power has decreased, but that's more than outweighed by other factors, such as the growth in the size of software, the number of sensors on platforms, the increase in the number and sophistication of defensive systems and the consequent increase in power requirements. Also, meeting contemporary work health and safety requirements and habitation standards has a cost.

Over time, those increases are massive, as we saw in Chapter 1. Annual increases of around 10% for some systems compound very dramatically, very rapidly. We should note, however, that individual projects don't experience cost growth at 10% per year. Rather, those high rates are what we experience when the step change in cost between different generations of equipment is averaged out over the longer term.

Estimating methodologies

As projects move through the acquisition process, they're moving from lesser to greater certainty about requirements, technological maturity, schedule and so on. That affects certainty about costs. Because of this uncertainty, different cost-estimation methods are more appropriate at different stages of the process. Broadly speaking, there are three main recognised estimation methods.

Analogous estimates

An analogous estimate starts with the known cost of a previous system and adjusts it. An analogy for a planned ship acquisition could be the class of ship being replaced or one recently constructed by another country. Since they're never identical, the analogous estimate needs to take differences into account, whether it be the size of the systems or the passage of time resulting in advances in capability that drive costs. As with any analogy, analogous estimates work better the more similar the things being compared are; a submarine is a poor analogy for a surface combatant. Since there are many possible analogous data points (that is, there are lots of previous shipbuilding projects to draw upon), estimators can produce multiple estimates relatively easily to develop a range of costs.

Analogous estimates based on earlier projects have to adjust for the passage of time. Due to cost growth, those adjustments have to use escalation factors much higher than regular inflation (which has averaged around 2.5% per year over the past two decades in Australia). An analogous estimate for a future submarine derived from the cost of the Collins-class submarine can't simply take the cost of the Collins and apply an annual inflation factor of 2.5%.

Parametric estimates

Parametric estimates are developed based on key technical parameters of the system (such as payload, sensor performance, range or endurance) and draw on historical data that correlates those parameters to cost. For a parametric estimate to be reliable, the estimators need to have a reasonable understanding of what the capability looks like, such as a multi-role surface combatant with a certain number of missile cells and certain speed and range requirements. Again, if the parameters change, the estimate will change. Estimators also need a robust database of reliable, consistent and structured costing data that they can draw upon.

Parametric estimates can be useful in understanding the cost–capability trade-off space (for example, in illustrating how a minor increase in performance may drive a major increase in cost).

Engineering build-up / work breakdown structure

An estimate based on engineering build-up breaks the system down into its key elements, such as the platform itself, FICs such as the training system and facilities, and so on. Those elements can be progressively further broken down: for example, the platform can be broken down into its major systems such as propulsion, sensors, combat system and so on. This work breakdown structure (WBS) can then be populated with cost data making use of industrial engineering techniques such as time standards, material and service inputs. Some data could be supplied by industry, as it develops a more granular WBS for individual subsystems in response to a tender, based on an understanding of how much work and materials are needed to produce particular elements. Analogous or parametric data could be used for particular lines in the WBS where industry responses aren't available.

When estimates generated by different methodologies coincide, it gives greater confidence that the estimates are about right. Early in the process, analogous estimates are more appropriate. As the solution becomes more defined (for example, a ship of a certain capability), a parametric estimate becomes feasible. However, when Defence seeks approval from the government to acquire a particular solution, a detailed estimate based on a WBS populated with data provided by industry in response to a tender is required. However, Defence might also do its own parametric estimate to check that industry's tendered response passes the reasonableness test.

Approved versus unapproved dollars

Because a cost estimate evolves over time as uncertainty decreases, another area where misleading comparisons can be made is between project provisions and contracted costs, or, put another way, between unapproved and approved dollars.

Let's look at the Australian system. A project begins when Defence determines that it will need to acquire a new system. This could simply be a replacement for an existing system (such as the Hunter-class frigate to replace the Anzac-class frigate), or it could be an entirely new capability to address an emerging threat (such as ballistic missile defence). Defence enters a new line in its investment plan (previously called the Defence Capability Plan, now called the Integrated Investment Plan, or IIP). The 2020 Force Structure Plan (FSP) is the most recent public version of the IIP.

The funding line in the IIP is a 'provision'; that is, the amount that Defence is willing to pay for the capability and that it holds in its financial plan. Quite often, this is less than a particular service might want, but prioritisation means everybody can't always get 100% of what they want.

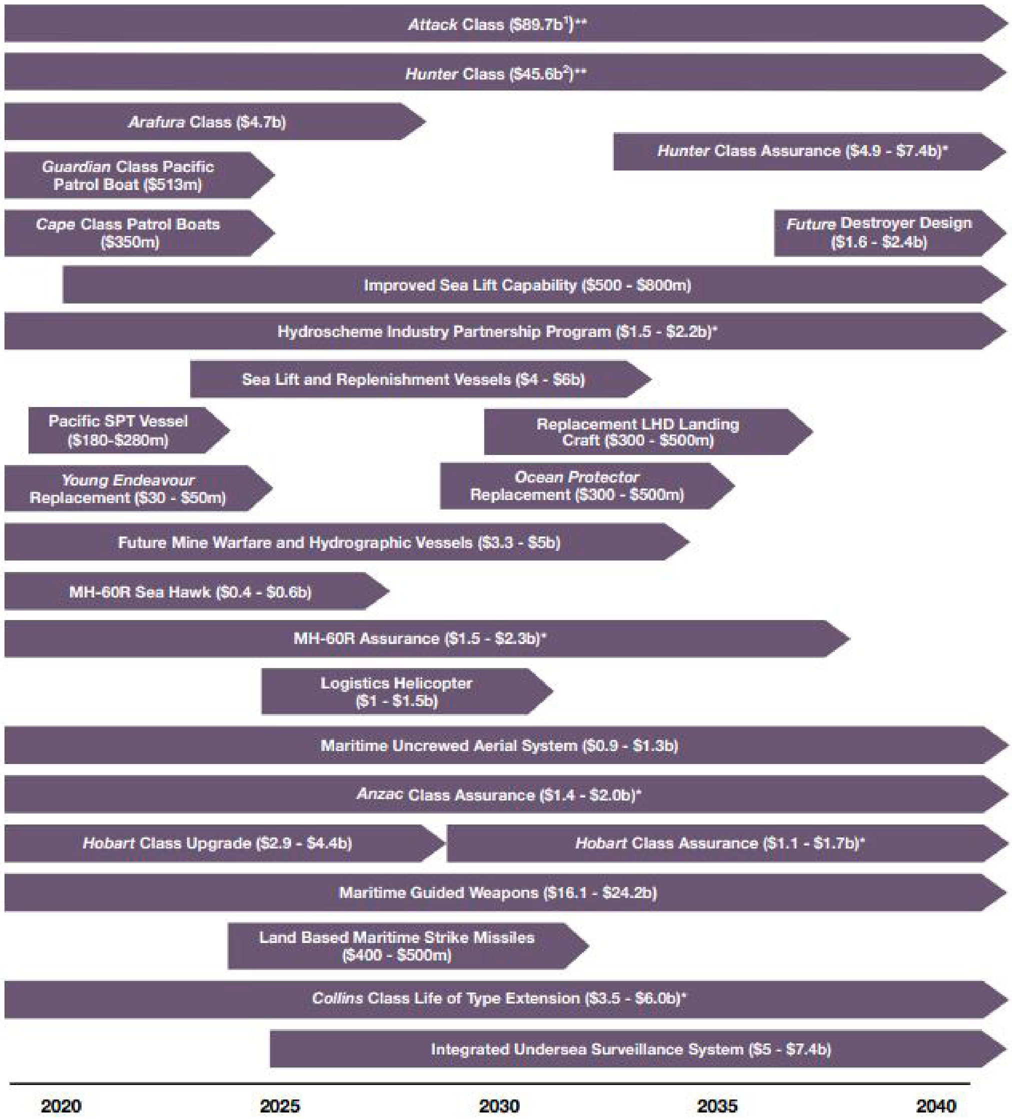
Provisions aren't based on tendered responses from industry but are usually generated by analogous or sometimes parametric cost estimation. Provisions can change significantly as Defence's requirements change. Very often, Defence might not completely understand its requirements in a changing strategic or technological environment and will need to adjust them. Also, engagement with industry may show that Defence's provision was simply unrealistic.

Between the 2016 IIP and the 2020 FSP, funding lines for some capabilities changed significantly, suggesting that the project provisions increased. I discuss this further in Chapter 7.

Defence doesn't make its project provisions public, fearing that doing so would reduce its commercial leverage. Incidentally, while the 2020 FSP presents the provision as a band, Defence's internal, classified provision is a point estimate.

The provision is an 'unapproved' budget, in the sense that Defence can't spend it (Figure 8). Once Defence develops a firm understanding of its requirements and the technological solutions available, it seeks first-pass approval from government (Defence now refers to this milestone internally as 'Gate 1'). Generally, this gives Defence approval to spend development funding to address technological risks and to put a tender out to industry.

Figure 8: The figures for capabilities in the 2020 Force Structure Plan are unapproved provisions in out-turned dollars



Source: Australian Government, Department of Defence, *Force Structure Plan 2020*, 45, online.

Once it has evaluated tender responses and determined its preferred option, Defence seeks second-pass approval (aka Gate 2) for an approved acquisition budget to acquire a particular solution. As we discussed in the previous chapter, this budget covers the acquisition of all the FICs needed to introduce the capability into service, not just the fly-away cost of equipment.

Large developmental projects may seek more than two approvals as they go through the development process and incrementally seek funds for upcoming stages of work. For example, before it was cancelled, the Future Submarine Program had received several approvals for a total of $6,355 million, but its total provision was $89.7 billion, so further approvals were still to come.[14] Similarly, the Future Frigate Program's approved budget is $7,058 million to date, but its provision is $45.6 billion.

It's potentially quite misleading to compare an approved budget, which is generally based on a contracted tender response, with a provision or unapproved budget, as they represent fundamentally different levels of certainty and risk. We discuss elsewhere the fact that Defence projects very rarely exceed their approved budgets; however, project provisions can and do change substantially as a project goes through the capability development process.

Contingency

All projects involve uncertainty and risk. Because defence projects often involve new technologies, they can face greater uncertainty than projects in other sectors. Defence project teams account for those uncertainties and risks by considering their state of knowledge of a system and what could go wrong in each area of the project and estimating the cost necessary to address that risk. This cost is called 'contingency'.[15]

Highly developmental projects require more contingency, as do IT-heavy projects. IT projects may have as much as 25% contingency. The rate of contingency is lower in areas that are well understood. Buying equipment off an existing US production line may only require at most 10% contingency, but small percentages of big numbers can still result in big numbers. If we assume that the $50 billion constant budget for the future submarine included 15% contingency, then the base estimate (termed the 'cash budget') was around $43.5 billion with $6.5 billion more in contingency.

All Australian defence projects' budgets contain contingency, but it's very difficult to tell from the public numbers for overseas projects whether they contain contingency. Since overseas numbers often refer to the contract price only, it's likely that they don't include any contingency that the acquiring agency has applied. This is another factor that makes direct comparisons difficult.

The government approves a total budget for a project, including contingency. Defence is then authorised to spend up to that amount. If it can't deliver the capability within that budget, it must inform the government so that the government can decide whether it wants to increase the budget (termed a 'real cost increase') or keep the same budget and reduce the capability to be delivered. We should note, however, that, despite popular perceptions of cost blowouts, very few defence projects here go over their approved budgets and require real cost increases; that's because their budgets already include contingency to cover things that can go wrong. If a project needs to spend all of its baseline budget *and* all of its contingency and needs to ask the government for more, something has gone seriously wrong.

There's no way to tell from the public data what percentage of any defence project's budget is contingency, or how much contingency it has spent. While few defence projects go over budget, many come close to spending their entire budget, which suggests that they're drawing on a lot of their contingency funds.

Because Defence doesn't want to tie up funds for things that might not occur, it doesn't hold projects' contingency in its financial plan. In plain English: there's no pot of cash if things go wrong. If risks are realised and the project needs to draw on the contingency, Defence needs to find those funds somewhere. It usually finds this in projects that have underspent against their estimated cash flow for the year due to unplanned delays in delivery—in fact, most defence projects miss their planned annual spend. Critics might call this a Ponzi scheme that would collapse if all defence projects delivered on schedule, but it's worked pretty well so far.[16]

Foreign exchange

Around two-thirds of Defence's equipment budget has gone overseas. This means that fluctuations in exchange rates can have a significant impact on what Defence pays. The Department of Finance compensates Defence several times each year on a no-win/no-loss basis for changes in exchange rates to ensure that project budgets maintain their buying power. If the Australian dollar goes down, projects are compensated to ensure that they can still acquire their agreed scope. If the Australian dollar goes up, projects don't get to pocket the rise as a windfall and acquire more equipment. Rather, their budgets are reduced. This means that projects have to identify how much of their planned expenditure is in various foreign currencies so that their budgets are properly adjusted.

This applies to approved and unapproved projects. Adjustments to exchange rates cover the whole future life of the project (projects obviously aren't compensated for funds already spent). Since some projects' planned spending extends far into the future, adjustments to exchange rates can cause large adjustments to their budgets. The Future Submarine Program's out-turned budget appears to have oscillated between around $80–90 billion depending on the exchange rate. At the Defence portfolio level, the adjustments can be substantial; in the 2021–22 PBS, the foreign exchange adjustment to the department's planned budget for 2023–24 was a decrease of just over $1 billion.

Australian premiums

The additional cost of designing and building military equipment in Australia is a controversial issue. Opinions range from the view of the Productivity Commission that the defence sector receives by far the highest rate of assistance of any in the Australian economy, to views that Australian industry is as competitive as any in the world, particularly if Defence provides it with consistent demand signals, thereby allowing it to benefit from learning curves. In the absence of reliable data, it's difficult to adjudicate between the claims. It's possible that they could both be true, depending on the sector and technology.[17]

There are, however, several factors that can drive high costs in Australia that can be present in projects to various degrees:

- the relatively small quantities required by the ADF, resulting in the stop–start nature of domestic production
- conversely, the additional costs associated with stretching out build programs to make them continuous (as is the case with the future frigate program)
- relatively small numbers of people with the appropriate STEM skills, exacerbated by competition for skilled workforce from the resources sector
- low levels of commercial acumen in Defence's CASG
- Defence's competition and contracting processes, which impose additional work on business, driving longer schedules and greater cost
- a defence version of the 'Australia tax' (To make it worthwhile for overseas companies to establish operations in small markets like Australia, they'll seek higher levels of profit; it's the same reason you pay 10%–20% more for a camera here than in the US).

The challenge for cost estimators, particularly when developing an analogous estimate, is to determine what's an appropriate percentage to apply to take these factors into account. The Department of Finance applied a 30% factor when it costed the government's election commitment to build self-propelled howitzers in Geelong. The RAND Corporation assessed that there was a 30%–40% premium to build ships in Australia, but it could be reduced through continuous build programs. That figure has been contested as too high by some observers, who claim the sample used was too narrow and didn't include projects that had minimal premium.

But, from our discussion so far, we can see that there are many other factors that can explain the apparent difference in price between Australian and overseas projects, and we shouldn't automatically default to ascribing apparent price differences to an Australian premium. It may well play a role, but it's not the only factor.

Chapter 5: A hypothetical example—or how $1 billion becomes $3.5 billion

In this chapter, I work through a hypothetical example to illustrate how the concepts we've looked at affect the cost of equipment.[18] It's essentially an analogous estimate, starting with a known cost and adjusting it to factor in those concepts. It's similar to the way Defence might develop the provision for a future project that it wants to enter in its investment plan.[19] It's certainly not how Defence would develop the cost estimate for a project for which it's seeking second-pass approval.

Meet the BEAST

Let's assume that the Army wants to buy a highly autonomous vehicle that can accompany dismounted troops, carrying their equipment and extra ammunition, as well providing power to recharge the batteries that operate the soldiers' communications equipment and sensors (Figure 9). It also functions as a launch and control station for smaller drones. *In extremis*, it can autonomously evacuate wounded soldiers from the battlefield. Equipping every infantry section of the Army with one would require around 250 of them.

Figure 9: Imagine something like these, but with more features …

Sources: (left) US Army, online; (right) Defence image library, online.[20]

Hypothetically, the US Army already has such a vehicle: the biologically emulating army systems transport (the BEAST), manufactured by Big American Prime Inc. (BAP). According to the US Defense Department's justification books (which provide extremely detailed cost information on actual equipment), the last BEASTs were produced in 2016–17 and cost US$3 million each.[21]

Exchange rate

Since the defence budget is developed in Australian dollars, we'll need an exchange rate. Let's assume that the Department of Finance has provided Defence with an exchange rate of A$1.00 to US$0.75.[22] Therefore, that would make each BEAST cost A$4 million, and the total cost of 250 BEASTs is a nice round 1 billion Aussie dollars (Table 2).

Table 2: Our starting point—250 BEASTs ($ million, 2021–22 constant dollars)

	2021–22	2022–23	2023–24	2024–25	2025–26	2026–27	2027–28	2028–29	2029–30	2030–31	Total
BEASTs			50	100	100						250
Unit cost			4.0	4.0	4.0						
Total cost			200.0	400.0	400.0						1,000.0

Out-turning

Our $1 billion starting point is in constant dollars. As we've discussed, however, the government works in out-turned dollars that take inflation into account. And to assess the impact of inflation we need an out-turning index as well as a schedule—the longer the schedule, the greater the effect of out-turning.

All cost estimates require making assumptions about schedule. We've assumed in Table 2 that the government will make a quick decision and Defence can take rapid delivery from an existing production line in the US.

The standard out-turning index used in Defence costing is non-farm GDP, which is essentially the rate of inflation across all industries except agriculture (because the latter can fluctuate dramatically, it's excluded). As we've seen, Defence can also choose other rates; for example, for components that experience higher rates of inflation than the broader economy. For simplicity in our example, we'll assume a constant non-farm GDP rate of 2.5%.

But we need a schedule to apply our out-turning to. Generally, shorter schedules are better—we want the improved or new capability as soon as possible and we want to avoid the overhead of operating a split fleet of two different, overlapping platforms for a long time. And, as we shall see, long projects lead to additional costs.

A traditional model would look something like this if Defence were buying the current model of BEASTs directly from BAP (or via the US Government's Foreign Military Sales program) off a production line that's up and running. Defence gets the first BEAST in two years' time and the rest within the following two years. That means the out-turning has little chance to escalate, and our $1 billion becomes only $1.082 billion (Table 3).

Table 3: Rapid off-the-shelf delivery of the BEAST ($ million, 2021–22 out-turned dollars)

	2020–21	2021–22	2022–23	2023–24	2024–25	Total
BEASTs			50	100	100	250
Unit cost			4.20	4.31	4.42	
Total cost			210.1	430.8	441.5	1,082.4

But let's assume that the government wants to get into the business of continuously building autonomous military vehicles here in Australia. First, even if the BEASTs are going to be manufactured by BAP's local subsidiary (AUSBAP), it's going to take a little longer to set up a new production line rather than buying them off an existing one. Also, the government wants to keep the production line going until it's time to start producing either the successor to the BEAST or some other vehicle to keep the production line going (yes, that does sound circular). Also, Defence's investment plan always has cash-flow pressures due to many different priorities competing for funding. A typical way to deal with them is to delay projects or stretch them out over time. This mitigates short-term cost pressures but generally has the result of increasing overall costs.

Let's assume that the combination of setting up a local build, plus stretching the build out both to ensure continuous production and to ease cash-flow pressures on Defence's investment program, means that the first vehicle will be delivered in 2025–26 with a build rate of 25 vehicles per year for 10 years. This means that the out-turning has a greater effect, for a total of $1.237 billion (Table 4). Our final BEASTs now cost $5.51 million each. However, at this point, since our out-turning index is roughly the same as broader inflation, there isn't any real difference between the constant and out-turned costs.

Table 4: Continuous BEAST build program ($ million, out-turned dollars)

	2025–26	2026–27	2027–28	2028–29	2029–30	2030–31	2031–32	2032–33	2033–34	2034–35	Total
BEASTs	25	25	25	25	25	25	25	25	25	25	250
Unit cost	4.42	4.53	4.64	4.75	4.87	5.00	5.12	5.25	5.38	5.51	
Total cost	110.4	113.1	116.0	118.9	121.8	124.9	128.0	131.2	134.5	137.9	1,236.6

Labour and materials growth

Military equipment generally increases in price at a greater rate than products in the broader economy. Making it can require skills or special materials that are in short supply. There are a lot of titanium components in the BEAST. Plus, like all modern military equipment, it's largely software driven, and demand for programmers far outstrips supply.

To address this, we'll add an additional 1.5% escalation per year for labour and materials growth, resulting in a total of $1.405 billion. The unit price of a BEAST at the end of our production run is now $6.66 million.[23]

This means that our out-turning index is now greater than inflation in the broader economy. This is why delaying projects or slowing them down increases their overall real cost. Time isn't a free good.

Capability growth

But we still haven't accounted for one of the key factors in the price of military equipment, which is that equipment increases in capability from one generation to the next due to increases in complexity, size and performance—all of which result in cost growth. In our hypothetical example, the last BEAST produced in 2016–17 was the first generation. Things move fast in the exciting world of autonomous systems, and the US Army and BAP are now developing the next-generation BEAST. The BEAST is becoming a mothership for mini-beastlets, so the ability to carry, launch, control and recharge them needs be included in the cost. Also, lithium-ion batteries have matured to the point that they can be used in the BEAST; that means more power per kilogram than traditional lead–acid batteries and therefore more capability, but more cost. Unfortunately, lithium-ion batteries have a tendency to catch fire, so the BEAST needs a fire suppression system (more cost). And it's making greater use of composites to reduce weight and increase its air-transportability (more cost). Plus, to protect the troops it will have a system that can detect the origin of sniper fire and jam improvised explosive devices and incoming missiles (more cost). The step change we want in the BEAST's operation, from remote control to autonomous navigation, requires investment in sensors and artificial intelligence algorithms (most cost).

To account for this change between generations of BEAST, we'll apply a 5% annual cost growth factor between the end of the first generation in 2016–17 and the completion of the design of the second generation in 2024–25. This isn't an excessive rate; studies of the cost of some classes of military equipment suggest substantially higher rates of 'intergenerational' cost growth.

Taken together, these three forms of escalation (inflation, labour and materials, and cost growth) mean that the first BEAST delivered in 2025–26 will now cost $6.15 million and the final one in 2033–34 will cost $8.75 million. Our $1 billion total is now $1.845 billion (Table 5).

Table 5: Continuous BEAST build program, including cost growth ($ million, out-turned dollars)

	2025–26	2026–27	2027–28	2028–29	2029–30	2030–31	2031–32	2032–33	2033–34	2034–35	Total
BEASTs	25	25	25	25	25	25	25	25	25	25	250
Unit cost	6.15	6.39	6.65	6.91	7.19	7.48	7.78	8.09	8.41	8.75	
Total cost	153.7	159.8	166.2	172.8	179.8	186.9	194.4	202.2	210.3	218.7	1,844.8

Cost estimators and analysts put a lot of time, research and thought into developing and applying the appropriate indices. One size does not fit all. Different metrics are used for different kinds of equipment, and different organisations disagree on how to apply them. Historical data is crucial, but it's in short supply in the Australian context, particularly in the public domain, so we draw heavily on US data.

Australian premium

As we've discussed, the Australian premium is a controversial issue. Regardless of the competitiveness of Australian industry, continuous build programs can have a cost of their own. Slowing production down or building in small annual quantities in order to generate continuous production for the number of vehicles the ADF requires creates inefficiencies, and also generates a premium. Twenty-five BEASTs a year might not be an economic quantity. In short, a continuous build rate isn't necessarily an optimal build rate.

Overall, we've applied a 10% local build premium to the BEAST project, which gets us to $2.029 billion.

Design and non-recurring engineering costs

So far, we've only looked at the cost of each vehicle. In US terminology, that's the unit drive-away cost. We haven't yet included any costs to update the design of the BEAST and set up our production line. These are non-recurring (that is, one-off) engineering costs. If we were building something unique for the ADF, we'd have to pay all the design costs ourselves. Fortunately, in this case we're acquiring something that BAP is developing for the US Army, so we'll pay only a share of those costs. We also need to cover the costs of setting up the local production line. We'll include $250 million at the front end of the schedule to cover both, which out-turns to $264 million.

The cost of our BEASTs is now $2.293 billion (Table 6). We're a long way from our original $1 billion round number estimate, but this is just for the platform itself, or the 'mission system', to use Defence's terminology.

Table 6: Mission system cost, continuous BEAST build program, including cost growth ($ million, out-turned dollars)

2022–23	2023–24	2024–25	2025–26	2026–27	2027–28	2028–29	2029–30	2030–31	2031–32	2032–33	2033–34	2034–35	Total
51.3	105.1	107.7	169.0	175.8	182.8	190.1	197.7	205.6	213.9	222.4	231.3	240.6	2,293.3

Other costs: fundamental inputs to capability

We've discussed that one reason for large discrepancies in cited costs of equipment is that commentators generally focus on the equipment itself (the mission system), whereas defence projects have to cost and deliver everything needed to operate the capability: the FICs. This is also known as the support system. A lot of effort is put into estimating FIC costs. They seem to range between 30% and 100% of the mission system cost.

Facilities are an important and expensive FIC. Our BEASTs need garages and maintenance workshops at many bases around Australia. Various metrics are used to estimate facilities costs, but around 3%–5% of the mission system cost is standard. However, if we're delivering a step change in capability, or acquiring a new capability that has no existing facilities, the facilities cost can be a lot higher (for example, if we need wharves for a new, bigger class of ship, which is why we're paying around $1 billion for facilities for the new offshore patrol vessels).

In the case of the BEAST, the garages it will be going into were largely built during World War II—which means demolition and costly asbestos remediation. Also, the fuel tanks are over 50 years old and have leaked into the watertable, requiring more remediation. Plus, construction costs in Darwin and Townsville where many BEASTs will be stabled tend to be higher than in major metropolitan centres in the south. We'll go with a 5% metric for facilities. That gets us to $2.339 billion.

The project also has to:

- acquire an initial tranche of spares
- conduct testing and evaluation to ensure that the BEAST meets our requirements and then address any performance shortfalls
- set up a training system with simulators, manuals and training rooms
- acquire intellectual property and technical documentation so that we can maintain and modify the BEAST as necessary
- set up a software lab to update the BEAST's artificial intelligence algorithms and the software interfaces with the beastlets
- acquire generators and solar panels to recharge the BEASTs' batteries in the field
- buy trailers so that we can transport the BEAST from base out to the field.

We'll go with 35% of the capital cost in our hypothetical example, including our 5% facilities metric, although it's probably on the low side, considering that the BEAST is a new kind of capability.

Between the mission system and the support system, our cost is now $3.099 billion.

Project-management costs

Project office costs aren't trivial. In addition to project managers, the project needs systems engineers (to define how it all fits together and will work with the rest of the ADF's systems), cost estimators, and people to write contracts, provide legal advice, manage the accounts and so on. Since the big reductions in Defence's Australian Public Service personnel, which have hit CASG particularly hard, Defence has turned increasingly to contractors, either to fill individual positions in project teams or to run entire projects. Contractors generally cost more than public servants.[24] They also show up in project costs, whereas the cost of Defence's own people is essentially an invisible 'free good'. We've included $5 million per year—out-turned, of course. This starts running before production and will continue after production ends to wrap the project up.

This gets our total acquisition cost to $3.188 billion (Table 7). In Defence terminology, this is the 'cash budget'.

Table 7: Total cost of BEAST mission system and support system, including project office costs ($ million, out-turned dollars)

2021–22	2022–23	2023–24	2024–25	2025–26	2026–27	2027–28	2028–29	2029–30	2030–31	2031–32	2032–33	2033–34	2034–35	2035–36	Total cash
5.0	76.9	147.1	150.8	233.7	243.0	252.6	262.6	273.0	283.9	295.1	306.8	319.0	331.7	7.1	3,188.2

Contingency

We've discussed the concept of contingency, which is an additional funding 'buffer' to address potential project risks. Our BEAST might look like a military-off-the-shelf project, since the US Army is also acquiring it, but there are still risks. There are still some developmental technologies involved in the new capabilities going into the second-generation BEAST. Also, we need to set up an Australian production line, which involves some risks, and the BEAST uses a number of exotic materials, the price of which tends to fluctuate dramatically. Moreover, there are uniquely Australian aspects, since we're using different drones, sensors and weapons from the US Army's, and a lot of the risk tends to be associated with the integration of subsystems.

A well-run project will assess contingency for each cost element individually, but for our hypothetical project we'll simply apply 10% contingency overall to the cash budget, or $318.8 million. This brings us to a total of $3.507 billion.

Table 8 shows our final acquisition estimate.

Table 8: Total acquisition cost of the BEAST ($ million, out-turned dollars)

2021–22	2022–23	2023–24	2024–25	2025–26	2026–27	2027–28	2028–29	2029–30	2030–31	2031–32	2032–33	2033–34	2034–35	2035–36	Total cash	Contingency	Total
5.0	76.9	147.1	150.8	233.7	243.0	252.6	262.6	273.0	283.9	295.1	306.8	319.0	331.7	7.1	3,188.2	318.8	3,507.0

Operating costs

Another way confusion is created is when acquisition costs are compared with whole-of-life costs. The latter include the cost of operating the capability as well as acquiring it. Military equipment is generally designed to operate for a long time, and the cost of operating it for 25–30 years is usually substantially more than the original acquisition cost. A standard rule-of-thumb is that lifetime operating costs are twice the acquisition cost.[25]

We won't go through a full cost exercise again for the operating costs. But as an autonomous, software-driven platform that has to integrate with many other systems, it's highly likely that the BEAST's continuous software updates are going to be a key cost driver. Suffice it to say that we probably need to budget for at least several billion dollars for the BEAST fleet over 25–30 years.

Chapter 6: A real-world example—the Hunter-class frigate

Public information often seems to suggest that there's a major discrepancy between what Australia is paying for military equipment and what other countries pay. Commentators often assume that this is caused by high premiums for local build or that Australia is being taken advantage of by the arms industry. While we can't rule those factors out completely, we've seen that there are many factors driving apparent differences in cost. I've illustrated how those factors work in a hypothetical example. We'll now look at a real-world example to see whether the price of an Australian project is significantly more than the price for comparable projects overseas.

The Hunter-class frigate

In June 2018, the Australian Government announced that, on the basis of a competitive evaluation process, it had selected the UK's Type 26 design as the basis or reference design for Australia's future frigate, of which there would be nine vessels, which were subsequently named the Hunter class (Figure 10).

Figure 10: The Hunter-class frigate

Source: BAE Systems, Defence image library, online.

There's been cost growth in the program both before and after that announcement. In the *2016 Defence White Paper*, the provision for the future frigate had been $30 billion (out-turned). In the 2017 Naval Shipbuilding Plan, that increased to $35 billion, and in the 2020 FSP it was increased once again to $45.6 billion. As the value of the Australian dollar has recovered somewhat since then, that number has decreased to $44.1 billion, according to Defence officials in June 2021.

What caused the increase? We can identify three reasons:

- The first is the systemic under-representation of the cost of megaprojects in the 2016 White Paper's integrated investment program. The future submarine was listed there at >$50 billion in out-turned dollars; it became close to $90 billion. The infantry fighting vehicle was $10–15 billion; it's now $18–27 billion. Since Defence was perfectly capable of developing a reasonable analogous or parametric estimate in 2016, it would appear that either its assumptions about these projects have fundamentally changed (even though their scope seems to have remained fairly stable), or it simply chose not to share with the Australian public its actual estimates in 2016.
- The second reason is that the government has now acknowledged that continuous naval shipbuilding comes with a massive premium. In order to align the completion of the Hunter frigate program with the replacement of the Hobart-class destroyers in the late 2040s, the frigate program's schedule has been deliberately slowed down. As we've discussed, slower schedules result in greater cost. This is in part due to the effects of escalation, but also to the fact that the shipyard won't be operating at the most efficient rate. The 2020 FSP acknowledges this, stating 'in its decision to approve the Hunter class frigate program, the Government allocated additional funding to enable construction of ships at a deliberate drumbeat over a longer period of time than originally planned to achieve a continuous shipbuilding program.' In essence, we're paying more to deliberately slow down construction and get the capability later.
- The third reason is that the Hunter class has grown significantly in size. The Type 26 design was over 8,000 tonnes full-load displacement at the time it was selected as the reference ship for Australia's future frigate. That grew to 8,800 tonnes. Defence officials have since informed the Senate that it's now over 10,000 tonnes. As we've discussed, cost is to a large degree driven by size. The increase in size is likely to be reflected in the cost increase.

So far, the cost estimate hasn't been adjusted to take into account the recently announced schedule delay, which effectively delays the start of construction by 18 months and the entry into service of the first vessel by two years. Defence has stated that the schedule will be recovered by Ship 4; nevertheless, the delay will have an impact on cost.

The Hunter class is costing a lot of money, but it would be misleading to state that each of nine frigates being acquired is costing $5 billion in current day dollars. Let's unpack the roughly $44–45 billion cost:

- It's an out-turned figure. Based on the program schedule, which will be delivering ships on a two-year drumbeat out to 2047, and an inflation rate of 2.5%, that's the equivalent of around $31 billion constant (or current day) dollars.
- The $45 billion includes all acquisition costs, including design and FICs; that is, everything in the US Navy's acquisition cost box in Chapter 3. It's not just the cost of the ship.
- Similarly, it's a total project cost, not just the cost of the contract with the shipbuilder.
- Assuming 10%–15% contingency, the $31 billion constant includes roughly $2.7–2.8 billion in contingency, so the estimate without risk provisions is around $28 billion.
- We should also note that, if the $44.1 billion out-turned estimate is based on a constant estimate that uses a 2016 baseline, then that figure will need to be increased by around 10% to bring it onto a 2021 baseline. For this analysis, we'll assume that $44.1 billion is already in a 2021 baseline, but that's merely an assumption.[26]
- $28 billion is still a lot of money for a nine-ship program. How does that compare to similar programs overseas? Some have claimed that we're paying twice as much, or more, per ship. Let's look at the data.

The Canadian surface combatant program

Perhaps the closest analogy is Canada's surface combatant program, which has also selected the Type 26 frigate (Figure 11). Canada plans to acquire 15 ships. The schedule appears to be broadly similar to Australia's: construction starts in 2023–24, first delivery will be in the early 2030s, and the project is to be completed in the late 2040s.[27]

Figure 11: The Canadian surface combatant, which shares the same reference ship design with the Hunter class, making it a close analogy for cost comparison

Source: BAE Systems.

As in Australia's frigate program, the Canadian cost estimate has risen significantly over time, starting at a very inadequate C$26.2 billion in 2008. Based on a Canadian Parliamentary Budget Office estimate of C$62 billion in 2017, the Canadian Government revised its estimate to C$56–60 billion. After the selection of the Type 26, the Parliamentary Budget Office updated its cost estimate for the program to C$69.8 billion.[28]

Recently, the office increased its estimate to C$77.3 billion, mainly due to an increase in the ship weight from 6,900 to 7,800 tonnes. That growth in size and, consequently, cost isn't surprising, given that the Canadian program is also undergoing major design changes to incorporate the Aegis radar and combat system.[29]

The C$77.3 billion estimate is in nominal (or 'then year') dollars, which are essentially out-turned. Since the project's schedule is very similar to SEA 5000's, the out-turning effect will be similar. The scope included in the cost is broadly similar to that of an Australian acquisition project (other than the number of ships), so our starting points of $45 billion and C$77.3 billion are broadly apples to apples.[30]

When we convert C$77.3 billion to Australian dollars, it's around $83.8 billion. If we convert Australia's nine ships for $44.1 billion to 15 ships to match the Canadian scope, we get to $73.5 billion. That is, the cost of the Canadian program is actually higher than Australia's on a 'per ship' basis.

One factor reinforced by the Parliamentary Budget Office's estimate is that cost is very sensitive to schedule delay. A one-year delay would increase the cost from $77.3 billion to $79.7 billion, and a two-year delay would increase it further to $82.1 billion. Time is not a free good.

The UK's Type 26 program

Another analogy can be made with the UK's Type 26 program. Unfortunately, there's little public data available on it, and certainly nothing as robust as the Canadian Parliamentary Budget Officer's series of estimates, even though the Type 26 program has started construction. I'd be pretty annoyed at the lack of transparency if I were a UK taxpayer.

According to public reporting, the UK Government signed a £3.7 billion contract with BAE for the first three ships in 2017. Adjusting for foreign exchange and a 2021 price basis results in a cost per ship of around $2.5 billion. The Hunter would appear to cost 36% more, but we aren't doing an apples-to-apples comparison. The £3.7 billion figure isn't the total program cost but just the value of the contract with BAE. We can't see what's included in the contract and what additional elements are costed separately (such as infrastructure to support the ships in service). It's possible that some systems to be installed on the ship are being supplied as so-called 'government furnished equipment' (that is, they're acquired directly by the government and provided to the prime contractor to install and therefore aren't included in the contract cost). Moreover, we can't see how contingency is being addressed.

Another factor that's likely to be holding down the cost is that some reports suggest the UK's Type 26 is being delivered without some key systems and in some key respects is 'fitted for but not with'. Moreover, it's not clear how weight growth since the signing of the contract is influencing the cost.

In short, the UK's Type 26 program appears at first sight to be substantially cheaper than the Hunter-class program, but, once the factors we've considered in this report are taken into account, any price difference will likely be substantially less that the initial 36%.

The US Navy's FFG-62 Constellation class

Another analogy is provided by the US Navy's new frigate program. On 30 April 2020, the US Navy awarded Fincantieri Marinette Marine a contract to build its new guided-missile frigate, which has since been designated the FFG-62 Constellation class (Figure 12). The chosen design is Fincantieri's FREMM, which was an unsuccessful contender in Australia's competitive evaluation process.[31]

Figure 12: USS *Chesapeake*—a ship of the planned FFG-62 Constellation class

Source: US Navy, online.

The US Navy estimated the cost of the first FFG-62 at US$1.2 billion and the total for the first 10 at US$8.7 billion. That looks like a bargain compared to the Australian Defence Department's figure of $44–45 billion for nine Hunter-class frigates. Even adjusting for exchange rates (assuming A$1 = US$0.75), at first glance it looks like a FFG-62 is costing $1.16 billion while a Hunter-class frigate is costing $5 billion. Are we really paying over four and a half times as much? Let's step through and see whether we can do an apples-to-apples comparison.

The first point we should make is that the US Navy estimate for the FFG-62 is probably too low. The US Navy consistently underestimates the cost of its programs. The Congressional Budget Office (CBO) has done its own analysis and concluded that the navy's estimate would make the FFG-62 the navy's cheapest surface combatant per ton in decades, despite being more complex and capable than many other vessels, such as the inadequately armed littoral combat ship.[32] Not only was the US Navy's estimate significantly lower than for other surface combatants, it was less than for a US Coast Guard ship that didn't have anywhere near the same equipment or build standards. The CBO developed an independent estimate that's 40% higher than the US Navy's at US$12.3 billion for the first 10 ships.

Looking at its analysis, I'd say that the CBO is in fact being too easy on the US Navy, but if we take the CBO figure as a starting point, the figure for 10 FFG-62s is $16.4 billion when converted to Australian dollars, or $1.64 billion per ship.

The next point is that the Hunter class is a significantly bigger vessel. The FFG-62's full-load displacement is 7,300 tons (6,622 tonnes). The full-load displacement of the Hunter class has grown since its selection and, according to Defence testimony at Senate estimates hearings, is now 10,000 tonnes. While weight isn't the only metric to take into account in developing cost estimates, it's an important one. So, for a legitimate analogy, we need to adjust the weight of the FFG-62 to bring it into line with the Hunter class. This makes it $2.48 billion per vessel.

The reader might ask 'But aren't we paying too much for a frigate if we could have gotten a significantly smaller (and therefore cheaper) one that still has the Aegis combat system, an advanced air defence radar, 32 vertical launch cells, a towed-array sonar and space for two antisubmarine helicopters?' That is, couldn't we have gotten similar capability from a smaller and cheaper frigate? That's a reasonable question, but it's asking whether we're paying too much for a *frigate capability*, which is a different question from 'Are we paying too much for the Hunter-class frigate?' To answer the first question, we'd need a better understanding of what Defence considered the key discriminators between the two vessels to be. In essence, we'd need to understand what additional value Defence assessed it was getting for the additional size and cost. We are unlikely to see Defence's business case until the second pass cabinet submission is made public in 2038.

The next factor we need to address is that the CBO figure for the FFG-62 is in real dollars, which are essentially constant dollars. The $45.6 billion for the Hunter class is in out-turned dollars. We noted above that that converts to around $31 billion constant (based on the public schedule for the Hunter and a 2.5% inflation rate). That means around $3.4 billion per Hunter-class ship when all program costs are included.

So, after adjusting for the exchange rate and the size of the vessels and undoing the out-turning, we've reached $2.48 billion per FFG-62 and $3.4 billion per Hunter class frigate in constant dollars. That suggests we're paying around 37% more (per tonne). But, as I discussed in Chapter 3, Australian project estimates tend to include more elements, as well as contingency, so while we're paying more, it's probably not 37% more. Even if we remove just the contingency provision, the difference falls to 26%. That's consistent with the RAND Corporation's assessment of the local Australian premium.

Observations

It's hard to make firm conclusions based on the limited data available for both Australian and overseas programs. The most robust public estimate and most direct analogy is the Canadian program. It appears to be costing at least as much as Australia's on a per ship basis. That probably isn't surprising in the light of the state of disarray of the Canadian shipbuilding programs.

Comparisons with the UK and US are harder due to the lack of data regarding the UK's program and the indirect analogy with the US Navy's. Nevertheless, Australia does appear to be paying more on a per ship or per tonne basis, but it isn't by the margins some commentators have claimed.

This brief analysis does confirm that costs are extremely sensitive to both size and schedule. Since both are driven by more demanding requirements, it's inevitable that increasing requirements will increase both cost and schedule.

Chapter 7: Do defence projects go over budget?

There's a deeply held popular view that defence projects always go over budget. Indeed, not only do they go over budget, but they experience (to use the media's favourite term) 'massive cost blowouts'. Let's take a look at whether that perception is accurate.

Answer 1: No, they don't

Popular wisdom states, or even shrieks, that Defence's projects are consistently over budget, but is that the case? The short answer is 'No'.

Every year, the Australian National Audit Office (ANAO) puts out its *Major projects report* (MPR), which includes a table like the one below, reproduced from the 2018–19 edition (Table 9). Every year, the media immediately publish stories about cost blowouts. It's perhaps not surprising that the media do that when the ANAO writes that 'the approved budget for Major Projects included in the MPR has increased by $24.4 billion (38.0 per cent) since initial Second Pass Approval'.[33]

Table 9: ANAO table reporting 'budget variation over $500m post initial second pass approval by variation type'

Project	Variation Type	Explanation	Year	Amount $b
	Scope Increases			**14.1**
MRH90 Helicopters		34 additional aircraft at Phase 4/6 Second Pass Approval	2005–06	2.3
Joint Strike Fighter		58 additional aircraft at Stage 2 Second Pass Approval	2013–14	10.5
P-8A Poseidon		Four additional aircraft	2015–16	1.3
	Real Cost and other Increases			**1.8**
AWD Ships		Real Cost Increase of $1.2b offset by $0.1b transfer for facilities in 2014	2013–14 and 2015–16	1.1
Overlander Medium/Heavy		Project supplementation[3] ($684.2m) and additional vehicles, trailers and equipment ($28.0m) at Revised Second Pass Approval	2013–14	0.7
	Other budget movements			**1.3**
Other	Scope increase/budget transfers (net)	Other scope changes and transfers	Various	1.3
	Price Indexation – materials and labour (net) (to July 2010)[4]			2.8
	Exchange Variation – foreign exchange (net) (to 30 June 2019)			4.4
	Total			**24.4**

Source: ANAO, *2018–19 Major projects report*, Table 3, p. 13.

But does that $24.4 billion represent a 'blowout'? Or any increase in real terms? Since the total approved value of the projects covered by the 2018–19 MPR is $64.1 billion, it seems like it's a significant increase. But let's unpack it.

The biggest category is 'scope increases' for three large projects, at $14.1 billion. That's simply the cost associated with the government agreeing to buy more stuff. If you want another 54 F-35As, you have to pay for them—$10.5 billion, in fact. It's misleading to describe that as a cost increase, let alone a blowout. It's an increase on the initial government approval of 14 aircraft, but, since the plan was always to get 72 once the Joint Strike Fighter program costs had stabilised and were better understood, it's not a change in the plan.

$2.8 billion was for 'price indexation', which is essentially supplementation for inflation. That's simply addressing inflation that occurs over the life of a project. And that practice ended in 2010, nearly a decade ago. Now inflation is taken into account in the second-pass funding approval; that is, it's built into the cost estimate, so it's hard to describe that as mismanagement or a blowout.

$4.4 billion addressed exchange-rate variations. As the Australian dollar goes down against other currencies, in particular the US dollar and the euro, Defence loses buying power. The government compensates it on a 'no win, no loss' basis for that. You could perhaps describe this as a cost increase, but one that Defence has no control over. Also, if the Aussie dollar goes up, Defence's budget is adjusted down.

$1.3 billion was for 'other budget movements', which are transfers of scope between projects. If a project is directed to buy stuff that another project was originally meant to get, it's only reasonable that it gets the funding needed to do so. Such adjustments are done with government approval but really just shift money between projects.

So that leaves $1.8 billion in 'real cost and other increases'. In Defence terminology, a 'real cost increase' is a case in which a project has insufficient funds to acquire its full approved scope, so Defence needs to seek approval from the government to spend additional funding. The table lists two cases. The first is the increase to the Air Warfare Destroyer's budget of $1.1 billion that was agreed to in July 2015 as part of the project's get-well program.[34] The other was 'project supplementation' of $684 million for LAND 121, which is Defence's constellation of truck projects. It's not clear to me whether this was even a real cost increase *per se* (that is, more money needed to buy the same amount of stuff) or simply rebalancing funding between different phases of the project that were acquiring different kinds of trucks. The MPR's discussion of the project isn't completely illuminating. Defence provides a separate table of real cost increases on page 84, and LAND 121 isn't listed there, so Defence doesn't regard it as one.

To be comprehensive, we should note that the ANAO's table doesn't include all real cost increases, only those above $500 million. Defence's list on page 84 includes more projects and totals $1,693.2 million.[35] If we go with that number, then actual cost increases are about $1.7 billion out of a total portfolio of $64.1 billion, or about 2.7%.

But if we want to get a complete picture, we should also take into account projects that were delivered *under* budget. Since its inception, 23 projects have exited the MPR because they have delivered their scope. Those projects had a total approved budget of $23.9 billion.[36] At the time they exited the MPR, they had $2.2 billion remaining in unspent funds. It's likely that they would have spent a little more as they wrapped things up and shut down, but essentially those projects were collectively 9.3% under budget. And that $2.2 billion exceeds the cost increases discussed above.

In short, based on the evidence in the MPR, the small number of projects that went over budget did so by an amount that was less than the amount by which a much larger number of other projects were under budget.[37]

An important caveat to this is that the MPR looks only at a small selection of Defence's capital equipment projects (albeit the largest ones) and doesn't look at any of Defence's ICT or infrastructure projects. But ASPI has compiled all the public data available on Defence's expenditure on equipment projects. That's a much larger sample of projects than the ANAO covers, and from that data we can see the same phenomenon—the vast majority of Defence projects deliver within budget.

Answer 2: Yes, they do

The ANAO's MPR looks only at a subset of projects that have received second-pass approval from the government. At second pass, the government agrees to a scope, schedule and budget and directs Defence to acquire the capability. As we've seen, Defence projects rarely exceed their second-pass budget, but they can experience major cost growth *before* second pass.

Defence enters projects in its acquisition plan (now called the IIP) when the projects are still a long way from second pass. At that stage, they're rather 'conceptual' (in fact, it can be premature to refer to them as projects *per se*), but they're assigned a funding provision based on Defence's understanding of its requirements and the cost of solutions at the time. That understanding can change; Defence might not fully understand its requirements, and, as technology, strategic circumstances and funding priorities change, the provision can change.

We've seen provisions change substantially between the public version of the IIP released with the White Paper in 2016 and the updated version presented in the 2020 FSP. Table 10 reproduces a table from Part 1 of the 2020–21 *The cost of Defence* with some key examples.

Table 10: Cost increases from 2016 to 2020 ($ billion)

Capability	2016 Integrated Investment Program cost	2020 FSP cost
Future submarines	>50.0	89.7
Replenishment / logistics support ship(s)	1.0–2.0	4.0–6.0
Future frigates	>30.0	45.6
Infantry fighting vehicles	10.0–15.0	18.1–27.1
Medium-range ground-based air defence	1.0–2.0	4.9–7.3

Sources: 2016 Integrated Investment Program and 2020 FSP.

So, substantial cost growth has occurred. In some cases, the scope has changed. For example, the scope of the logistics support ship line has grown from one to two ships, and they're bigger and more capable. But, in other cases, it's still the same scope: nine frigates or 450 infantry fighting vehicles.

In the case of submarines, it appears that Defence's internal cost estimate was always much higher than the $50 billion it used publicly, at least since late 2015. According to Department of Finance evidence to the Senate's inquiry into naval shipbuilding, Defence's internal estimate in late 2015 was actually $78.9 billion out-turned.[38] Once exchange-rate fluctuations are taken into account, that number is broadly consistent with the 2020 FSP figure of $89.7 billion.

In the case of the frigates, the FSP stated that slowing down production to ensure steady work for the industry required a substantial increase to the funding requirement. The increasing size of the future frigate to cope with the design changes directed by the government could also be a driver of the increased provision.

Because, due to scope increases, we aren't always comparing apples with apples, it's difficult to determine how much cost growth has occurred. Substantial work has been done in the US showing that cost growth also occurs there both before and after the decision to commence acquisition.[39] But there's no comparable work here; the ANAO isn't tracking cost growth before second-pass approval and, because Defence's internal project provisions are classified, ASPI doesn't have access to the relevant data.

Since this cost growth occurs before second-pass approval, it's possible for the government to change the plan before it gets into contract with industry. Theoretically, it could decide not to proceed with the project, but examples of that are very rare, such as the case of self-propelled howitzers in 2012 (and in 2019, during the election, the government announced that it would get them after all). Generally, Defence tweaks the scope of a project to get it inside its funding provision (225 combat reconnaissance vehicles became 211, for example) or it asks the government to approve a bigger budget. As long as it comes out of Defence's existing budget in the form of scope reductions or delays to other projects, the government usually says yes.

Notes

1 Defense Security Cooperation Agency (DSCA), 'India—AGM-84L Harpoon air-launched Block II missiles', media release, US Defense Department, 13 April 2020, online; DSCA, 'Morocco—AGM-84L Harpoon air-launched Block II missiles', media release, US Defense Department, 14 April 2020, online.

2 US Defense Department, 'Contracts for May 13, 2020', US Government, online.

3 Mark V Arena, Irv Blickstein, Obaid Younossia, Clifford A Grammich, *Why has the cost of navy ships risen?* RAND Corporation, Santa Monica, 2006, online.

4 Another graph that extends the line back to 1920 can be found online.

5 Edward N Luttwak, 'Breaking the bank: why weapons are so expensive', *The American Interest Magazine,* September/October 2007.

6 Augustine's 52 'laws' are reproduced online.

7 For example, in Franklin C Spinney, 'Defense death spiral', slide show, September 1998, online. The challenge of reversing its declining numbers of ships is one that the US Navy has been grappling with for many years with minimal success.

8 This shouldn't be confused with the 30 projects with the largest *total* acquisition budgets. As they ramp up, even very large projects may only have relatively small annual cash flow and therefore do not show up in the Top 30 table. Similarly, as delivery winds down, they'll fall out of the Top 30 table even though the project hasn't closed.

9 *The cost of Defence*, ASPI, online.

10 Email from Defence, 31 May 2019.

11 In fact, when cost estimators in the Australian Defence Department build an estimate, often the first place they go for data is the US Defense Department's justification books. Under Secretary of Defense, 'Defense budget materials – FY2023', US Defense Department, 2022, online.

12 Foreign Affairs, Defence and Trade Committee, Defence portfolio, 2018–19 Budget estimates, question on notice no. 117, portfolio question no. 125.

13 Email from Defence media, 21 July 2021.

14 It has been stated that Defence's cost estimate for the Future Submarine Project was $50 billion constant. If we're to be precise, this was actually the provision in the public IIP; that is, it was a broad indication of what Defence expected to pay. Defence didn't publish its actual cost estimate. After the project was cancelled, documents released in response to freedom of information requests state that, at the time of cancellation, Defence's actual cost estimate for the Attack-class submarine program was $46.4 billion in 2016 constant dollars. Naval Shipbuilding Coordination Group, 'Attack class submarine (SEA 1000)', Defence Department, Australian Government, 10 August 2021, online.

15 Risk and uncertainty are two separate things and aren't quite interchangeable terms. In general, risk is measurable but uncertainty isn't. An uncertainty could be that a project team is unsure what the exact power requirements for a system are, so it needs to make an assumption about it. That assumption could be incorrect. Risk management attempts to control uncertainty. The project might assume that the system's power consumption will be *x*, but there's a quantifiable risk that it might exceed that and the project may need to spend $*y* and *z* months to redesign the power source.

16 Defence's ability to manage contingency could be challenged if the IIP is dominated by a small number of megaprojects such as the Joint Strike Fighter, the future frigate and submarine and future armoured vehicles. If a megaproject is in trouble and needs more cash, it will need a lot, which will require many smaller projects to be delayed.

17 For a discussion of local premiums in defence projects, see Rob Bourke, *Defence projects and the economy,* ASPI, Canberra, 2019, online.

18 This chapter is an updated version of one first published in Marcus Hellyer, *The cost of Defence: ASPI defence budget brief 2018–19,* ASPI, Canberra, online.

19 This exercise is intended simply to illustrate the concepts discussed in the previous chapter. It's certainly not a 'how to' manual for professional cost estimators.

20 I have no idea what the systems in these photos actually cost.

21 If this sounds familiar to those who follow military technology, that's because the US Army was developing such a vehicle, called the 'MULE', as part of an ambitious and technologically challenging program of modernisation of its vehicles and weapons. The entire program was cancelled in 2009, as cost predictions exceeded US$300 billion after billions of dollars in development spending hadn't delivered anything. See Christopher G Pernin, Elliot Axelband, Jeffry A Drezner et al., *Lessons from the Army's Future Combat Systems Program,* RAND Corporation, Santa Monica, 2012, online.

22 The Department of Finance doesn't want government departments speculating on possible future changes to exchange rates and speeding up or slowing down projects as a result. Consequently, Finance compensates Defence for changes to exchange rates on a no-win, no-loss basis to maintain its purchasing power. If the Australian dollar goes up, Defence gets less money; if it goes down, Defence gets more. So projects need to accurately estimate their exposure (that is, which of their costs will be in overseas currency) so that they're appropriately compensated.

23 It's pure coincidence that that's the number of the beast.

24 On the cost of contractors, see Chapter 4 of Marcus Hellyer, *The cost of Defence 2020-21. Part 2: ASPI 2020-21 Defence budget brief,* ASPI, Canberra, online; and Marcus Hellyer, *The cost of Defence: ASPI defence budget brief 2021-22,* ASPI, Canberra, 41-42, online.

25 Defence's Naval Shipbuilding Plan suggests a rule-of-thumb metric of 30% acquisition cost plus 70% operating cost.

26 We should note that the $50 billion constant estimate for the Attack-class submarine used a 2016 baseline even into 2021, so it's possible that the Hunter program is still using a 2016 baseline.

27 'Canadian surface combatant', Canadian Government, 4 August 2021, online.

28 Office of the Parliamentary Budget Officer, *The cost of Canada's surface combatants*, Ottawa, 1 June 2017, online; Office of the Parliamentary Budget Officer, *The cost of Canada's surface combatants: 2019 update*, Ottawa, 21 June 2019, online.

29 Office of the Parliamentary Budget Officer, *The cost of Canada's surface combatants: 2021 update and options analysis*, Ottawa, 24 February 2021, online. It's not clear how the Canadians have kept the weight to under 8,000t while Australia's version of the Type 26 is now over 10,000t.

30 Ideally, we'd want to compare real dollars with real dollars, as that avoids the potentially distorting effect of out-turning, but we don't have a real figure for either the Canadian or the Australian program, and converting the 'then year' numbers to real values would require us to make a number of assumptions about the out-turning indices the programs used. Since the schedules for the programs are broadly similar, we can compare the 'then year' figures.

31 Congressional Research Service, *Navy Constellation (FFG-62) class frigate program: background and issues for Congress*, US Congress, Washington DC, updated 10 August 2021, online.

32 Congressional Budget Office, *The cost of the Navy's new frigate*, US Congress, Washington DC, October 2020, online.

33 Australian National Audit Office (ANAO), *Major projects report 2018–19*, report no. 19, 2019–20, Australian Government, 11, online. 'Approved' means that it's the official project budget that the government has agreed Defence can spend on an agreed project scope.

34 According to the 2021–22 Defence PBS, the Air Warfare Destroyer Project is aiming to close this year. With $8,147 million spent to 30 June 2021 and a further $238 million forecast for 2021–22, it will have around $700 million of its increased budget unspent, or, put another way, it will only need around $400 million of its $1.1 billion real cost increase.

35 They're SEA 4000 Phase 3 (Air Warfare Destroyer), $1,199.5 million; AIR 9000 Phase 2/4/6 (MRH-90 helicopters), $31.4 million; AIR 5431 Phase 3 (civil–military air traffic system), $247.5 million; SEA 1448 Phase 2B (Anzac anti-ship missile defence), $214.7 million.

36 ANAO, *Major projects report 2018–19*, Table A1, p. 108.

37 And it's looking like the Air Warfare Destroyer Project won't need all of its increased funding.

38 Senate Standing Committees on Economics, 'Additional documents', Inquiry into Australia's sovereign naval shipbuilding capability, Australian Parliament, 2022, online.

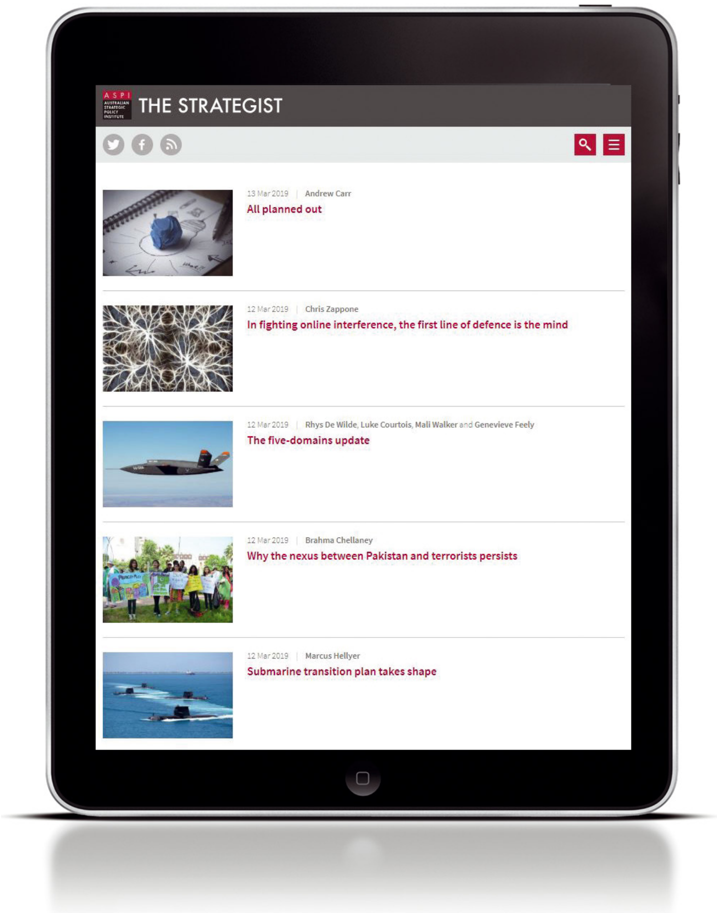
39 RAND Corporation has published several studies on the cause of cost growth in US defence projects, including Joseph G Bolten, Robert S Leonard, Mark V Arena, Obaid Younossi, Jerry M Sollinger, *Sources of weapon system cost growth: analysis of 35 major defense acquisition programs,* RAND Corporation, Santa Monica, 2008.

Acronyms and abbreviations

ADF	Australian Defence Force
ANAO	Australian National Audit Office
BAP	Big American Prime Inc.
BEAST	biologically emulating army systems transport
CASG	Capability Acquisition and Sustainment Group
CBO	Congressional Budget Office
CPI	Consumer Price Index
DSCA	Defense Security Cooperation Agency (US)
FIC	fundamental input to capability
FSP	2020 Force Structure Plan
GDP	gross domestic product
IIP	Integrated Investment Plan
IT	information technology
MPR	*Major projects report*
PBS	Portfolio Budget Statements
STEM	science, technology, engineering and mathematics
WBS	work breakdown structure

Stay informed via the field's leading think tank, the Australian Strategic Policy Institute.

The Strategist, ASPI's commentary and analysis website, delivers fresh ideas on Australia's defence and strategic policy choices as well as encouraging discussion and debate among interested stakeholders in the online strategy community. Visit and subscribe to an email digest at www.aspistrategist.org.au.



facebook.com/ASPI.org

@ASPI_org

A S P I
AUSTRALIAN STRATEGIC POLICY INSTITUTE

Supported by

LOCKHEED MARTIN THALES

To find out more about ASPI go to www.aspi.org.au
or contact us on 02 6270 5100 and enquiries@aspi.org.au.

Understanding the price of military equipment