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Mind the gap

Getting serious about submarines

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Overview

The Defence White Paper of 2009 promised to deliver *Force 2030*, which had as its centrepiece a force of twelve new highly capable long-range submarines. That's not going to happen. We're already past the point at which a force of that size and capability can be in place even by the mid-2030s.

So where do we go from here? The Collins class fleet reaches the end of its currently planned life between 2022 and 2031. Based on Defence's own planning figures, new-design replacement submarines can't be delivered fast enough to even replace the Collins as they leave service. If current plans are adhered to, a capability gap is inevitable sometime in the late 2020s, and a period of no submarine capability at all is possible.

HMAS *Dechaineux* (left) and HMAS *Waller* (right) alongside Fleet Base West, HMAS Stirling, Western Australia. © Defence Department

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If the Collins fleet were able to have its life extended by eight years, a capability gap could be avoided, but the feasibility of such an extension remains unclear. Information needs to be gathered as a matter of urgency to allow informed decisions to be made. But, even if successful, a life extension program followed by a new-design submarine would only deliver a six-boat fleet in the early 2030s.

Similarly, on a credible approval, building and delivery schedule, a fleet of nuclear submarines would be able to replace the Collins boats, but with no increase in numbers. And there are many practical problems with such a proposal.

The purchase of off-the-shelf conventional submarines from an established supplier is the only credible option for reaching a fleet of twelve in anything like the White Paper's timeline. However, such submarines would have less endurance and payload than the Navy wants.

One way or another, *Force 2030* will have a submarine fleet that is a compromise on the original vision.

Introduction

Back in 2009, the government surprised many people by announcing plans to replace Australia's existing fleet of six Collins class submarines with twelve more advanced vessels sometime next decade. Three years later, very little progress has been made and time is running out for a seamless transition to another class. Absent a substantial life-of-type extension of the Collins fleet, many options—including that of a locally designed submarine—are looking increasingly implausible.

This paper explores the difficult choices the government faces and highlights the consequences of further delays.

Where are we today?—the future of the Collins class

Built at a cost of $8.5 billion in today's dollars[1], Australia's six Collins class submarines were delivered between July 1996 and March 2003. From the start, the Collins class experienced a succession of problems. The last boat was accepted into service 41 months late, and work to bring the fleet up to the desired standard continues to this day. The current state of the fleet is discussed below in terms of both the vessels' capability and the interdependent factors of reliability and maintainability.

Capability

The true extent of problems with the Collins class wasn't disclosed to the public until the late 1990s, long after the first two submarines had been commissioned and the remainder of the fleet was nearing completion. As is usually the case with a new class of submarine, or any high-tech platform for that matter, there were many engineering problems to be solved—a point that should be borne in mind when contemplating the follow-on class. The story has been told in detail elsewhere[2], but the biggest problems were that, even with many engineering fixes in place, the Collins class still lacked a working combat system and its diesel engines were highly unreliable.

Remediation of the defects began in 1999 with the $275 million Submarine Augmentation project, which sought priority modifications and an interim combat system capability. Then, in 2002, work began in earnest to fix the problems through the ongoing $525 million Replacement Combat System and $415 million Reliability and Sustainability Improvements projects.

Because of the capability shortfalls and reliability problems, full operational release of the class did not occur until April 2004, almost eight years after the first vessel was commissioned. In fact, no submarine with a fully capable combat system was available until May 2008, and the operational release of that configuration wasn't granted until December 2009.

To date, three submarines have been fitted with the new combat system and new torpedoes (under the $426 million New Heavyweight Torpedo project), and work is almost complete on the fourth. On current plans, all vessels in the fleet will have the new combat system fitted by 2016, six years later than originally planned. The combination of the new combat system and torpedoes is reportedly working well, so at least some of the problems with the Collins class have been solved. Nonetheless, the solution has come at a cost, as the combat system—derived from a system designed for nuclear submarines—has a very high power consumption, limiting the power available for other purposes.

Today, the fleet's manufacturer, the government-owned ASC Pty Ltd, claims that the Collins class is 'widely regarded as the best conventional submarine in the world'. Presumably, that assessment refers to the in-principle performance of the vessel according to its specifications and weapons fit-out. In reality, there are still unspecified operational restrictions on the fleet because of unresolved equipment performance problems and, perhaps more seriously, there are serious problems with the reliability and maintainability of the vessels (see Table 1 for definitions of these and other relevant terms).

Reliability and maintainability

The diesel engines on the Collins class suffer from ongoing reliability and availability problems, exacerbated by a shortage of spares. At the heart of the problems is the decision to fit engines that were originally designed for purposes other than their application in the Collins class. Experience has shown that the 18-cylinder engines are prone to excessive vibration and uncommonly frequent component failures. Problems have also emerged with the vessel's electric motors and generators, although progress has been reported in fixing those systems through in situ repairs.

With three diesel engines aboard each boat, there's some redundancy inherent in the vessel's design. However, from an operational perspective, the unreliability of the engines is especially problematic. While deployed, conventional submarines spend most of their time running quietly on batteries so as to

Table 1: Key concepts in submarine logistics

Concept	Definition	Indicative metric
Reliability	The extent to which the submarine and its constituent subsystems can be relied upon to operate as intended.	Mean time between failures of mission-critical equipment.
Maintainability	The extent to which the maintenance demands of the vessel can be met by available infrastructure, labour, engineering knowledge, finance and stocks of spares.	Actual versus planned time spent in maintenance.
Availability	The extent to which the vessel is available for use. Availability is constrained by both the reliability and maintainability of the fleet as well as by the availability of trained crews.	Vessel-days per year available for deployment on training or operations.
Sustainability	The extent to which acceptable levels of availability can be affordably maintained, given expected changes to the reliability and maintainability of the fleet. Generally speaking, sustainability is adversely affected by the ageing of vessels and the obsolescence of components.	Projected future availability, given expected resources.

evade detection. Between times, they put up a 'snorkel' to take in air so that the diesel engines can recharge the batteries before the submarine returns to quiet running. While recharging, the submarine is vulnerable to detection from the acoustic and thermal signature caused by the diesel engines and their exhaust—not to mention the radar and visual signature from the snorkel.

The ratio of time spent recharging batteries to that running on batteries is referred to as a submarine's 'indiscretion ratio', and is a key measure of the vessel's operational capability because it's directly related to the probability of detection. If one of the three engines on board a Collins boat fails, the indiscretion ratio is increased by 50%; if two fail, the increase is 200% (at that point, there being no further redundancy, the mission will almost certainly be aborted). Similarly, failures elsewhere in the submarine's propulsion system—such as the generators or electric motors—would probably also necessitate the termination of a mission in order to return to port for repairs.

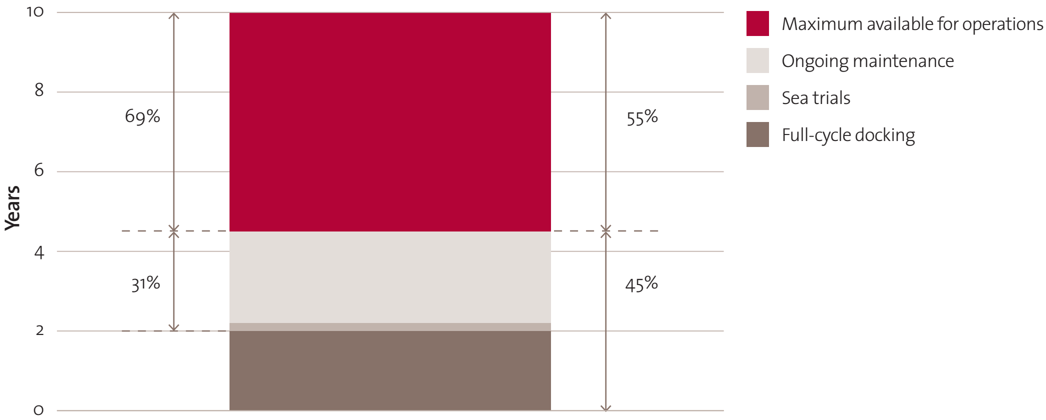
... although the Collins class is at least allowing the RAN to rebuild its submarine workforce, its usefulness as a practical weapon of war is uncertain.

The quantitative extent of the reliability problems associated with the Collins class propulsion system is being kept secret. However, we know that boats are frequently forced to return for unplanned repairs, and it's broadly accepted that the propulsion system remains highly problematic. What we *don't* know—and what's absolutely critical—is the extent to which the Collins fleet provides real military options for the government to employ. Even with an effective combat system and the modern torpedoes fitted, the combination of poor reliability and operational restrictions (not to mention low submariner numbers and limited crew experience) must limit the practical employment of the boats. So, although the Collins class is at least allowing the Royal Australian Navy (RAN) to rebuild its submarine workforce, its usefulness as a practical weapon of war is uncertain. The picture only gets worse if the vessels' unexpectedly high maintenance demands and consequent poor availability are taken into account.

The maintenance cycle and availability

The Collins class is currently maintained on a roughly decade-long cycle composed of a two-year 'full-cycle' docking period and an eight-year operating period. Within the eight-year operating period, the vessels undergo a major mid-cycle docking, two intermediate dockings, and a variety of dockings associated with certification extension, battery change and assisted self-maintenance. During the four-year period from 2002 to 2006, for which detailed maintenance information is available, those Collins class submarines not in full-cycle docking underwent an average of 15 weeks maintenance each year. In addition, each full-cycle docking has been followed by an average 10-week trials period before the vessel returned to service. As a result, of the 520 weeks that make up a decade, under current practice just under half (234 weeks or 45%) are spent with the vessels in maintenance or trials (Figure 1). Outside of full-cycle dockings, the maximum average availability for operations is 69%—a number that isn't at all unusual by world standards and better than some.

Figure 1: Indicative Collins class 10-year operating cycle
Percentages on the left are operational availability outside of full cycle dockings; those on the right are overall availability.



Source: ASC and Defence annual reports; Hansard.

In fact, the situation has been somewhat worse. Because of the need to undertake remedial maintenance, coupled with a shortage of crews, the first operating cycle for the six submarines was truncated from a planned initial six-year operating period to an average of 5.1 years, and the time spent in either full-cycle docking or lying idle on dry land extended to an average of four years. Assuming 69% availability outside of full-cycle dockings, the Collins boats were available for operations for *at most* 41% of their average initial 8.8-year truncated cycle because of maintenance and crewing issues. At least the full-cycle dockings appear to be doing what they're meant to do—those vessels that have completed their first full-cycle docking are well on their way to completing a full eight-year period before returning for the next.

It's worth putting the maintainability of the Collins in context. In 2002–03, a full-cycle docking was expected to involve 3,500 maintenance tasks and to consume 400,000 work-hours. By 2004–05, this had grown to 4,129 tasks plus 1,251 emergent items consuming some 642,000 work-hours. In 2012, ASC reported that full-cycle dockings were typically taking 1,000,000 work-hours, but that this had been cut to 900,000 in the last instance. In comparison, a typical European conventional submarine undergoes a 10–12 month full-cycle docking entailing less than 200,000 work-hours every eight years.

Notwithstanding the recent claimed improvements with the Collins class, it's clear that one or more factors are at work. Either the maintenance demands of the vessels have grown substantially over the past decade, or insufficient investment was made earlier, or there have been inefficiencies in the maintenance process. Regardless of the explanation, annual sustainment costs have grown from $376 million in 2007–08 to $479 million in 2011–12, a 27% real increase over four years. Ironically, the Collins class was envisaged (and supposedly designed) to be more maintainable and affordable-to-operate than its predecessor, the Oberon class. In fact, the original objective was for the Collin class full-cycle docking to take a mere 150,000–250,000 hours.[3]

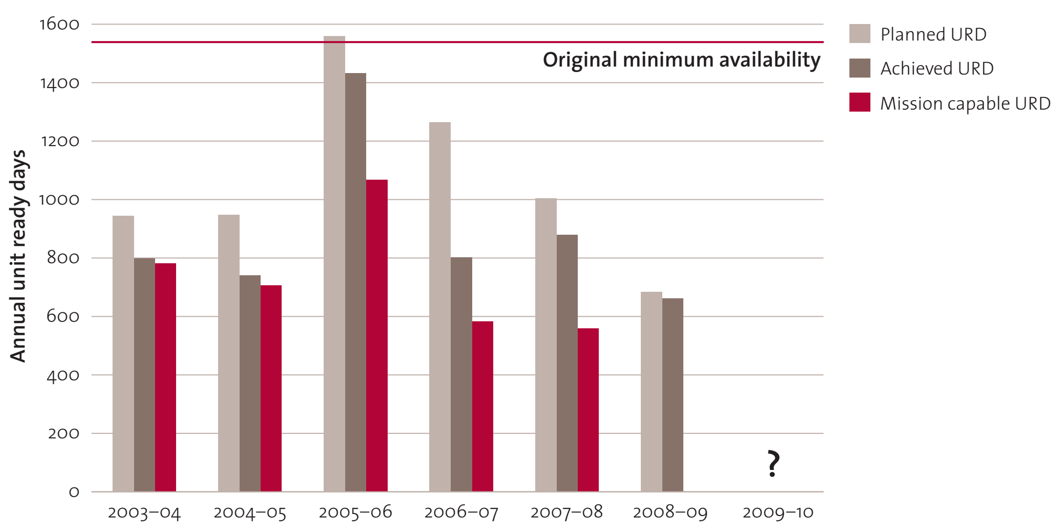
The combined effect of crew shortages, high maintenance demands and unreliable equipment has resulted in disappointingly low levels of availability (measured in 'unit ready days') for the Collins fleet. Until reporting ceased in 2009–10 (the silence was explained on national security grounds), the annual number of unit ready days for the Collins class fleet was well below the level envisaged in the original specifications, and had been declining for several years (Figure 2).

Sustainability—how long can we keep the Collins class in service?

One might expect that with more than $10 billion having been spent to acquire and upgrade the Collins fleet (not counting annual operating costs of more than half a billion dollars) the life-of-type for the vessels would be well understood. Indeed, after 17 years of fleet operations, one would expect the engineering reliability and durability of the boats' subsystems to be known quantities, along with all the issues associated with obsolescence and spares availability. In fact, nothing of the sort has occurred. Neither ASC, nor the RAN, nor the Defence Materiel Organisation is able to answer the basic question, 'How much longer can the Collins class be kept in service'?

Instead, a detailed Service Life-Evaluation Program (SLEP) study is underway to determine the feasibility of keeping the Collins boats up to and beyond their nominal life-of-type. If deemed feasible, the follow-on might be a Submarine Life of Type Extension Program (SLOTE). Pending the results of the SLEP, here's how things look. Each of the six Collins class boats has either completed, or will soon complete, its first full-cycle docking, and the first two boats built, HMAS *Collins* and HMAS *Farncomb*, will enter their second full-cycle docking over the next two years. On current plans, and assuming that the next round of full-cycle docking can be completed in 24 months for each boat, the vessels will complete their second eight-year operating cycle between 2022 and 2031 (Figure 3). This is broadly consistent with the 2026–2030 pay-off dates envisaged back when the Collins were entering service. The seemingly peculiar decision to keep the youngest (rather than the oldest) boats out of the water for extended periods during the first full-cycle docking period has elongated the prospective pay-off dates of the fleet into two blocks: *Collins*, *Farncomb* and *Waller* will pay off in the 2022–2025 period, and *Dechaineux*, *Sheean* and *Rankin* between 2028 and 2031.

Figure 2: Collins class availability, 2003 to 2009

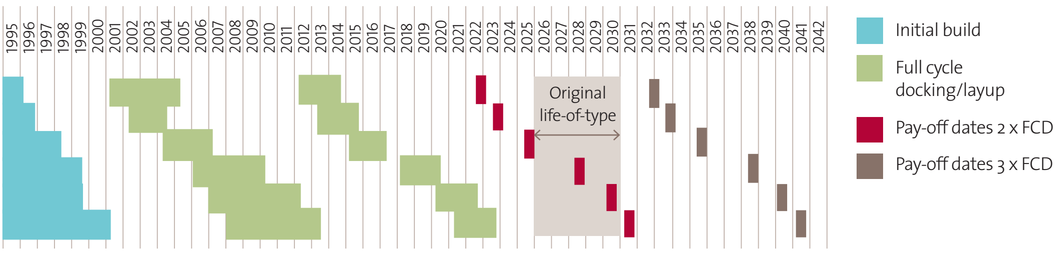


URD = unit ready days.
Source: Defence annual reports.

As a benchmark for the analysis that follows, Figure 4 shows the expected maximum number of submarines available to the RAN for operations from now until 2035, based on the Collins class alone, with two full-cycle dockings. Recent information suggests that the maintenance cycle at ASC has stabilised. Assuming that will continue to be the case, the calculations also assume that each full-cycle docking will take a boat out of the operating cycle for two years (including trials before a return to service) and that the availability between dockings will be as per the historical average.

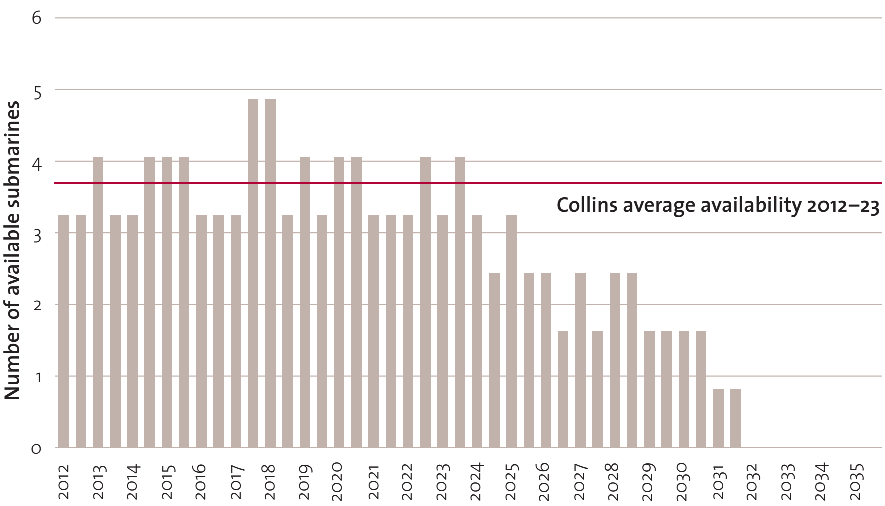
Note that these figures are somewhat idealised—they represent the results that we can expect provided that the maintainability and reliability of the boats do not deteriorate between now and the planned end of their service lives. Moreover, it's not suggested that the graphed number of submarines will be deployed or available to be deployed at any given time. Actual activity and readiness levels are a matter for the government and the RAN to decide based on operational requirements, funding and crew availability. The broken horizontal line in Figure 4 is the *projected average* availability of Collins in the 2012–2023 period, calculated at 3.7 submarine years per year—a number consistent with the expected availability of three or four boats at any given time, but better than has been the case in recent years.

Figure 3: The Collins class operating cycle



Source: Defence and ASC annual reports.

Figure 4: Expected availability of the Collins class, 2012 to 2035 in six-month increments



A looming capability gap

The pay-off dates for the Collins boats and the lack of real progress so far with the future submarine project portend a problem next decade. To see why, it's necessary to understand how long it might be before a replacement based on a new design is available. A new design is the logical consequence of the goals for the new submarines set out in the White Paper, which set a very high bar for the capability of the future submarine. To allay any suspicion of exaggeration, it's worth quoting the White Paper:

> The Future Submarine will have greater range, longer endurance on patrol, and expanded capabilities compared to the current Collins class submarine. It will also be equipped with very secure real-time communications and be able to carry different mission payloads such as uninhabited underwater vehicles.
>
> The boats need to be able to undertake prolonged covert patrols over the full distance of our strategic approaches and in operational areas. They require low signatures across all spectrums, including at higher speeds.

Elsewhere, the White Paper says that the new submarines will be able to undertake certain strategic missions where the stealth and other operating characteristics of highly capable advanced submarines would be crucial. Consistent with this, planned enhancements include air-independent propulsion and land attack cruise missiles. Given Australia's geography, no off-the-shelf conventional submarine can fully meet all of those requirements. The White Paper conceded this when it said (three years ago now):

> The complex task of capability definition, design and construction must be undertaken without delay, given the long lead times and technical challenges involved.

To meet all of those specifications simultaneously, a new design would be required, either a largely ab initio *design or a substantial modification of an existing design.*

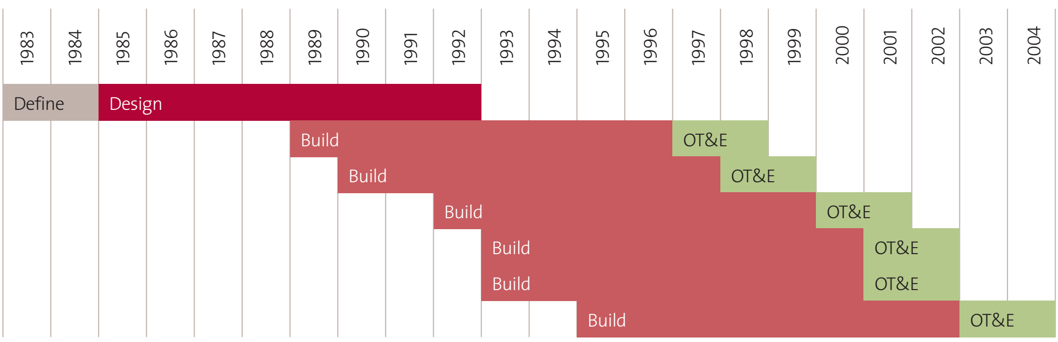
To meet all of those specifications simultaneously, a new design would be required, either a largely *ab initio* design or a substantial modification of an existing design. Either way, a significant amount of time and effort would be required before a boat was ready for service. In principle at least, it would be possible to build more Collins class submarines, taking the opportunity to fix outstanding problems and upgrade systems as required, but in some ways that could prove to be less straightforward than a new design. Working with a blank sheet, a designer is free to make trade-offs as work progresses, whereas fitting new systems into existing spaces can be highly problematic. And even given success at the design stage, the net result of that approach would ultimately leave the RAN in the second half of this century with a 1980s era submarine design that falls short of modern benchmarks and far short of the goals of the White Paper.

A first approximation is that the future submarine project will follow a similar schedule to the Collins class (Figure 5). As will be discussed below, that's an optimistic assumption because the Collins timeline was compressed because of the looming retirement of the Oberon class.

If design work on the future submarine were to be instigated today, a Collins-like timeline would see the first boat finish its sea trials and enter operational service in 2027, and the sixth in 2033. The net result would be a shortfall in nominal submarine numbers compared to the current fleet of six boats from 2022 (when HMAS *Collins* reaches the end of its second eight-year operating cycle) through until 2033—a decade long 'capability gap', in defence parlance. The gap can be quantified: Figure 6 shows submarine availability from 2012 to 2035 if a Collins-like delivery schedule could be instigated tomorrow. By 2035, the seventh boat of the new class would be delivered to service, and the availability would begin to move above the Collins average. But in the span from 2023 to 2032, a full 20 submarine-years would be lost, the same number of years that were lost in the transition from Oberon to Collins.

In fact, the problem is probably worse than that. An indicative range of schedules for meeting the White Paper specifications was provided by Defence's submarine project office at a conference earlier this year (Table 2). As well, the possibility of a two-year production interval, predicated on retaining the option of moving to a continuous-build mode based on a 24-year life-of-type, was mooted.

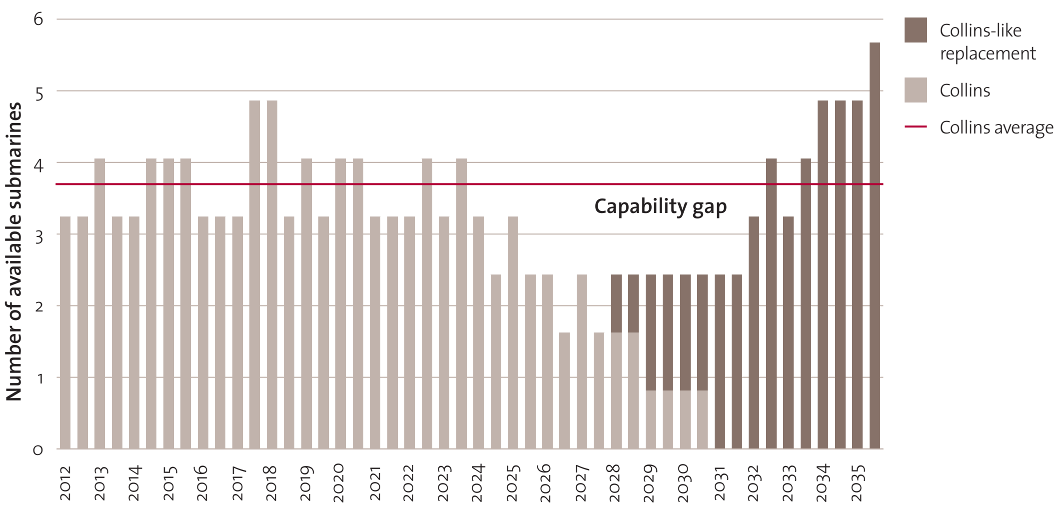
Figure 5: The Collins submarine project timeline



OT&E = operational trial and evaluation.

Source: Australian Parliament House Library reports, The Collins class submarine story.

Figure 6: Submarine availability, 2012 to 2035, with a Collins-like replacement schedule



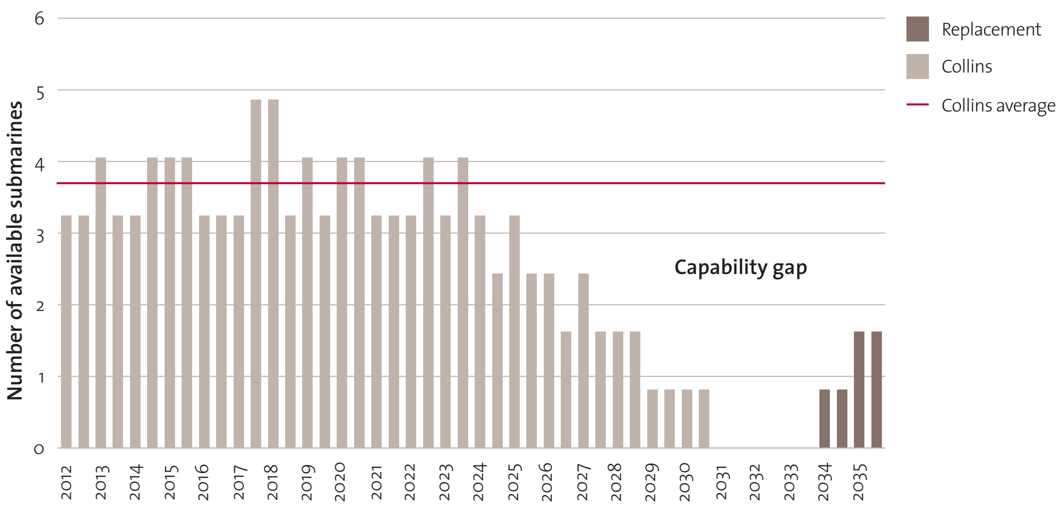
Compared to the 16 years after definition and design work began to deliver HMAS *Collins* for service (albeit not fully functional) and the final delivery of HMAS *Rankin* in the 21st year, it seems that the planning timetable sensibly allows more time to iron out difficulties along the way than was the case with the Collins program. Unfortunately, even the lower estimate for delivery time is problematic, as demonstrated above. Defence's upper estimate is nothing short of catastrophic—as Figure 7 amply demonstrates. The shortfall becomes a full 40 submarine years, and there are three years of no submarines at all. In this scenario, Australian submarine capability would essentially be run down and then restarted. And it might be worse still: the severity of the prospective capability gap is magnified substantially if a two-year production interval is assumed for either the lower or upper schedules.

Table 2: Defence estimates of the time required to design and build a future submarine

Stage	Time (years)
Definition	2–4
Design	7–8
Build	7–8
Operational trials and evaluation	1–2
Total	17–22

Source: Defence presentation to Sea Power 2012 conference.

Figure 7: Submarine availability with replacement on Defence's upper schedule



Other options

All of the above was predicated on *maintaining* a level of availability. In fact, the 2009 White Paper set out to not only replace the Collins class with very capable boats, but to double the size of the fleet. While no date was specified, the expansion of the submarine arm of the navy was part of the *Force 2030* initiative. As the results of the previous section indicate, even maintaining the size of the fleet by 2030 is a task that will require considerable application.

> *... the government is now considering a wider range of options, including 'military off-the-shelf' designs.*

Perhaps as a result of the many difficulties described above, and probably exacerbated by the problems that have been identified with the management of the Collins class, the government is now considering a wider range of options, including 'military off-the-shelf' designs. The range of options is surveyed in this section, and the resulting effect on fleet availability is estimated.

The relative military capabilities of the options and their respective strategic merits, and the many difficult questions surrounding alternative acquisition and contracting approaches, have been discussed before (and probably will be again) but are beyond the scope of this paper. The different options described here don't offer the same level of capability—as with any defence acquisition, a balance must be struck between capability, cost and risk. For completeness, a short examination of the one option that the government has so far ruled out—submarines with nuclear propulsion—is included.

Option 1: Extending the Collins class life-of-type

The danger is that the looming capability gap will result in another accelerated schedule. The Collins schedule was compressed by the imperative to have boats available when the Oberon class submarines reached the end of their life-of-type. The engineering development process was truncated, leading to, among other things, an eight-year delay in operational acceptance and the legacy of a number of designed-in flaws, some of which persist to this day. And, despite the rushed effort, there was still a shortfall in submarine availability (see ASPI's April 2011 publication, *The once and future submarine*, for details). Repeating that experience in order to stave off a capability gap as the Collins class boats pay off is certainly to be avoided.

In some ways, we're now in a much better industrial position than we were at the start of the Collins project, although successive reviews into naval projects show that the naval engineering expertise available to be brought to bear is less than was the case in the 1980s and 90s—and often less than is required for complex projects. So there would still be real risks in trying to crash through with an accelerated schedule. Ideally, given what we've learned from the Collins project, there would be a two- or three-year gap between the first and second boat to allow emergent problems to be identified and fixed, rather than built into the remainder of the fleet. Practically, such a prototyping arrangement would be difficult to implement while keeping the shipyard and workforce efficiently occupied.

Given the state of the fleet and the challenges inherent in scheduling a replacement for the Collins class, there are two critical questions for the SLEP study to answer:

- What can be expected from the Collins class boats as they enter their second full-cycle docking and the subsequent eight-year operating period? Specifically, can the reliability of the boats be improved or will it erode further as they age? Are there critical systems aboard that will need to be replaced due to obsolescence or age?
- Is it feasible to take the Collins boats into a third full-cycle docking and extend their life-of-type from the 2020s into the 2030s? And, if so, what will be the costs, risks and capability consequences? Does it make sense to operate a submarine designed in the 1980s in the third decade of the 21st century?

Intrinsic to both questions is the problem of the propulsion system. As noted above, the ‘sharp ends’ of the boats—the combat systems and weapons—are in good shape but the ‘back ends’ continue to pose problems. There’s only so much that can be done (especially after 16 years of trying) to squeeze better reliability out of equipment installed in the 1990s. Accordingly, the SLEP will examine the option of replacing the diesel engines and other major components of the propulsion system. With the current state of knowledge, the cost, risk and timing of such work isn’t known. However, depending on the level of reliability being achieved today and expected in the future, such a replacement may be necessary to deliver a militarily credible submarine capability. On the positive side, other submarine classes around the world have had their service lives successfully extended. In a potentially helpful precedent, Swedish boats have received propulsion system upgrades—including the fitting of air-independent propulsion systems—during the standard full-cycle docking process.

But much work has to be done before we could embark on a Collins SLEP with confidence, and that will take time. Complicating the already difficult engineering challenge of upgrading the propulsion system is the question of scheduling. Given how long it would take to properly assess the problem and design a solution, there’s not enough time to incorporate a propulsion upgrade into the soon-to-commence second full-cycle docking of the oldest two (and probably three) boats. The most likely course of action would be to begin with the fourth boat, HMAS *Dechaineux*, when it enters its second docking in 2018. This would effectively split the fleet into two groups, with the upgrade of the oldest three vessels either deferred until their third docking or forgone altogether. As with work on the Collins replacement, the SLEP study should have ideally commenced six years ago. In practice, there mightn’t have been sufficient data on the Collins fleet’s maintainability in 2006 for that, but there’s no doubt that time has been lost in recent years.

There’s not much more to be said about the life-of-type of the Collins fleet until the SLEP study is complete, except to caution that we’re about to enter uncertain territory. Our regrettable experience with the F-111 strike reconnaissance aircraft illustrates the hazards. Back in the late 1990s, extensive studies were done to explore the feasibility of retaining the F-111 in service until 2020. On the basis of initially favourable assessments, hundreds of millions of dollars was spent buying spares, upgrading equipment, establishing in-country support expertise, undertaking research and development and buying new weapons (with mixed results). Yet by around the middle of the 2000s, after some unfavourable structural testing results were reported, the plan was abandoned and the F-111 was retired from service in 2010.

But that's not the only lesson to be taken from the F-111 debacle. For at least the last decade of their service lives, the aircraft were effectively useless in all but the most permissive environments. The net result was that we spent hundreds of millions of dollars and got a very poor return on investment in terms of additional service life—and didn't actually have much in the way of frontline capability along the way. The same risks attend the choices to be made about extending the Collins class life-of-type.

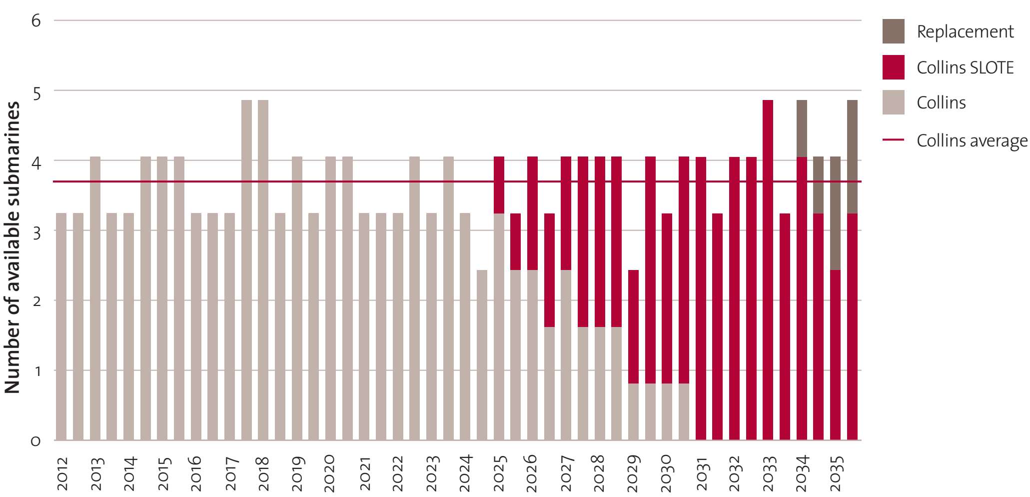
However, making the optimistic assumption that a SLEP could be carried out successfully before or at the end of the Collins class's second operating cycle, giving another eight-year operating period, the net result would be to fill in the capability gap even on Defence's upper schedule (Figure 8). However, that strategy would require life-of-type extension work on three or four of the Collins class hulls concurrently with construction of the first few follow-on submarines—a big ask for the industrial infrastructure if all of the work is done in the same yard, but perhaps not out of the question once work on the air warfare destroyer project is finished.

Option 2: Buying and/or building an off-the-shelf submarine

Another alternative is to pursue the rapid acquisition of an existing military off-the-shelf (MOTS) design. To meet the time constraints, any such venture should involve only those changes required to meet Australian regulatory requirements, with no attempt to 'boost' the capability of the boats to meet RAN aspirations. It would be a compromise in many ways—the resulting boats would be smaller than the Collins class, with attendant limitations on their payload and endurance. However, while they would fall well short of the aspirations set out in the 2009 White Paper, they would be relatively modern and reliable.

If such a decision were made, the new submarines could be brought into service relatively quickly. If an Australian build were deemed necessary, the boats would need to be largely assembled from imported components—to do otherwise would introduce delays as local subcontractors were selected and brought into production. The quickest way to bring MOTS boats into service would be to have them built (or at least the first vessel built) in their home shipyard. Splitting the build between yards risks

Figure 8: Submarine availability, 2012 to 2035—Option 1: Collins SLOTE



introducing differences across the class, but if construction in Australia is judged to be an imperative, building at least one overseas has the benefit that Australian shipyard personnel can be included in work in the home yard, observing at first hand the work practices and techniques required for efficient construction.

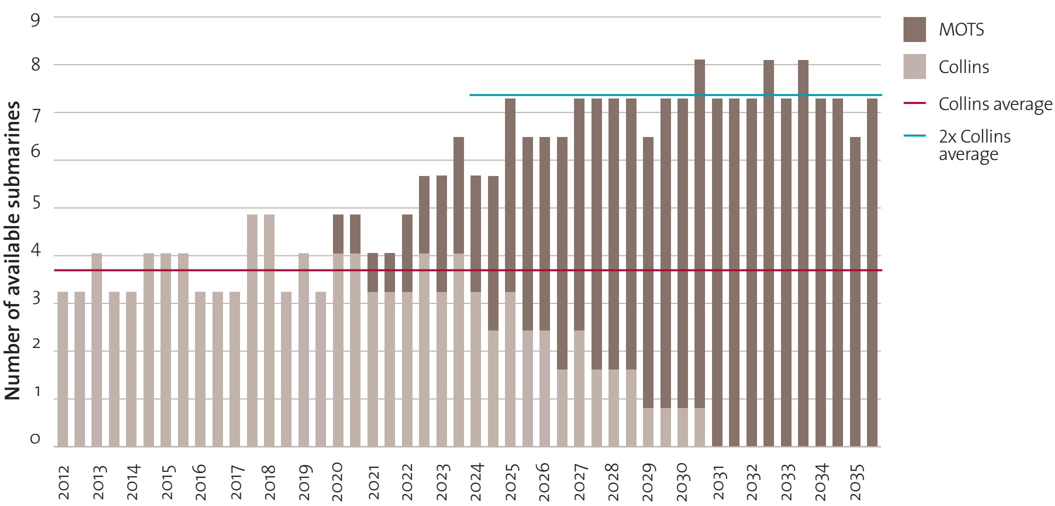
Based on the experience of other countries that have ordered existing submarines from European suppliers, the first boat could be delivered approximately seven years after contract signature, with one every 12 to 18 months after that from the home yard, or on a similar schedule but with an additional upfront delay of a couple of years for the construction of subsequent boats in Australia. Figure 9 shows the resulting submarine availability for this option, assuming the first delivery from the designer's own yard in 2020, a two-year gap and then annual delivery from an Australian yard thereafter. Note that the actual schedule might be limited by factors other than construction—standing up the personnel to crew a new boat every 12 months would be a difficult task, albeit one made easier by the smaller crew requirements of the likely MOTS contenders.

The rapid acquisition of an existing MOTS conventional submarine would not only alleviate the current schedule dilemma with the Collins class, but would also allow the early retirement of the existing fleet.

The rapid acquisition of an existing MOTS conventional submarine would not only alleviate the current schedule dilemma with the Collins class, but would also allow the early retirement of the existing fleet. Given the high cost and poor reliability of the Collins boats, it might make sense to effect a quick transition to the new class of vessels—depending on the assessed strategic demand for boats next decade.

Alternatively, if a life-of-type extension of the Collins turns out not to be feasible but the imperative for a bespoke design remains strong, the rapid acquisition of MOTS conventional submarines could be done as an interim measure. Although this would be very costly, it's effectively the strategy that's been adopted for the Royal Australian

Figure 9: Submarine availability, 2012 to 2035—Option 2: Off-the-shelf replacement



Air Force air-combat capability with the acquisition of the F/A-18F Super Hornet in response to mounting delays to the F-35 Joint Strike Fighter project and the unplanned early demise of the F-111 fleet.

The difference in that case, however, was that the Super Hornet is a considerable step up in performance from the F-111 in a modern environment, whereas a MOTS boat would fall short of the Collins' designed (though perhaps not current) performance in some areas. As well, transitioning aircrew from the Hornet to the Super Hornet was an easy task due to the similarity of the systems and platforms. Moving from Collins to a MOTS boat, especially one with a different combat system, would come with significant transition overheads.

However, of the options examined here, this is the only one that allows the fleet size to be doubled, as per the White Paper aspiration, in anything like a 2030 timeframe.

Option 3: A nuclear attack submarine

It's recently been suggested that Australia should acquire Virginia class nuclear attack submarines from the US. Whether this is a credible option is unknown, as the first critical issue is whether the US would be willing to sell or lease them to us. That's far from guaranteed. They're not embargoed from export by legislation in the way the F-22 Raptor air superiority fighter is, but they're a very high-value capability to the US and there's no precedent for export (although the US did help the United Kingdom design its own nuclear attack submarines and released to it ballistic missiles to put on board its later deterrent boats). As well, given that Virginia class boats are fuelled by what is essentially weapons-grade nuclear fuel, there may be nuclear proliferation concerns to be managed.

Moreover, given the absence of anything resembling a nuclear industry in Australia, a high level of dependence would have to be accepted. For example, there's no doubt that the vessels would have to return to the US for periodic major refits. However, the US currently bases a number of Virginia class boats in Guam, so it's clear that the subs could nonetheless be based at an Australian port. The regulatory requirements for a nuclear-powered vessel for even day-to-day maintenance would dictate a specialised support workforce. Given that Australia has no pool of suitably qualified personnel, we would either have to grow the workforce—a time-consuming endeavour that would require extensive overseas training—or contract for American support. The extent to which such an arrangement would be consistent with Australia exercising sovereign control over the vessels would require careful examination.

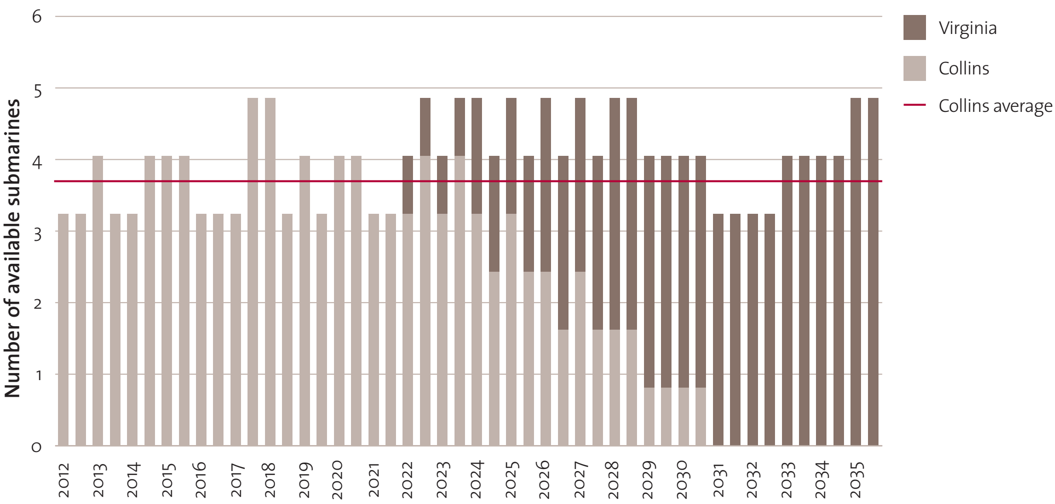
At present, the US is building and commissioning Virginia class submarines at the rate of one or two per year. So far, twelve vessels have been commissioned. Final fleet numbers are unknown, but the Virginia class is replacing the Los Angeles class, of which 43 remain in active service. On this basis, we can expect the Virginia class to remain in production into the 2030s. Provided that the vessels become 'releasable' to Australia, it should be feasible to slot Australian demand into existing production capacity—especially given the chronic budget pressures faced by the US military.

However, the lead time for delivery of a Virginia class submarine would be substantial, even after all of the releasability and regulatory issues were sorted. The US Government Accountability Office's *2011 Assessments of major weapon programs* report noted that the acquisition cycle time as of September 2009 (the earliest builds in the program) was 151 months (more than twelve and a half years). The most recent couple of boats produced were built in 84 months (seven years), and the program is on track to bring that down to 60 months (five years). Based on that, our working estimate for the minimum acquisition time for such a boat is 10 years. The delivery rate would depend on the capacity of US yards to build them concurrently with boats for the US Navy, but would probably be something like one boat every two years. Of course, if the US Navy were willing to defer its own demand and divert boats currently under construction, the schedule could be accelerated. That's what the US Air Force did with our recent rapid C-17 transport aircraft acquisitions, but it already has around 200 aircraft and there's less opportunity cost to it in releasing some. The US Navy, however, is in the early stages of receiving Virginia class submarines.

In any case, manning Virginia class boats with crews of 135 each would effectively triple the difficulties we have now crewing each of our Collins vessels. However, the greater endurance, payload and speed of the nuclear boats would allow capability to be maintained with a smaller fleet. How much smaller is a matter for detailed analysis and is beyond the scope of this paper.

To model the overall fleet availability, we need to know the maintenance-limited availability for nuclear submarines. The scant data available in public suggests that the numbers for the Virginia class may be coincidentally similar to those for the idealised Collins availability cited above—an eight-year operating cycle followed by an extended period of deep maintenance/overhaul of around three years.[4] In the absence of hard data, it must be assumed that the between-overhaul availability is about the same as for a conventional submarine—about 80% (for an overall availability of between 50% and 60% over the boat's lifetime). Figure 10 shows that the lead-time and slow delivery of nuclear submarines nonetheless is well-matched to the timetable for the withdrawal from service of the Collins class. In fact, rather than a capability gap, there is an *excess* of submarine years compared to the baseline—14 extra years by 2035.

Figure 10: The nuclear submarine option



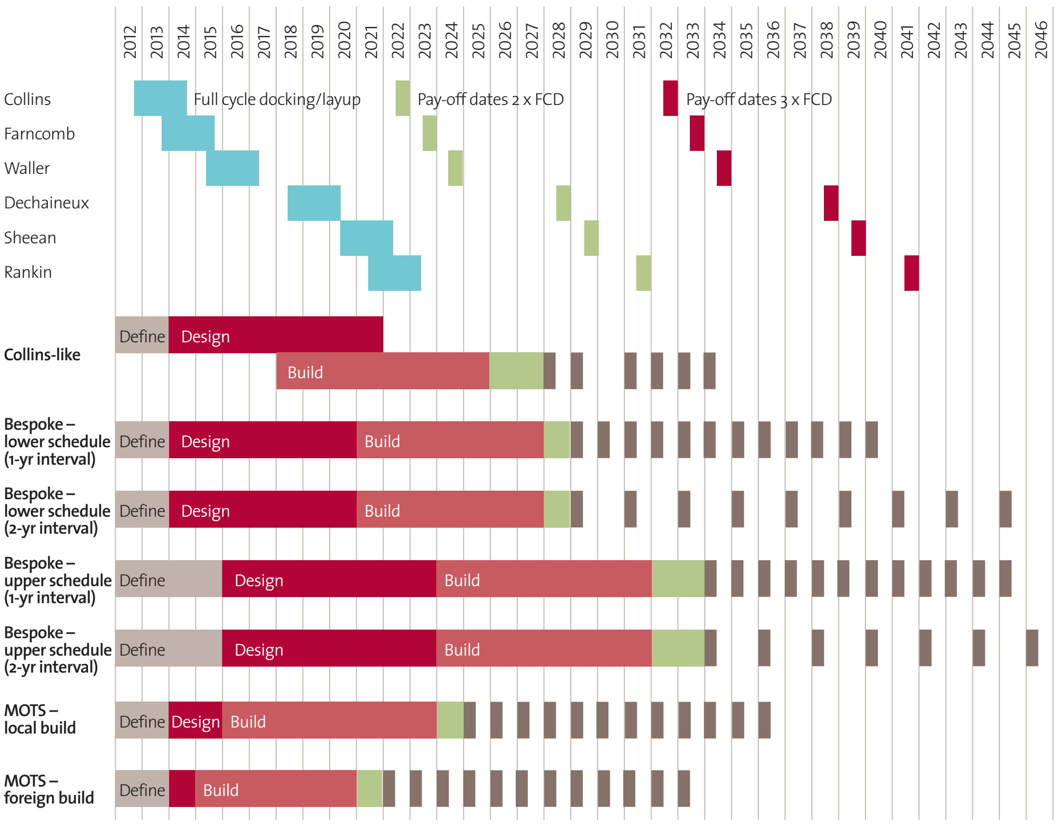
Conclusions

Designing and building an entirely new submarine for the RAN will result in a capability gap unless the Collins class life-of-type can be extended to include a third full-cycle docking, the feasibility and advisability of which are currently unknown. The prospective life-of-type schedule for the Collins class with and without a life-extending third full-cycle docking is shown in Figure 11, along with indicative schedules for the conventional submarine options explored above. Note that adopting a two-year production interval consistent with a rolling production schedule greatly exacerbates the problem. The picture is not encouraging. In the absence of a Collins SLEP, the gap will be at least as bad as the Oberon to Collins transition, even with an optimistic Collins-like timeframe for a new-design replacement class. With Defence's upper timeline, the submarine capability will be completely offline for several years—*Force 2030* will have effectively no submarine capability.

If a nuclear-powered Virginia class replacement could be negotiated with first delivery in 2022, followed by a boat every two years, the effective fleet size would be modestly increased in the 2025–2035 period, but with much more capable submarines. However, there are many practical obstacles to that approach.

The lowest risk (and lowest cost[5]) option is a MOTS submarine from an established builder, with or without Australian assembly of the fleet. With an annual delivery from 2020, not only will a gap in the submarine capability be avoided without a Collins SLEP and its attendant risks, but the White Paper

Figure 11: No easy options



aim of doubling the fleet size by 2030 can be achieved. Alternatively, a MOTS acquisition could be used as an interim measure to allow time for a bespoke design to be developed, albeit at greater overall cost.

The best course of action will depend on many factors—strategic, financial and industrial. For one thing, no government should commit to a costly and risky bespoke design until it can better assess the ability of local industry to execute the project. Among other factors, this will depend critically on the success or failure of the $8 billion air warfare destroyer project presently underway at the ASC site in South Australia, as well as on the improvement or otherwise in the cost effectiveness of maintenance of the Collins fleet at the same site.

Equally, the strategic imperative for building the world's most advanced conventional submarine will need to be confirmed through the forthcoming Defence White Paper, currently slated for 2014. The fact that the government is actively exploring the option of off-the-shelf boats shows that this can't be taken for granted. Between those options is an evolved Collins approach—an option that warrants and needs much more study.

Most critical of all will be the advice that the Department of Defence tenders to the government as a result of the SLEP study. As with the sustainability studies of the F-111 bomber fleet undertaken in the late 1990s, the government will be asked to stake billions of taxpayer dollars—and Australia's security—on the assessment. Given the sad precedent of the F-111 and the manifest mismanagement of the Collins fleet over the past 15 years, that will be a daunting prospect.

Recommendations

Inaction is not a responsible option. The government needs to deal with the cards it has dealt itself in allowing the current situation to develop. Concurrent activity is needed pending the SLEP.

Four things need to happen:

- The strategic imperative for a conventional submarine with the ambitious characteristics described in the White Paper needs to be considered as soon as possible by the National Security Committee of Cabinet. Although a decision can't properly be taken without reliable information about the costs, risks and advantages of the competing capability options, the committee needs to start now to immerse itself in what will be one of the most costly, and perhaps most important, force development decisions to be taken by an Australian Government in the first half of the 21st century.
- The government needs to ratchet up the priority of the project and marshal the resources needed to accomplish the task. As ASPI has argued in the past, there needs to be a single senior experienced submarine design and management authority and a consolidation of government-owned expertise.

- Initial design work and acquisition strategy development need to commence immediately so that the costs, benefits and risks of the competing options—new design, evolved Collins and MOTS—can be assessed in the light of the SLEP report. Assuming it hasn't already occurred, this should include a quiet approach to the US about the possibility of nuclear submarines, and the timing and cost of any such program.
- The government needs to put in place a mechanism to ensure that Defence brings forward rigorous and independent recommendations of the SLEP. Over the past two decades, Defence has consistently underestimated the cost, schedule and risk of projects—especially during the early planning stages. This is to be expected, as Defence planners and defence industry have every incentive to try to lock the government into a course of action that will maximise capability outcomes and profits respectively, irrespective of the ultimate cost to taxpayers. Given this reality, it's imperative that the Defence Materiel Organisation, as the government's defence acquisition adviser, seek independent advice on the conduct of and recommendations emerging from the SLEP and be able to present the advice and recommendations to government. To do otherwise would risk a repeat of the costly F-111 end-of-life saga.

Notes

1 All costs here are expressed as near as possible in real 2011–12 dollars using the Australian Bureau of Statistics Consumer Price Index.

2 Peter Yule and Derek Woolner, *The Collins class submarine story: steel, spies and spin*, Cambridge University Press, New York, 2008.

3 *Procuring change: how Kockums was selected for the Collins class submarine*, Parliamentary Library research paper no. 4, 2001–02, available from http://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp0102/02RP04.

4 The current US Navy plan is for a 96-month operating cycle with three major depot availabilities (equivalent to full-cycle dockings) and 15 deployments over the 33-year life of the submarine (an operating cycle is the time between overhauls/major depot availabilities). That lets us estimate the time for major depot availabilities as three years. See Rear Admiral John D Butler USN (Retired), 'The sweet smell of acquisition success', *United States Naval Institute Proceedings*, June 2011, available from http://www.usni.org/magazines/proceedings/2011-06/sweet-smell-acquisition-success.

5 See ASPI's recent *What price the future submarine?* by Andrew Davies, *Policy Analysis*, March 2012. http://www.aspi.org.au/publications/publication_details.aspx?ContentID=332&pubtype=9.

Previous ASPI papers on submarines

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Policy Analysis—The once and future submarine: raising and sustaining Australia's underwater capability
by Andrew Davies and Mark Thomson
Released 14 April 2011

Policy Analysis—Subaqueana australis: the future evolution of Australia's submarines
by Andrew Davies
Released 11 November 2011

Policy Analysis—What price the future submarine?
by Andrew Davies
Released 2 March 2012

Important disclaimer

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