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Keeping our heads below water: Australia's future submarine

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Media reports of the endorsement of the launch of a planning process to replace Australia's *Collins* class submarine fleet sometime in the 2020s have cited a cost of up to $25 billion. This ASPI *Policy Analysis* explains why the cost might be so high, and examines some of the compromises that would be necessary to reduce the price tag.

There is little doubt that Australia will acquire submarines beyond the *Collins*. Submarines remain flexible and powerful warships. Because of their ability to operate covertly, the suspected presence of a submarine in an area of operations during a conflict creates significant tactical difficulties for an adversary. The same characteristic makes them ideal platforms for covert intelligence collection or for special forces operations. They can strike targets on land with cruise missiles or at sea with torpedos, mines and missiles. They are also increasingly able to target aircraft with missiles. And they remain a capable counter of adversary submarines.

As discussed in the ASPI Special Report *The enemy below*, many regional nations are acquiring submarines. By 2020 there will be dozens of new submarines operating in waters of strategic interest to Australia. Some will be 'off the shelf' purchases of European submarines with limited range and endurance but potent capability in their areas of operation. In addition, there will be nuclear submarines operated by the navies of China, India, Russia and the United States.

By 2025, Australia's six *Collins* class submarines will be thoroughly outnumbered and, despite a series of progressive upgrades under project SEA 1439, will also be far short of 'state of the art'. To maintain its operational effectiveness, the Royal Australian Navy's (RAN) submarine fleet will need to be replaced and, as argued below, expanded.

Numbers matter

The current *Collins* fleet consists of individually capable submarines. However, the fact that there are only six severely limits their ability to conduct concurrent tasks at well-separated locations. Because there is always the need for some boats to be in maintenance or undergoing modification as upgrades become available, not all of the six *Collins* boats are available at any given time. For planning purposes, three or four boats can be assumed to be available in a contingency. If a deployment far afield is required, the transit times to operating areas have to be factored in. That means that only one or two boats would be available for defensive patrols nearer to home. Even allowing for the fact that submarines—especially conventionals—are most effectively deployed in natural bottlenecks, the fleet of six looks to be less than adequate.

It is worth recalling why we have only six *Collins* submarines. Originally plans were for a minimum build of six, with an option for another two. But the well-publicised development problems of the class, coupled with cost and schedule overruns of approximately 20%, resulted in the government declining to take up the option. That is an important (if obvious) lesson—it is easier to buy more submarines if the unit cost and project risks can be kept down.

If a fleet of twelve submarines could be acquired, around eight would be available for concurrent tasking. That would allow for two boats to be continuously on station at distance, as well as providing a number for operations closer to home. As a bonus, a fleet of twelve boats would allow for a production strategy that would avoid the industry sustainment problems that result from a 'stop start' approach, a point returned to later.

Of course, extra boats will require extra crews and larger submarines generally have larger crews. The RAN has experienced difficulties in recruiting and retaining submariners in recent years. But the Navy is essentially competing in a labour market and should be able to meet its manning requirements with the appropriate incentives. The cost of doing so will be another factor in evaluating the cost-effectiveness of any of the options discussed later.

Size matters

The weapons and sensors that allow modern submarines to perform a range of missions necessarily take up space, a quantity that is usually at a premium in submarine design.
As well as missiles, torpedoes and mines, future submarines will be able to deploy a range of Unmanned Underwater Vehicles (UUVs) that extend the reach of the parent boat. While the technology is far from mature and the operational concepts still under development, UUVs promise to allow a submarine to conduct operations in shallow waters or in areas that would be too risky for the submarine itself. Potentially, the UUV could operate for days at a time before returning.

Most new conventional submarine designs incorporate some kind of Air Independent Propulsion (AIP) system, allowing them to operate submerged and quiet for periods of days or weeks without having to run their diesel engines. Various technologies have been used, including Stirling engines that burn stored liquid oxygen and diesel fuel, or fuel cells that use reservoirs of hydrogen and oxygen to produce electricity. While providing tactical advantages, AIP systems come with weight and space penalties.

As well as systems, submarines must have space for the fuel required for operations. Requiring a submarine to be able to make high speed transits to operating areas at long ranges from home base brings further demands for space for fuel and provisions. It was such considerations that were responsible for the *Collins* class being over 3,000 tonnes. The *Collins* high-level specification was for a boat that could remain on station for a month at an operating range of 2,500 nautical miles from base. Requiring even more demanding ranges and/or transit speeds would necessarily push up the size of the submarine. And with that would come significant design challenges and therefore increased project risk.

Nuclear option?

The navies that require a genuinely 'blue water' capability for their submarine fleets operate nuclear submarines. The energy density and power output from nuclear fuel largely obviates the space and size constraints faced by conventionals. Nuclear submarines can be both large and fast, albeit at the cost of increased noise signatures. To give an outsized example of what is possible with nuclear propulsion, the ex-Soviet *Typhoon* class of nuclear missile submarine had a submerged displacement of around 40,000 tonnes but still had a sustained speed of 25 knots.

However, all of the countries that operate nuclear submarines have a sophisticated civilian and military nuclear industry that provides the infrastructure and expertise required to maintain and support them. Even then the requirements for safe operation can be onerous, and at least one operator of nuclear submarines has found that the regulatory requirements imposed on nuclear submarines in port have had a significant impact on their operational availability.

A nuclear submarine is not an option for Australia in the near future. It is (barely) conceivable that Australia could import much of the expertise that it requires to operate a nuclear submarine and could send naval personnel to work on allied submarines to gain operational experience. But the result would be difficult to maintain and would not provide adequate levels of self-sufficiency and sustainability. Once the stringent regulatory requirements that would inevitably be applied are factored in, the Navy would find itself unable to support the skill base required.

But nuclear submarines are capable of missions that conventionals cannot perform. Their speed makes them capable of escorting transiting surface task groups, allowing them to provide constant protection from manoeuvring adversary submarines. A conventional submarine simply cannot keep up. That means that Australia's large amphibious vessels will not have submarine escorts (at least by Australian submarines) during transits. Instead, submarines would be dispatched to take up patrol in the forward area where amphibious lodgements would be conducted in advance of a task group sailing.

So if Australia's future submarine is not—for reasons that are eminently practical— nuclear powered, it will necessarily be a compromise in which the delivered capability will fall short of the ideal in some roles, though conventional submarines do offer some advantages over nuclear ones. When operating on batteries, they are capable of being extremely quiet, greatly increasing the difficulty of locating them. As well, they are able to operate more easily in shallow littoral waters. So the question then becomes: what is the next best solution and what performance parameters will be obtainable? And not far behind should be the questions: how much will it cost? and what risks are there in pursuing that performance?

Off the shelf purchase?

As we saw with the development of the *Collins* class, building a sophisticated submarine from an indigenous design is not without its challenges and does not come cheaply. If the aim is to build a fleet larger than the six *Collins* boats, it is worth looking at some broad options for reducing costs and risks.

One obvious option is to forgo the pain of development work and simply buy 'off the shelf'. There is a range of conventional submarines on the world market. Compared to an indigenous construction effort they would offer, at least, the benefit of high confidence of delivery and reduced unit cost. Acquiring a larger fleet would be proportionally cheaper. An off the shelf purchase would be an attractive option if the boats on offer could meet Australia's requirements, at least closely enough that additional numbers or alternative operational concepts could offset any individual shortfall. Offsetting advantages of this option is that there would be no capability advantage in buying boats similar to those of potential adversaries.

The range and endurance requirement that drove the *Collins* specification is an obvious sticking point. Export-ready submarines are generally not able to operate at long ranges from home for extended periods. In particular, the smaller French and German submarines cannot compete with a *Collins* in that respect. One possibility is forward positioning of fuel and provisions, allowing smaller submarines to replenish their supplies before moving into their operational area. For example, North Asian deployments could be supported by replenishment at US facilities on Guam.

While probably workable, there are several downsides to such a concept. One of the benefits of a high-endurance submarine is that, once it has left port, an adversary has little knowledge of where it is deployed—whether it is close to home or further afield. It has little option than to assume that hostile submarines might be operating in or close to its home waters. But if the submarine has to put into another port before its operational patrol commences, it would provide useful intelligence as to its likely area of operations and timing of its arrival in area. As well, there is a loss of autonomy when relying on facilities provided by other nations.

However, a large fleet of smaller boats also offers some advantages over a smaller number of larger boats. For operations in the inner arc closer to home, the smaller range and endurance is much less important, while extra numbers would allow for patrols in more areas concurrently. As well, the smaller crews would allow for easier manning and personnel management.[1]

Collaborative effort?

Other than Australia, there are also two Western-aligned Asian nations that build large conventional submarines. Japan's latest submarine class, in production for over a decade, is larger than 3,000 tonnes and South Korea is about to commence a program to build up to nine large boats of its own design. A possible approach is to enter into a collaborative build program, or even to subcontract the building of Australian submarines to an overseas yard. Given the relative cost of Australian and Japanese submarines (see later) and the proven efficiency of South Korean shipyards, there is potential for savings.

There are also difficulties with this approach. If Australia wanted a design that was significantly different from the Japanese or Korean designs, economies of scale would begin to dissipate. As well, the language difficulties of collaborations with non English-speaking nations should not be underestimated, and translation issues caused some of the problems with the *Collins* project. As well, Japan is not an arms exporter and it is not clear that an arrangement could be brokered for a collaborative project.

Finally, the level of access to US technologies is not uniform across the three nations. If Australia judged it crucial to incorporate leading edge US technologies into its submarines, possibly insurmountable releaseability issues would emerge. European and Asian technologies would be less problematic, though still not a given—submarine technologies are jealously guarded. And there are advantages in using the systems of a close ally.[2]

Industry issues

Given the issues discussed above and the natural, if sometimes misplaced, tendency of governments to favour home-built programs, it is likely that the Australian Submarine Corporation (ASC) will build the future submarine class. Indeed, the Minister for Defence has already said that building the new class in South Australia is the only credible option. So it is worth looking at some of the issues that will arise as Australia gears up to build submarines again.

After building the *Collins* class, ASC found itself without submarine building work. If construction of the new submarines begins late next decade, that will mean a period of fifteen years between submarine building programs. Such a gap makes it almost impossible to sustain the corporate knowledge and technical expertise required. Regenerating the capability to design and build submarines will take time and will add to the cost of the program. However, the state of knowledge in-country from the building, and subsequent refit and maintenance work on the *Collins* will be significantly higher than it was when the *Collins* program began, reducing the risk of any new program. As well, it will not be necessary to build from scratch the infrastructure required to construct submarines.

Until the next submarine class begins construction, ASC will build three Air Warfare Destroyers (AWDs). However, the AWDs that result will be more expensive than others on the world market. (See ASPI Policy Analysis *Air Warfare Destroyer project - Decision time* for a discussion of relative AWD costs.) It appears that keeping in-country submarine building capability that produces a new class as a discrete entity every couple of decades is complex and expensive. Swapping from submarine work to other projects and back again may introduce significant inefficiencies.

Like all other military platforms, the cost of successive generations of conventional submarines has increased steadily over the years. If we again go down the road of building an indigenously-designed large submarine, we can confidently expect the *Collins* replacement to cost more than the $1 billion unit cost of the *Collins*. Depending on methodology, estimates can give factors of 1.5–2.5 above the *Collins* cost. That means that each boat would cost (in current dollars) somewhere around $1.5–2.5 billion.[3] (The figure of 'up to $25 billion' quoted in the press is presumably for a fleet of ten boats at the upper estimate.)

A model that is worthy of consideration is a 'rolling' production line that produces new boats at regular intervals on a sustained basis. New technologies can be folded in as they become mature, obviating the need to specify the fit of the entire class in advance, albeit at the cost of having a diversity of configurations in service simultaneously. One example is provided by the Japanese submarine building program. They have launched a new boat every year since 1989; seven *Harushio* class boats from 1989 to 1995 were followed immediately by eleven *Oyashio* boats, the last of which will be commissioned later this year. In this way their submarine building capability has been maintained for two decades and each of these capable boats has cost less than 60% of the cost of a *Collins*.[4] Admittedly, Japan has a long history of submarine design and construction, as well as an active shipbuilding industry.

The rolling production strategy does not work for small fleet sizes, and there will be a minimum number for which it is viable. As a 'back of the envelope' calculation, it is probably hard to sustain a build rate of less than one every two years. If the service life of each submarine is twenty to twenty-five years, then a steady state fleet of twelve would be sustainable. And as we saw above, twelve submarines would allow concurrent tasking for offensive and defensive operations in near- and far-field deployments. To get to twelve in the first place may require a faster initial build rate, reducing as the fleet matures.

Conclusions

There is a good argument for the construction of a new class of submarines in Australia starting late next decade. Australia's requirements for its submarine fleet are not easily satisfied by submarines on the world market.

Risks of a new submarine construction project will be mitigated to an extent by knowledge retained in-country from the building and maintenance of the *Collins* class. However, because we have allowed a large time gap between the *Collins* class project and its replacement, the costs and risks of the project will be higher than they might have been. As with the *Collins* project, delays or cost overruns have the potential to result in the acquisition of a relatively small number of submarines, with the unit cost of each being commensurately large.

That is a problem because the biggest shortcoming with the fleet of *Collins* submarines is its size. Owning six submarines in total means that, on most days, only three or four will be available, which in turn limits the concurrent operations that can be conducted. In terms of operational flexibility and capacity, a larger fleet of 10–12 boats would be preferable.

One way to acquire a larger fleet is to buy smaller submarines of an established design. Such a buy would offer some operational advantages for short range and duration missions, though long range missions would become more difficult and less covert.

Cost trends in submarine design and building means that indigenously-designed large replacement submarines are likely to cost more than the *Collins* unit cost of a billion dollars each. Finding ways to bring down the unit cost will be important if a sizeable fleet is to be built.

The balance that will have to be struck is between loading the design with high-end capabilities at the leading edge of submarine technology and producing a design that can be delivered close to schedule and budget with a reasonable degree of assurance.

The project risks arising from the 'stop start' approach to building submarine classes could be mitigated by a rolling production model of continuous building. That would require a fleet of probably twelve boats to sustain, but the unit cost of each would be brought down and industry sustainment would be much more manageable. This approach would require a sustained government funding commitment beyond the usual forward estimate period.

Endnote

1. For example, the complement of the *Collins* class is 43 personnel, while the German *Type 214* has a crew of 27.
2. The problems with the combat system in the *Collins* were eventually resolved by using the Raytheon AN/BYG-1 Combat Control System that is used by the United States Navy (USN) *Virginia* class. The USN is moving towards standardised modular architectures, which will make configuration management more efficient.
3. The lower estimate assumes that the cost per tonne is the appropriate metric, while the upper estimate is based on a naive extrapolation of the curve through previous classes, which does not allow for a trend towards larger boats.
4. Costs cited publically for the *Oyashio* class is about 50 billion Yen, or about $540 million, compared to the unit cost of the *Collins* class of approximately $1 billion. The usual caveats of not having a detailed breakdown of what is included in each figure should be applied. The Collins cost cited here is a project cost, and therefore includes infrastructure including the ASC shipyard, training school sound ranges, tracking ranges, magnetic ranges and submarine rescue capability.

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