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Future Submarine Project Should Raise Periscope for Another Look

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Executive Summary

The Future Submarine project seeks to replace the ageing Collins Class submarines with 12 new submarines (commonly called the Future Submarines). Early estimates indicate building the new submarines could cost anywhere between $10 billion and $40 billion over the next 15 to 20 years, making this the largest and most complex defence project ever undertaken by Australia.

In May 2012, the government committed $214 million to conduct design studies, scientific appraisals, and industry skilling needs analysis for the project; initial approval is expected in late 2013 to early 2014.

The current Collins Class submarines have serious flaws, including poor availability, high sustainment and running costs, and a history of classwide defects. Some of these flaws are systemic to the Royal Australian Navy, while others are the result of risks inherent in substantially redesigning an existing submarine to operate different systems and meet different objectives.

Despite the risks of this 'evolutionary' submarine design process and the poor outcomes from the Collins Class submarines, the government is likely to follow a similar design process for the Future Submarines. It is looking at submarine design options, has committed to assembling the submarines in Adelaide, and has repeatedly refused to consider leasing nuclear powered submarines like the US Navy's highly capable nuclear-powered fast attack submarine, the Virginia Class.

With a much greater range, higher top speed, greater endurance, fewer 'indiscretions,'[1] much higher power output, better sensors, and superior unmanned undersea vehicle (UUV) technology, the nuclear-powered Virginia Class is an altogether better submarine than any diesel-powered Collins Class replacement might be.

The Virginia Class is much more reliable and cost effective than the Collins Class. Acquiring eight Virginia Class submarines might cost between $23 billion and $27 billion (including the upfront cost of leasing the submarines as well as program, facilities and set-up costs), a saving of more than $10 billion over current estimates for evolutionary designed Future Submarines. In addition, up to three-quarters of a billion dollars a year can be saved in operational and maintenance costs from the Virginia Class if the costs of the Collins Class are any guide.

Acquiring finished submarines from the United States would also avert a potentially disastrous capability gap developing between the retirement of the Collins Class and the commissioning of an evolutionary-designed Future Submarine.

Neither the arguments against nuclear-powered submarines (such as defence self-sufficiency needs, skills shortages, and safety concerns) nor the protectionist rhetoric on behalf of the defence industry stand up to scrutiny.

Nuclear-powered submarines require careful planning to ensure their safe operation, but US nuclear-powered submarines have a proven safety record over many decades. US submarines have often visited Australia without nuclear incidents. Also, the nuclear reactor in a submarine is tiny compared to a nuclear power plant on land, so the potential damage in an accident is much lower. Too often an ideological phobia of nuclear power is behind these concerns.

Australia's self-reliance is arguable at best. Australia is heavily reliant on the international defence community for the development and sustainment of its platforms (e.g. through Australian subsidiaries of global defence companies). The extent of Australia's self-sufficiency also needs to be re-examined in light of capability concerns stemming from Australia's declining defence budget.

As for skills shortages, leasing US submarines will give Australia access to the US sustainment supply chain. Australia can import capabilities for low-level maintenance and access US facilities for deeper reactor-level maintenance. The United States could also upgrade Australian submarines alongside US submarines and dispose of Australia's spent nuclear fuel after the submarines are decommissioned.

It is unfortunate that the Future Submarine selection process to date has been marred by indecision and waste, conflicts of interest, and substandard procurement practices. Decisions already made have not been justified and long delays have occurred, all in an environment where the Australian Defence Force is facing serious challenges both at home and abroad.

The government needs to take immediate action to rectify this situation. A good first step would be to revisit some of its previous decisions on the Future Submarine project and ensure that the cornerstone of the Navy of the future is the best submarine for the job.

Introduction

As an isolated island nation depending on sea lines for both security and trade, Australia benefits greatly from submarines. While surface ships maintain and project force in a particular area, and modern aircraft detect and engage threats offshore, submarines can do both *and* collect intelligence covertly. Submarines are also much harder to detect and are a more effective deterrent against aggression.

Australia currently operates six Collins Class diesel-powered submarines, which were designed in the 1980s, constructed in the 1990s, and commissioned in the late 1990s and early 2000s. These submarines have had some success, notably in training exercises with US surface ships, but their history and reputation is more marked by failures.

The white paper in 2009 heralded the purchase of a new fleet of submarines to replace the Collins Class, with the transition occurring in the 2020s.[2] The white paper also detailed Australia's very challenging strategic environment, such as the potential risks of an ascendant China, unstable countries like North Korea, the increased economic importance of the region, and the potential decline of US military power. These risks present a serious challenge to Australia's security and defence policy.

The government's response was to update and expand Australia's defence force in key areas such as the new, more powerful Future Submarines. The white paper listed the broad capabilities that the Australian Defence Force (ADF) expects from the Future Submarines:

- 'greater range, longer endurance on patrol, and expanded capabilities compared to the current Collins Class'[3]
- 'anti-ship and anti-submarine warfare; strategic strike; mine detection and mine-laying operations; intelligence collection; supporting special forces ... and gathering battlespace data in support of operations'[4]
- capable of carrying UUVs
- 'low signatures across all spectrums, including at high speeds.'[5]

The summary dismissal of a nuclear option with the barest consideration of its feasibility is concerning.

Unfortunately since the white paper, the government has reduced the defence budget and failed to follow the white paper roadmap.[6] Very little of substance has been achieved in the Future Submarine project since the release of the white paper, yet the government has committed to assembling the new submarines in Australia (at the Adelaide facilities of the government-owned submarine builder ASC) and ruled out any consideration of nuclear-powered submarines (known as SSNs) ensuring the Future Submarine will be a diesel-powered submarine (known as SSGs).[7]

These two decisions, together with the outline of capabilities given in the white paper and the absence of an Australian submarine design capability, have practically ensured that the Future Submarine project will follow the same path as that of the Collins Class. The Future Submarines will be evolutionary designed SSGs adapted from an existing foreign design and manufactured and assembled largely in Australia.

There are many problems with this approach: the potential for a capability gap during the time taken to get an evolutionary design into the water; the Future Submarines inheriting the reliability and maintenance costs of the Collins Class; the systemic issues within the Royal Australian Navy about sustainment; and the flawed consideration given to aspects of protectionist industry policy.

The summary dismissal of a nuclear option with the barest consideration of its feasibility is similarly concerning. The main reasons given by the government and commentators for excluding this option are skills gaps and attendant self-reliance issues as well as high costs. Others have raised nuclear proliferation concerns or claimed that nuclear-powered submarines are too unsafe.

Options for the Future Submarine project

Four broad options have been cited for the acquisition of the Future Submarine:

- a newly designed developmental submarine
- evolution of an existing submarine design
- modification of an existing design for Australian needs
- purchase of an existing military off-the-shelf (MOTS) submarine design.[8]

In all four options, the submarines would be assembled in Adelaide. A potential fifth option—acquiring finished submarines by foreign military sale (FMS)—has been ruled out by the government.[9]

A MOTS purchase is unlikely even though it is the cheapest option because it would require substantially changing the profile of the Future Submarines.

Notwithstanding this, the government has selected three MOTS submarines for design studies to examine their suitability: the Scorpene Class (by French company DCNS); the Type 212 and Type 214 classes (by German company HDW); and the S-80 Class (by Spanish company Navantia). These submarines cost significantly less than $1 billion each (India purchased six Scorpene submarines for US$3 billion in 2005 and Pakistan purchased three Type 214 submarines for US$1 billion in 2008).[10]

However, the government has already indicated that the Scorpene and the S-80 do not meet 'Australia's broad needs as outlined in the Defence White Paper.'[11] Similar comments were made about the HDW's Type 209 submarine design (from which the Type 212 and Type 214 submarines are derived).

Regardless, some commentators have called for an expanded fleet of these smaller MOTS submarines (potentially as many as 24) as an alternative to the white paper plan.[12] These designs, typical of conventional export submarines, have a short range and are better at shallow water operations near the coast, making them a poor fit for the profile of the Future Submarines. Although these smaller submarines may together provide a greater time on station than a fleet of larger SSGs[13] (like the Collins Class), their patrol radii would be much smaller (which means, for example, they cannot spend substantial time in the South China Sea without a forward base).

Development of a new submarine design is by far the riskiest option.

The smaller size of the MOTS submarines greatly limits their capacity for unmanned undersea vehicle (UUV) deployment and other functions (such as Special Forces insertion). It may be worth considering a fleet of MOTS submarines if the expected capabilities or the desired role of the Future Submarines changes substantially. However, considering these issues and their impact on Australia's ability to meet the challenges described in the white paper are beyond the scope of this report.

A new submarine design is also an unlikely option. Although this option would likely meet Australia's needs, Defence is unlikely to risk a new submarine design. Both in terms of potential schedule impacts (due to unforeseen problems with the design) and potential cost implications, the development of a new submarine design is by far the riskiest option of the five listed above.

Estimates of 15 years to bring the first boat of a developmental class to operational status might be optimistic (for example, the Collins Class, an evolution of Kockums' Västergötland Class design took 15 years to commission. A developmental boat might be expected to take longer).[14] This timeframe would put the first Future Submarine in the water in around 2030. Given the intention to retire the Collins Class between 2022 and 2031, this would create a capability gap requiring either a bridging capability or a costly life-of-type extension program for the Collins Class.[15]

Even if we ignore the potential cost and time risks, Australia simply does not have the ability to design a submarine from scratch.[16] A functionally similar result can be achieved by altering an existing submarine design for Australian conditions (similar to the process of designing and manufacturing the Collins Class). The degree of redesign will be determined by the suitability of the underlying design for Australian conditions and the changes necessary to meet the required range and endurance profile and to fit systems like a MOTS US combat system and (potentially) an Air Independent Propulsion (AIP) capability.[17]

The Soryu Class—a MOTS contender?

Until December 2011, Japan exported its military technology only to the United States, but that has changed.[18] High-level discussions have been held this year between the Australian and Japanese navies to explore whether the Japanese Soryu Class meets the capabilities listed in the white paper.[19]

The Soryu Class has three advantages that make it worth considering: it has the Kockums AIP system; it is larger than all other current SSKs or SSGs (with a similar displacement—4,000 tonnes—to that expected of the Future Submarines); and it is in service with the Japanese Navy (which has a similar defence relationship with the United States as Australia).[20]

However, there are significant obstacles to procuring Japanese submarines. Both the Japanese Maritime Self-Defense Force and the submarine's builders have very limited experience at defence exporting, which may add risks and delays to the program. Also there is no guarantee Japan will export current generation submarines given its ban on military exports until recently.

Moreover, Australia should be cautious about the permanency of Japan's reversal of its ban on military exports (a concern for ongoing access to the original builders for maintenance and technical support).

Finally, almost nothing is known about the Soryu class submarines, including their interoperability with Australian systems, range, maintenance costs and readiness profiles, and alterations needed for Australian combat systems. Defence should look into the Soryu Class, but it does not appear to be the answer to Australia's submarine needs at this stage.

It is hard to avoid the conclusion that a repeat of the Collins Class process was the intention all along.

Repeating the Collins Class mistakes

It is hard to avoid the conclusion that a repeat of the Collins Class process was the intention all along—the white paper specifies broad capabilities that cannot be met by an existing SSG and excludes existing designs that could meet those capabilities (SSNs).

Given that it is years before a design will be selected, it is difficult to build a clear picture of an evolutionary designed Future Submarine. However, given the similarities to the development of the original Collins Class, some useful information might be gained by examining the Collins Class itself.

Reliability, availability and number of submarines

While the need for a submarine force is relatively clear, and the need to replace the Collins Class submarines as they rapidly approach the end of their useful life is self-evident, it is much less clear why the submarine force should be doubled from six to 12.

Details of the expected mission profiles of the Future Submarines, like a lot of the capability data on submarines, are confidential so it is difficult to independently analyse defence needs. In addition, Defence has not publicly justified increasing the size of the submarine force.

Some guidance has been provided by the defence minister who, citing a classified force structure review conducted to support the white paper, said in February 2010 that operating three submarines allows one to be patrolling on station at all times.[21] On this basis, 12 submarines will allow for 'four submarines to be on station at one time—of which two could support the anti-submarine warfare requirements of a Surface Action Group, while two could be engaged in other strategic missions.'[22]

This seems optimistic. SSGs take a long time to transit to their patrol stations (as their speed while snorting is about 10 to 12 knots).[23] An SSG travelling 3,500–4,000 nautical miles (a distance similar to that from HMAS *Stirling* to the South China Sea or the Middle East) could take more than four weeks to travel there and return. An eight-week deployment would therefore mean a maximum of four weeks on station.[24] Consequently, two submarines would have to be deployed in order to cover one eight-week period on station. Allowing time for routine maintenance and other activities pre- and post-deployment, a minimum of four submarines would be needed to have one submarine continuously on station in the South China Sea or the Middle East. If long-term maintenance schedules are added (taking three to four years out of every 11 years for the Collins Class), then at least five submarines would be needed. Six would be needed to cover for unforeseen contingencies or if the submarines have frequent equipment failures.

Goals were overly ambitious and are nowhere near being met.

Obviously the South China Sea is not the only relevant patrol area, but even the US Navy operating much faster SSNs (capable of spending a much greater portion of their time on station, as discussed below) from its forward base in Guam doesn't seem to expect one submarine permanently on station with only three submarines (the US target is roughly 106 mission days a year).[25] The United States needs 44 submarines, including forward-based submarines and the home-based submarines in the United States, to meet its day-to-day requirement of 10 deployed attack submarines, a ratio of nearly 4.5 submarines for each deployed submarine.[26]

This ratio of three total submarines to one submarine on station is even less plausible if the availability of the Collins Class submarines is taken as a guide.

Before entering into service, the deputy secretary for Defence (Acquisition) said, 'five [Collins Class submarines] could be expected to [be] available for operations at any given time.'[27] The initial contract for the maintenance of the Collins Class specifies that each submarine would be available at sea for 80% of its whole of life, a goal the Australian Submarine Corporation (ASC)[28] expected to exceed.[29] Those goals were overly ambitious and are nowhere near being met.

In theory, at any given time Australia has two submarines deployed, two in training or preparing for deployment, and two are in deeper maintenance (similar to the one for three goal the then defence minister postulated in 2010).

While specific data on unit ready days[30] is not available after 2008–09, the data on major maintenance periods of the Collins Class submarines ought to give pause. For recent periods where data has been provided to parliament (January to September 2009 and January 2010 to June 2012), there does not seem to be any period when fewer than three submarines were undertaking major maintenance activities.[31] Aside from a few months in mid-2010, at least four submarines were undertaking major maintenance (planned and unplanned) or were awaiting maintenance; at different stages totalling approximately six months during that period, five submarines were unavailable.[32]

It should be noted these figures demonstrate the number of submarines that were unavailable due to major maintenance. It cannot be assumed that submarines that were available were on station, or even deployed. This clearly shows the specific, ongoing issues with the availability of the Collins Class (such as problems with its diesel engines).[33]

There have also been serious crew shortages over the last few years, with Australia only operating three submarine crews. The Navy's review in 2008 into its workforce issues noted the systemic nature of these problems, stating that 'there have been several submarine workforce crises over the last 40 years but the corrective measures that have been implemented seem to have been unable to achieve an enduring impact.'[34] A fourth crew is being stood up in 2012 but its current status is unknown.

Bryce Pacey conservatively estimates that 12 submarines would allow for three to be continuously at sea (not on station), a ratio of 4 to 1.[35] Given the above data on the Collins Class, a ratio closer to 5 or 6 to 1 seems to be more realistic if the Future Submarines are similar to the Collins Class.

While continuous deployment is extremely important, it is also necessary to consider the force that could be surged in an emergency (such as a major global conflict). While the theoretic maximum surge of the Collins Class (based on the 2-2-2 model above) would be four boats, given the maintenance issues and crew limitations, only three boats out of six can be surged (this number could be even lower, as more submarines have been idle for months either in maintenance or awaiting repair of serious defects at times; in effect, Australia probably was limited to surging two boats most of the time). Applying this rationale to the Future Submarines would mean 5 to 7 Future Submarines available in an emergency.

Sustainment

While on operations, the Collins Class may seem like an effective tool. However, from a support and sustainment perspective it appears to have been largely a failure—its ongoing costs are far too high and it is taking longer and longer to complete maintenance activities (for example, Full Cycle Docking[36] on the Collins Class takes a 'long time even by modern nuclear submarine standards').[37]

This perspective has been supported by several reviews into naval sustainment. The Collins Class Sustainment Review (the Coles review) was established in 2011 because 'there are some serious issues around the sustainment of the Collins Class.'[38] The Coles review followed from the Rizzo plan, also in 2011, which found that the Navy had 'ongoing systemic failure' in ship maintenance and sustainment.[39]

The Rizzo plan also notes (somewhat diplomatically) that 'the need for the sustainment of assets is understood in Defence and DMO [Defence Materiel Organisation], but it is not given the same rigorous attention as asset acquisition.'[40] Too often, discussion around the acquisition of a new capability focuses on the acquisition cost, and if sustainment is discussed at all, rarely are concrete plans for sustainment management given the same priority. For example, discussions on the Future Submarine project to date have focused on the headline costs with little attention given to how to avoid the Future Submarines from falling into the same mess as the Collins Class.

A key area of concern is the likely transfer of these reliability and maintenance issues to the Future Submarines.

The subjugation of sustainment to operations, as well as the low regard for sustainment issues, can also be seen in examples such as the process of transferring crew from one operating submarine to another. This transfer is often accompanied by a 'cannibalisation' of equipment from the non-operating submarine to the new operational submarine, yet this lack of parts and stores has not been addressed so far.[41]

As these submarine sustainment failures are the result of both the Collins Class design process and broader issues within the Navy and its contractors, a key area of concern is the likely transfer of these reliability and maintenance issues to the Future Submarines.

Acquisition and operating cost

An evolutionary designed Future Submarine will be an orphan submarine class,[42] and no better example of the potential cost issues associated with orphan classes can be found than the Collins Class.

The cost of operating and maintaining the Collins Class in 2011 was $642.9 million, which included operating costs of $165.6 million and maintenance costs of $477.3 million.[43] Maintenance costs have increased 50% in the last four years, with most of that change coming from 2009–10.[44]

Estimates provided in Senate committee hearings indicate that maintenance costs are expected to peak this year and then reduce substantially.[45] Unfortunately, Defence seems to regularly and substantially underestimate the sustainment costs of the Collins Class—an additional $709 million was allocated to the sustainment budget of the Collins Class over the next four years in the 2012 Budget.[46]

Operational and maintenance costs only need to increase at an annual compound rate of 4.5% to exceed $1 billion a year by 2021. The 2012 Defence Capability Plan (DCP) indicates that 'sustainment expenditure is expected to rise at a compound annual growth rate of 4.7 per cent, primarily associated with support for the Collins Class,' so this growth rate may be an underestimation.[47]

The Future Submarines would see maintenance, operations and upgrade costs of nearly $2 billion a year.

Including the substantial upgrades to the Collins Class planned under DCP Project Sea 1439 (conservatively estimated at $30 million per ship per year to 2021), the cost of each Collins Class submarine exceeds $150 million per annum.[48] A similar cost for the Future Submarines would see maintenance, operations and upgrade costs of nearly $2 billion a year.

In terms of acquisition cost, it is very difficult to estimate the costs without knowing more about the design to be chosen. However, the Australian Strategic Policy Institute (ASPI) has estimated, based on historical cost trends together with a rough estimate in cost increases per tonne, that the Future Submarine project might cost $36 billion (in 2009 dollars—approximately $40 billion in today's money).[49]

An Australian SSN

Given the importance of this project and the potential costs, all likely options should be considered, including the acquisition of an SSN. Before considering whether Australia *should* acquire an SSN, we need to explore whether Australia *could* acquire an SSN.

Australia does not have the technical capability or the background knowledge to design and manufacture a nuclear reactor to propel a submarine, and it would be foolish to attempt it. If Australia is to acquire an SSN, it must be either a MOTS/FMS export purchase or a lease.[50]

Five countries—China, Russia, France, the United Kingdom and the United States—manufacture SSNs though none exports completed nuclear-powered submarines. Given Australia's strategic military ties to the United States and Australia's dependence on US defence technology (including stringent International Traffic in Arms Regulations (ITAR) restrictions on foreign access to US technology[51]), Russian and Chinese submarines can be ruled out straightaway.

Of the remaining submarines, the US Virginia Class SSN is clearly the best option for several reasons.

First, the US program is about three times the size of the French and UK programs combined, so it is likely to have the flexibility to accommodate Australian requirements and a broader base to support development costs for upgrades. The United States has a deep submarine manufacturing capability and will build Virginia Class SSNs for several decades, with planned upgrades along the way. The UK program on the other hand has a limited submarine production run, and identified skills shortages are already causing serious cost and delivery issues.[52] The French Barracuda is a developmental submarine, so selecting it would expose Australia to risks similar to those of evolutionary designed Future Submarines.

Moreover, the larger US program (and Australia's familiarity and historical cooperation with the US Navy) should make it easier for Australia to integrate its training program with that of the United States. As the training of future crew for an SSN would be a major challenge, this benefit cannot be overlooked.

Second, as Australia lacks a domestic nuclear power industry, it also lacks an industrial base for reactor maintenance. Australia will need to rely on either importing a reactor maintenance capability or finding access to offshore facilities for deeper maintenance of the submarines.

The United States has facilities in the Pacific region (and within the likely area of operations for Australian submarines) with a base at Guam, fewer than 6,000 kilometres from Perth and fewer than 3,500 kilometres from Cairns, and a substantial submarine maintenance centre at Pearl Harbor, fewer than 8,000 kilometres from Australia's northeast. The British and French by contrast operate their submarines from bases in northern Europe more than 15,000 kilometres from Australia. This means it will be much more efficient for Australia to seek maintenance support from the United States.

Moreover, the United States currently operates 54 attack submarines (all SSNs), which is forecast to drop to 43 in 2028.[53] The decline in total SSN numbers will coincide with a reduced maintenance need due to the improved reliability of the Virginia Class.[54] This means the United States is likely to have excess maintenance capability that could be used by Australia (something that is unlikely either with the United Kingdom or France).

The US Virginia Class submarine represents the lowest risk and most feasible entry into SSN ownership.

There are other advantages as well. The Virginia Class is a reliable and highly capable submarine, probably the best SSN in the world. Its costs, unlike those of the UK and French options, are declining in real terms.[55] Operating a US submarine would further improve Australia's coordination with the US Navy (a significant advantage given the potential threats facing Australia). The Virginia Class submarine never needs to be refuelled (nor does the UK Astute) unlike the French Barracuda.[56] The Virginia Class submarine has world-leading UUV technology, while the Barracuda is merely 'configured to enable back-fitting' of UUVs.[57] Australia's submarine program (SUBSAFE) is based on US submarine safety protocols of the same name, a good starting point for upgrading SUBSAFE to handle nuclear propulsion.[58]

Consequently, the US Virginia Class submarine represents the lowest risk and most feasible entry into SSN ownership—an option worth further investigation.

The US Virginia Class SSN

The Virginia Class SSN is the next generation US fast attack submarine. The United States has plans to build 33 Virginia Class fast attack submarines, mostly two per year through 2025, and 13 submarines based on a redesign and improvement of the Virginia Class, with production of the new version to start in 2033.[59] Two shipyards in the United States are building Virginia Class submarines.

Although the United States has traditionally opposed the transfer of sensitive SSN technology, there is a precedent for such transfers. The United States transferred a nuclear propulsion system for the United Kingdom's submarine HMS *Dreadnought* (launched in 1959) under the 1958 US-UK Mutual Defence Agreement.[60]

Perhaps more relevant is the US government's decision in 1988 to approve the transfer of nuclear submarine propulsion technology to Canada.[61] The Canadians had announced plans in their 1987 defence policy paper to manufacture 10 to 12 nuclear-powered submarines in Canada based on an existing submarine design.[62] This approval was given notwithstanding nuclear non-proliferation concerns, as it was noted that 'because of Canada's excellent non-proliferation credentials and its membership in the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), Canada obviously was not a cause of proliferation concern.'[63] Other issues raised included the submarines being manufactured in Canada (not an issue for Australia, given that the submarines would be manufactured in the United States) and submarine safety (less of a concern for Australia given its commitment to the SUBSAFE program).[64]

Another issue was potential conflict of objectives of the US and Canadian navies. This is not an issue for an Australian SSN program. In fact, the United States recently announced its aim to alter the balance of its deployment between the Pacific and Atlantic oceans from its current rough 50/50 split to a 60/40 split. In light of this decision, the acquisition of US SSNs by Australia should be seen as an advantage for the United States—an effective force multiplier.[65]

The acquisition of US SSNs by Australia should be seen as an advantage for the United States—an effective force multiplier.

Despite these issues, the United States approved this transfer to Canada (a country with similar historical and defence ties to the United States and the United Kingdom), so it is reasonable to conclude that the United States would be at least willing to consider a similar transfer to Australia. Indeed, the US ambassador to Australia, Jeffrey Bleich, was reported in February as having indicated that the United States might be open to the possibility of supplying SSN technology to Australia (although the interpretation of those reports has been disputed).[66]

In addition, Australia has also bought increasing amounts of sensitive US defence technology in recent years, including the Boeing EA-18G Growler electronic warfare system (the only country other than the United States to operate it), the MH-60R 'Romeo' naval helicopter, and the C17 Globemaster military transport plane.[67] There are strong precedents for Australia acquiring both platforms and support from the United States.

Finally, the US defence department may have financial incentives to consider exporting a fleet of SSNs to Australia. US defence is looking at sequestration (uniform automatic spending cuts of 10% across all programs) in January 2013, which might hinder its plans to build one to two submarines each year.[68] By stepping in to make up program spending with long lead purchases (or possibly buy or lease complete submarines), Australia could ease some of that pressure.

Capabilities

In most areas, the capabilities of SSNs greatly exceed those of SSGs. The Virginia Class submarine has an unlimited range and is capable of travelling vast distances underwater at a much greater speed than its SSG counterparts.[69]

The Virginia Class also has vastly superior endurance, allowing it to be deployed for months at a time, continually submerged and virtually undetectable. An SSG must snort every few days (up to several weeks if an AIP system is used, provided that AIP fuel is available) and its endurance is limited by its fuel load—for example, the maximum deployment of the Collins Class is 55 days.[70]

The combination of speed and endurance greatly increases the flexibility of an SSN. An SSG might be able to patrol in one area for 20 days but would then have to return to base. An SSN on the other hand could do 20 days in one area, transit (rapidly) to another patrol area and do 20 more days of patrol, and then transit to another area and do 20 more days of patrol, covering missions that would require three conventional submarines to complete. It could also reposition much more rapidly in a crisis.

Given the increasing number of complex computerised systems being operated by modern submarines, another important concept is a submarine's 'hotel load.'[71] As SSGs are limited by the power stored in their batteries (which can only be recharged by surfacing), they strictly ration power among their systems. SSNs are capable of generating and sustaining a much greater power output while submerged due to their nuclear reactor. This power output allows SSNs to carry a greater number of far more powerful sensors and systems (which increase sensor range and awareness), greatly increasing the flexibility, stealth and usefulness of SSNs.

The advantages of size and much greater power also allow SSNs to carry greater payloads and weaponry, as well as equipment such as UUVs and Special Forces team vehicles, further demonstrating the capability edge that SSNs might give to Australia in the Southeast Asian region.

One area where commentators have claimed SSNs might be deficient is in their ability to carry out 'intelligence work and listen in coastal waters, even go into estuaries and find out what's going on there.'[72]

This issue has not escaped the notice of US submarine designers. The Virginia Class has improved 'brown water' capability, and advanced electronic warfare systems (like the Virginia Class AN/BLQ-10(V) system) mean that the Virginia Class has been specifically designed for 'Special Operations Forces insertion and extraction' and 'intelligence-collection and surveillance missions.'[73] An SSG operating on battery power is quieter than an SSN (which always emits a low level signature because of the continual operation of the reactor), but SSGs can only operate on battery power for short periods of time—when recharging, SSGs are vulnerable to detection and attack.

Importantly, this counterargument ignores the potential of UUVs. Using relatively inexpensive UUVs for surveillance and intelligence-gathering makes more sense than using multibillion-dollar submarines to scout estuaries. While UUV technology (like unmanned aerial vehicle (UAV) technology) is still in its infancy, it has enormous potential. It is quite possible that UUVs will follow the increasing use of drones in aerial surveillance, not to mention the potential weaponisation of UUV platforms.[74]

The advantages of size and much greater power allow SSNs to carry greater payloads and weaponry.

A larger SSN with its greater hotel load and longer deployment can carry, deploy and operate more UUVs of different types, and possibly act as an intelligence hub and oversee the deployment and intelligence gathering of a fleet of battery-powered UUVs.

How many SSNs are needed?

It is not easy to determine how many SSNs might be needed to cover the same missions as 12 SSG Future submarines. There is a trade-off between time on station (where SSNs substantially outstrip SSGs) and the ability to carry out concurrent missions (where overall numbers matter and more reliable submarines are preferred).

SSNs are capable of transiting at a much faster rate (between two and three times as quickly as SSGs) and consequently are able to spend substantially longer periods on station (meaning fewer submarines are needed to cover the same time on station).[75] Further to the example of the time on station in the South China Sea, an SSN might take 10 to 12 days to get to the station and return. If the submarine was deployed for 90 days, this would mean 80 days on station (an SSG would have a longer transit time and a shorter total deployment time and so would only be on station for a fraction of that time).

There is also a clear advantage in the ability to rapidly redeploy to changing circumstances. Former US Rear Admiral John B Padgett III has cited studies indicating that 'it takes 2.2 to six [SSGs] to obtain the equivalent effectiveness of a single [SSN].'[76] This would suggest that a force of between two and six SSNs would have the same time on station as the 12 Future Submarines.

However, time on station is not the only relevant variable. One SSN may average the same time on station as three or four SSGs, but those SSGs could carry out three or four missions simultaneously. There would also be a greatly reduced capability when those SSNs are in maintenance. Therefore, it is necessary to consider how many submarines might be available at any one time given the total fleet numbers.

As noted above, a force of 12 Future Submarines is likely to result in two (or possibly up to three) submarines continuously deployed and a maximum surge of five to seven.

It is early days yet but the Virginia Class has proven to be a very good submarine, more reliable and capable of being deployed for longer than its predecessor, the Los Angeles Class.[77] Currently, it is believed that a force of 44 submarines (primarily made up of Virginia Class submarines) could provide at least 10 submarines available on a continuous basis (suggesting a ratio of roughly 9 to 2).[78] However, the United States also believes that forward-based SSNs (for example, from Guam) would be able to average 106 mission-ready days a year on a shorter but more frequent deployment schedule (meaning that seven forward-based SSNs might be able to provide two continuously available submarines).[79]

US SSNs based in the continental United States typically have a single six- or seven-month deployment every two years.[80] These submarines transit greater distances than Australia's submarines to reach their expected operations areas (Australian submarines transit between approximately 1,000 nautical miles and 4,000 nautical miles while it is 10,000 nautical miles from the US submarine base in New London on the northeast coast of the United States to the South China Sea). The profile of a forward-based submarine in Guam might be closer to the expected profile of an Australian submarine. On that basis, it seems likely that eight SSNs would make two submarines continuously available. If the Virginia Class continues to demonstrate excellent reliability, and the trend of fewer submarines needed to meet requirements continues, this overall force need may reduce to seven.

Leasing Virginia Class SSNs is preferable to an outright purchase.

The total surge for a force of 44 US SSNs is expected to be 32 (or eight submarines for every 11 in the fleet).[81] On that basis, Australia would need eight or nine SSNs to be able to surge six.[82]

Therefore, if Australia acquired eight Virginia Class SSNs it would have submarines that:

- had more powerful weaponry and greater flexibility than a force of SSGs
- would be on station for at least twice as long
- had a greater power output and so more powerful systems and sensors
- could perform at least as many concurrent missions (and possibly more total missions because of their flexibility) as 12 SSGs
- were more reliable and much less risky than an evolutionary SSG class
- could surge a similar number of submarines as a force of 12 SSGs.

Buy or lease?

There are several reasons why leasing Virginia Class SSNs (for the operating life of the submarines) is preferable to an outright purchase.

First, leasing submarines would allow Australia to hand them back at the end of the lease term and avoid any issues with the disposal of spent nuclear material.

Second, Australia could obtain a combined package for the acquisition, sustainment, training, logistical support and upgrades for its fleet of Virginia Class SSNs, and ensure that the capabilities necessary to operate nuclear submarines would be maintained throughout the life of the lease.

Third, Australia could reasonably expect to lease submarines that had already been run through their initial trials, so the risks of manufacturing defects would remain with the United States.

Finally, it is unlikely that there would be a substantial cost difference between buying and leasing over the life of the submarines, but the initial risks would be lower if the submarines were leased.

Acquisition costs

As a key argument against the procurement of SSNs is that they are much more costly than SSGs, the potential costs of acquiring a Virginia Class submarine should also be examined in detail, including acquisition costs, facilities costs, and operational and support costs.

The 2013 US Budget estimates the combined procurement cost of the seventeenth and eighteenth submarines to be US$5,108 million (approximately AU$2.5 billion each).[83] These costs are decreasing in real terms because of the US Navy's strong push of '2 for 4 in 12,' two submarines for US$4 billion (in 2005 dollars) in 2011/12.[84] On that basis, Australia should be able to acquire eight Virginia Class submarines for between $19 billion and $21 billion.

Facilities costs for an SSN

Australia should be able to acquire eight Virginia Class submarines for between $19 billion and $21 billion.

Australia will have substantial costs in constructing facilities and developing systems for SSNs. However, it is likely to need either a substantially enlarged facility at HMAS *Stirling* or a second submarine facility anyway when the Future Submarine project doubles the size of the submarine force.

A starting point for estimating the cost of these facilities might be the cost of relocating Amphibious Afloat Support Force Element Group from Sydney's Garden Island naval base outlined in the recent Hawke review—approximately $1 billion.[85]

While an SSN base is likely to be more expensive than relocating one force element, given the complexity of SSNs and security concerns, it seems unlikely it will cost significantly more than $2 billion.

There may also be upgrade costs at HMAS *Stirling* in Perth; however, these costs should not exceed $1 billion (a comparable cost to those sited to create a nuclear capable home port for a US aircraft carrier).[86] There may be additional costs for test equipment and facilities for the submarines, but neither of these costs is likely to significantly hold back a multibillion-dollar acquisition budget.

Additional costs will be incurred in establishing a maintenance presence for SSNs in Australia. However, a rough estimate of infrastructure costs can be taken from the current facilities to support the Collins Class (especially since the deeper maintenance and more routine maintenance is divided between South Australia and Western Australia respectively).

Construction and recent upgrades to the site of ASC's maintenance facility at the Australian Marine Complex in Western Australia cost approximately $265 million.[87] By way of comparison, Techport Australia's facility in South Australia (home to ASC's Air Warfare Destroyer (AWD) shipyard, common user facilities (CUF), and other infrastructure) cost approximately $300 million to build.[88]

The additional size and complexity of SSNs (even for routine maintenance purposes), together with the need to replicate equipment and facilities currently in South Australia, might mean that a conservative estimate for SSN maintenance facilities is twice the combined cost of the current facilities.

However, taking into account the above figures and the potential synergies from building a new/upgraded base, it is difficult to see the costs of establishing additional maintenance facilities exceeding $500 million to $1 billion. The top end of this estimate is nearly double the total asset value of ASC Pty Ltd (whose balance sheet includes substantial value from the AWD project in Adelaide and substantial deeper maintenance facilities for submarines in South Australia).[89]

Training and upskilling costs for technicians and crew might be a growing expense given crew levels and training needed to operate SSNs. These costs are unlikely to exceed $100 million a year; given the intention to use the existing US training systems, this comes to about $1 billion across the program. It is worth noting that once the SSNs are launched, without the need for rapid upskilling and with reduced training requirements, these costs would diminish (ongoing costs would be covered under operating expenses).

Thus the total acquisition cost of the Virginia Class is likely to be between $24 billion and $27 billion, less than most cost estimates for the Future Submarines and even after allowing a buffer for the estimates.

Moreover, previously quoted acquisition costs for SSGs do not appear to factor in potential facilities costs—some of these costs will be incurred regardless of the design of the Future Submarines.

The data does not show that the Virginia Class SSN is more expensive than the Collins Class SSG.

Operating and support costs

The other frequently cited cost objection to SSNs is that they will cost a lot more to operate and maintain than their conventional counterparts.[90]

The increased size of SSNs and the complexities of dealing with a nuclear reactor do mean that SSN maintenance costs are *likely* to be higher than those of SSGs. However, design flaws and issues with specific equipment across a submarine class can have an enormous impact on maintenance costs for individual classes, especially for orphan submarine classes, as seen above.

Using VAMOSC (Visibility and Management of Operating and Support Costs) data,[91] the US Department of Defense estimated the cost of operating and supporting each Virginia Class submarine at an average of US$35.4 million per year (calculated in 1995 dollars on an estimate of 30 submarines operating for 33 years).[92] At a conservative Australian dollar valuation and allowing for inflation, this adds up to $69.7 million.[93] These costs include $29.41 million per ship per year for maintenance and sustaining support; $17.67 million for crew; and $12.54 million for continuing system improvements.[94]

Several elements of the US Cost Analysis Improvement Group guidelines are worth noting in this context, including the incorporation of overhead costs for depot-level maintenance (equivalent to Full Cycle Docking) in their cost allocation for 'maintenance'; systems engineering and program management oversight in 'sustaining support'; and base operating support and family housing within 'indirect support.'[95] It is not clear whether these costs are included in the Australian cost data.

It is not sufficient to simply assume that Australian support costs will be the same as the US costs, given Australia's relative inexperience in operating SSNs. However, if all major maintenance is conducted at US facilities, the upside cost risk is substantially lessened. Also, importing routine maintenance capability initially from the United States should keep overall costs in a comparable range.

While it might be more expensive to operate an SSN than an ordinary SSG, the data does not show that the Virginia Class SSN is more expensive than the Collins Class SSG. Certainly, this comparison of the figures gives does not support the claim that SSN costs would be greater in the order of 'thirty or forty per cent.'[96]

Table 1: Benefits and drawbacks of Future Submarines and the Virginia Class

Criteria	Evolutionary Future Submarine	US Virginia Class submarine
Program basics		
Number acquired	12—estimated 4,000-tonne displacement, estimated 60 crew	8—approximately 7,900-tonne displacement, 135 crew
Acquisition options	Unsuitability of current SSG designs means this program will rely primarily on Australian resources	Options include buying or leasing complete submarines from the United States—likely together with a support package
Project risk	Serious risk of program failure and unforeseen issues creating substantial problems for class going forward	A proven, in-service solution with an impressive track record. Risks with adopting nuclear technology
Capabilities		
Range	Longer range than most SSGs but needs to regularly snort and refuel	Unlimited range—has no need to refuel over life of submarine
Speed	Limited capacity to travel stealthily at speed—AIP/batteries much more effective at low speed	Capable of much higher speeds and stealth though potential issues with wake at high speeds given its size
Endurance	Likely to be limited to around 55 days	Limited only by crew endurance
Sensors and systems	Hotel load limited to battery power. Power used sparingly—as a result, sensors and systems less powerful	Capable of much greater hotel load due to nuclear reactor. Operates much more powerful systems and sensors
Intelligence gathering/close shore deployment	Likely better at in-shore deployment than SSNs but less capable than other conventional submarines due to size	Limited by size but this should be somewhat offset by greater UUV and mini-submarine capability
Stealth	AIP and battery technology gives short-term stealth advantage but potential issue with Indiscretions from snorting. Larger target for active sonar than smaller SSGs	Capable of very stealthy, long deployment but minor noise from nuclear plant unavoidable. Larger target for active sonar than SSGs
Estimated costs		
Acquisition	\$36 billion to \$40 billion, plus expected facilities costs (unknown)	\$19 billion and \$21 billion, with \$4 billion to \$6 billion in set-up costs
Maintenance and operation	Based on Collins Class—upwards of \$110 million per submarine per year	Based on US data, \$70 million per submarine per year
Potential issues		
Capability gaps	Very high risk; likely to require expensive bridging program to ensure no capability gap between the Collins Class and the Future Submarines	No domestic nuclear power industry—would require importing reactor maintenance capability from the United States
Skills gaps	A risk in construction and design phase—limited design experience, potential limitation on numbers of engineers depending on level of manufacture in Australia	A risk with initial crew operations—need to engage early with the United States to recruit appropriately skilled captains, technicians and crew
Cost risk	High risk with evolutionary design	Limited risk with a mature and proven production line in the United States
Schedule risk	High risk with evolutionary design, exacerbates risk of capability gap	Limited risk with a mature and proven production line in the United States

Objections to an Australian SSN program

The defence minister has repeatedly ruled out the possibility of acquiring an SSN.[97] While the government has provided several reasons justifying this move—and commentators have cited a few more—issues such as the treaty on the non-proliferation of nuclear weapons, potential safety concerns with nuclear fuel, lack of infrastructure and maintenance capabilities, and sovereignty concerns, it is worth examining whether these justifications are valid reasons why Australia should not pursue a nuclear option.[98]

Nuclear safety and community concerns

One of the likely objections to Australia operating a fleet of SSNs is the possibility of dangerous radiation from 'unsafe' nuclear-powered submarines. This objection is not justifiable on the evidence and is based on an ill-founded fear of nuclear power.

The United States has a perfect safety record with its naval propulsion reactors.

US Navy ships with nuclear-powered reactors have been visiting Australia since 1960.[99] The United States has a perfect safety record with its naval propulsion reactors. Its navy has 'accumulated over 6,200 reactor-years of accident-free experience involving 526 nuclear reactor cores over the course of 240 million kilometres, without a single radiological incident, over a period of more than 50 years.'[100]

In addition, the risk posed by a reactor in a submarine is much lower than a nuclear power plant on land because the reactor and the fuel required are so much smaller. The United States operates 104 nuclear reactors that generate about 1,000 megawatts (MW) on average.[101] The Chernobyl nuclear power plant had four reactors with an output of 1,000 MW each.[102] By contrast, the Virginia Class SSN reactor has an output of about 30 MW,[103] a fraction of the generating capability of a nuclear power plant.[104]

In addition to the low risk from US submarines, Australia already has a sophisticated management plan for the visits of US submarines to HMAS *Stirling*, involving joint oversight[105] by the federal and state governments, as well as Defence.[106] As part of this management plan, radiation monitoring is carried out during the visits. The most recent reports (2009 and 2010) note no detected releases of radioactive material and that the radiation levels recorded were not in excess of normal background levels of radiation, either during or after these visits.[107]

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) has assessed the danger posed to Australian ports by visits by nuclear-powered ships via a (theoretical) contained loss of coolant accident,[108] called the Reference Accident.[109] The reference accident is used to evaluate 'the radiological consequences of a hypothetical "reference accident" to a nuclear reactor on board a vessel in port.' Importantly, the reference accident is 'modelled using conservative assumptions and is considered to represent an upper bound risk to the surrounding population.'[110]

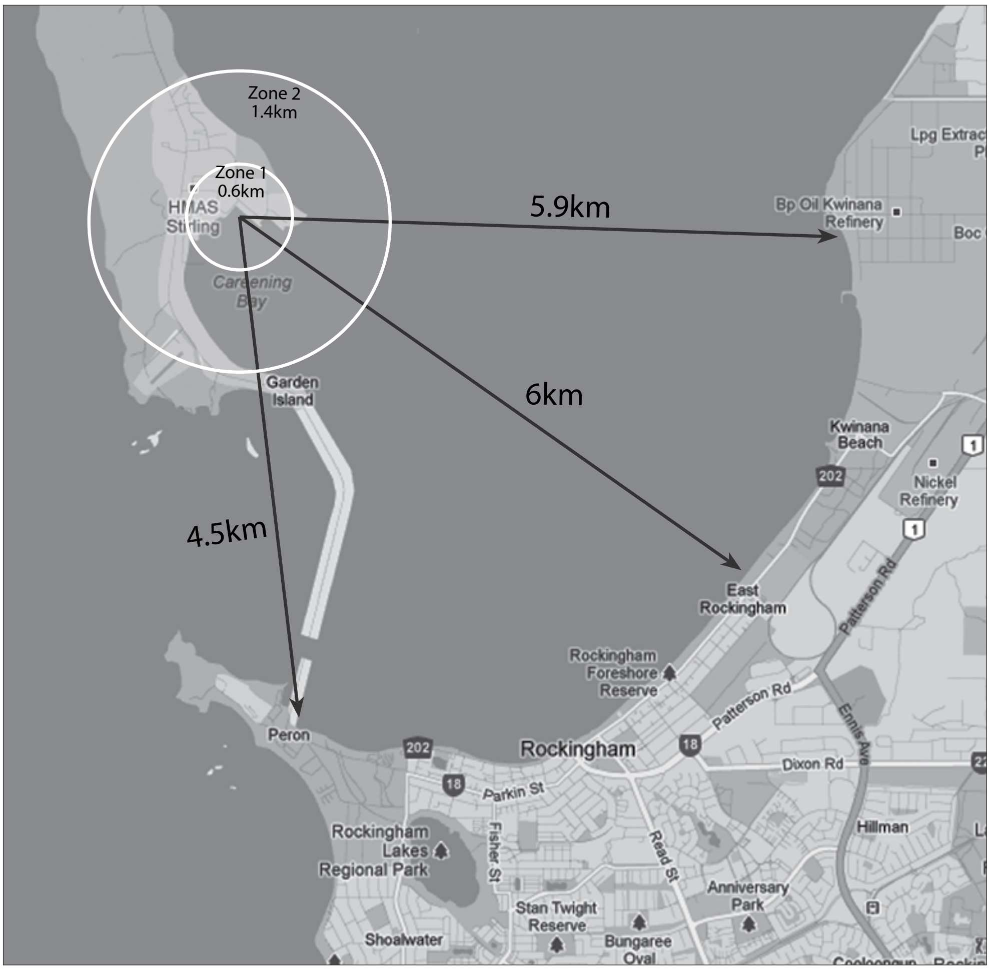
The reference accident is modelled on a power plant from a Los Angeles Class submarine with an average operating power of 40 MW(t)[111] and a maximum reactor operating power of 160 MW(t).[112] This appears to be a greater operating power than that of the Virginia Class. In assessing the consequence of the reference accident, ARPANSA identifies several zones based on distance from the accident site—with Zone 1 representing 'the maximum distance to which immediate evacuation would be required,' and Zone 2 an area where 'projected doses do not justify evacuation [but] may justify sheltering as a countermeasure.'[113]

Figure 1 shows these zones overlaid on a map of HMAS *Stirling*. It is clear that these zones do not overlap any large civilian population. On that basis, even in the unlikely event of an accident aboard an Australian SSN, civilian casualties are highly unlikely.

Nor are personnel operating SSNs subject to excessive regular radiation—in fact, the crew receive less radiation exposure in a year than the average exposure to natural background and medical radiation in the United States.[114]

While there undoubtedly will be opposition from those who are ideologically opposed to nuclear power, the argument that a nuclear-powered submarine is a completely different proposition to a massive nuclear power station is compelling. It is reasonable to think the Australian public would accept procuring a fleet of SSNs based on the impeccable safety record of US SSNs.

Figure 1: Reference Accident Radiation Zones overlaid on HMAS *Stirling*



Source: Google Maps.

Even in the unlikely event of an accident aboard an Australian SSN, civilian casualties are highly unlikely.

Skills gaps—training a crew for an SSN

One of the biggest challenges in establishing an Australian SSN program will be the lack of available skilled crew members when the submarines first come into service, especially senior officers capable of commanding Australian SSNs.

The only realistic solution is to seek training assistance from the United States, which has well-established paths through its naval Nuclear Power School for transitioning enlisted personnel and officers into roles in a nuclear submarine.[115] The United States takes university graduates (with degrees primarily in engineering, physics or mathematics) and runs them through a 17-month intensive training program to prepare them for deployment on a nuclear submarine.[116]

There should be little issue with Australia sending recruits to complete this program—Australians have participated in training programs like the US Navy's

Submarine Command Course.[117] However, the important step would be for some Australian submariners to be deployed on the US Virginia Class submarines. There are two possible objections to these deployments. The first is that Australians would be deployed on missions that the United States would rather not share information about, a concern that needs to be managed. The other objection is allowing Australian submariners access to secret US submarine technology, but this is not much of a concern because Australia would be accessing this technology anyway as part of the submarines acquisition. Nor is it unknown for individuals who have served in the US Navy to serve in the Australian Navy—in fact, Australia was seeking to recruit US submariners in early 2012.[118]

Australia would need to identify the next generation of submarine commanders with an appropriate background and interest in nuclear submarines. These submariners would then be seconded to the US Navy for nuclear submarine training and junior officer placements. These submariners would be the initial senior officers of the Australian SSN fleet, and later joined by technicians (who will have shorter training timeframes). Australia would almost certainly seek to recruit (or second) some experienced US officers and technicians to augment these ranks.

It is important to note that crew shortages exist in the Collins Class too and require serious remedy. In June 2008, Australia had a critical shortfall of submariners—423 officers and sailors were available but 667 were needed—and the workforce was in serious decline.[119] The response to this crisis is the basis for ensuring that the Future Submarines (which would also require a large expansion of the submarine force) have sufficient skilled personnel to be able to operate 12 submarines.

Australia has sufficient time to create and execute a comprehensive training plan to train enough skilled personnel to operate nuclear submarines.

An additional issue is that the Future Submarines are likely to be a unique design, so it will not be possible to train submariners before building the submarines the way it is with the Virginia Class.

It will take many years for Australia to train enough skilled personnel to operate nuclear submarines and involve a high degree of support from the United States. Fortunately, Australia has sufficient time to create and execute a comprehensive training plan to meet this need; provided there is sufficient money, this issue can be overcome.

Skills gaps—establishing a nuclear power industry?

A frequently raised objection is that the absence of a domestic nuclear power industry makes sustainment unviable.[120] There are good reasons to doubt Australia's ability to develop a full cycle sustainment solution without external assistance (a similar problem for Australia's submarine designers developing their own submarine design). However, this is much less of a concern if Australia accesses sustainment skills and experience from the United States.

Career opportunities for people with an interest in nuclear engineering are limited in Australia, but we do have some facilities that focus on nuclear energy. One of the best examples is the Australian Nuclear Science and Technology Organisation (ANSTO) Institute of Materials Engineering, which focuses on the 'nuclear fuel cycle and next generation power generation systems.'[121]

The Australian Institute of Nuclear Science and Engineering (AINSE) is also involved in nuclear research, aiming to 'provide a focus for cooperation in the nuclear scientific and engineering fields.'[122] ANSTO also operates the Open Pool Australian Lightwater (OPAL) reactor at Lucas Heights, primarily as a research facility.[123] Clearly, Australia can build on its research interest in nuclear technology.

Given the acknowledged difficulties for Australia to build a nuclear capability from scratch, Australia should initially use US maintenance capability in Pearl Harbor and Guam while building up a limited, submarine specific domestic capability.

As Australia will have a sizeable fleet of SSNs (eight), it should be commercially viable for a US company with experience in maintaining Virginia Class submarines to establish a presence in Australia to carry out low-level maintenance.

As a result of the reduction in overall SSN numbers and the lower maintenance requirements of the Virginia Class submarine, the United States will probably have spare maintenance capacity that could be redirected to Australia. Although it is important not to underestimate the difficulty of setting up a new business in a highly technical field, setting up maintenance capability with the support of the United States is achievable with careful planning.

This capability, if supported by US experience, need not extend to a domestic nuclear power industry. It may be slightly more expensive to keep the capability current (as it would at least initially depend on a steady influx of US nuclear engineers), but this shouldn't substantially hamper an Australian SSN program.

It should be noted that while Australia does not have any experience in operating a nuclear submarine, there is a sophisticated safety regime already in place for protecting civilians from any dangers of SSNs.

There is a reasonable body of evidence to suggest that Australia doesn't have a self-reliant defence force.

Australian 'self-reliance' and US dependence

Concerns that acquiring US SSNs and relying on the United States for deeper maintenance facilities will diminish Australia's capacity for independent sovereign action and render the Australian Navy subservient to the US Navy are ill founded.

The defence minister has said, 'The reason we have ruled out a nuclear option is that Australia ... would effectively see the outsourcing to another country of our maintenance and sustainment of our submarine fleet.'[124]

There are two problems with this approach. First, there is a reasonable body of evidence to suggest that Australia doesn't have a self-reliant defence force now so the loss of self-reliance in this case (if any) would be fairly small. Second, even if Australia is considered to be self-reliant, there are good reasons to reconsider the boundaries of this approach.

A key tenet of the white paper is Australia's defence policy should be founded on:

> The principle of self-reliance in the direct defence of Australia and in relation to Australia's unique strategic interests, but with a capacity to do more when required, consistent with those strategic interests that we might share with others, and within the limits of Australia's resources.[125]

The white paper goes on to discuss self-reliance in the broader strategic context, that is, the ability to defeat an armed attack on Australia without relying on foreign forces. In a sense, Defence self-reliance can be seen as three related, tiered elements.

1. **Operational self-reliance:** having sufficient troops and hardware to be able to meet all credible threats without relying on support from an ally
2. **Sustainability:** having sufficient expertise and capital investment in country to be able to fully support all troops and hardware through their working life
3. **Developmental self-reliance:** having the ability to design and develop new platforms to meet changing defence needs.

Making judgments about Australia's operational self-reliance lies beyond the scope of this report; however, it is clear that Australia has substantially underspent the plan laid out in the white paper. If the white paper has any credibility in its assessment of future force needs and threats, then it is reasonable to assume that some of Australia's self-reliance has been compromised by these spending cuts. Certainly commentators, including ex-military personnel, have repeatedly suggested that the recent defence funding cuts will undermine Australia's ability to respond to crises.[126]

The Collins Class submarine was the flag bearer for self-reliance. There is no need to repeat that experiment to know the likely results.

Although Australia may notionally be able to manufacture some complete platforms (submarines and surface ships), it has never had developmental self-reliance, instead relying heavily on foreign design (and construction) expertise in selecting platforms. The Air Warfare Destroyers were designed by the Spanish company Navantia, and the Collins Class by the Swedish company Kockums.

It is not economical for Australia to design and build aircraft or tanks, which is why we import these capabilities. Australia can produce helicopters yet recently decided to import them as well. Australia long ago accepted that some capabilities are beyond its budget and industry skills, and needs to rely to an extent on the global supply chain and international support.

This leaves only sustainment. It is certainly questionable whether Australia has self-reliant sustainment. Australia currently outsources (at least in part) the sustainment of several major platforms worth billions of dollars to other countries. For example, Australia is acquiring an FMS sustainment package for its $3 billion acquisition of 24 MH-60R helicopters from the US Navy (deeper maintenance of these helicopters is expected to be done in the United States) and is part of the US led Globemaster III Sustainment Partnership (where the US-based Boeing company coordinates the global sustainment of C17 aircraft in Australia assisted by Boeing's subsidiary).[127]

Even the maintenance and support of platforms carried out in Australia is generally done by Australian subsidiaries of foreign defence companies, who rely heavily on their parent company's expertise. Most of Australia's leading defence companies, including BAE Systems Australia, Raytheon Australia, Thales Australia, and Lockheed Martin Australia, are subsidiaries of foreign defence primes.

Often a local subsidiary of a global defence prime contractor leads the sustainment of an Australian platform manufactured by the parent company. Typically, this involves a reliance on the knowledge (and sometimes personnel) of the prime. While SSNs are quite complicated, there is no reason why that familiar sustainment model wouldn't work for their support in Australia.

The Collins Class submarine was the flag bearer for self-reliance but has proven to be unreliable and very costly. There is no need to repeat that experiment to know the likely results.

As defence platforms become more complex and development costs increase, Australia needs to carefully consider all options that give value for money and high capability. This may mean that even if the acquisition of an SSN is against an absolutist view of Australian defence self-sufficiency, the boundaries of self-reliance should be re-examined before discarding the nuclear option.

There are good arguments why a rigid approach to self-sufficiency is wrong. For one, Australia is a small to middle power, vocal in its support for internationally responsible action; its capacity for unilateral action is constrained much more by these policy factors than by its defence independence. As a responsible international citizen, how independent must Australia be? How much should Australia pay to retain a right that is unlikely to be used?

Second, while a case certainly can be made that Australia needs access to some maintenance capabilities in country to support Defence in an emergency, this does not automatically extend to time-intensive overhauls conducted once every decade. Australia must have access to some reactor maintenance technology, but obtaining reasonable access to US expertise to bolster the development of local capability shouldn't be difficult—it can only be considered problematic if Australia decides to be completely self-sufficient.

Third, as the limitation on Australian independence created by sourcing cost-effective, deeper maintenance for submarines seems limited, it is worth discussing the merits of trading extra capability for a minor loss of independence. This consideration should also apply to the potential benefits of leasing a submarine rather than buying it. Excluding SSNs from even the most basic consideration is an error.

Finally, in an environment where Australia's defence spending is at its lowest point (as a share of GDP) since 1938, surely ways to acquire enhanced capabilities without the extra spending and risk inherent in Australianised developmental programs are worth investigating.[128] The consistent underspending of the white paper is evidence that, in practice, the government has abandoned self-reliance—and defence capability planning must acknowledge that reality and go forward.

Treaty on the non-proliferation of nuclear weapons

The objection that Australia acquiring a SSN breaches the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is rarely clearly articulated, generally couched vaguely as NPT concerns.[129]

It is hardly surprising that no concrete objections have been raised, because the exemption of nuclear-powered naval propulsion reactors from the NPT is well known.[130] While the NPT restricts transfer and receipt of nuclear weapons and nuclear explosive devices, a reactor powering a submarine is neither a nuclear weapon nor a nuclear explosive device in the ordinary meaning of those words.[131]

The draft Fissile Material (Cut-Off) Treaty prepared by the International Panel on Fissile Materials acknowledges this exemption, including references to 'military non-explosive purposes,' and notes 'some states choose to … produce highly enriched uranium (HEU) for use in naval fuel.'[132]

The consistent underspending of the white paper is evidence that, in practice, the government has abandoned self-reliance.

While Australia has been vocal in its opposition to all forms of nuclear proliferation, acquiring SSNs can be distinguished from this position because:

- Australia would not take possession of any HEU that was not already inside the submarine reactor.
- Australia would not manufacture any HEU for use in the submarines.
- Australia would not retain any nuclear material after the end of the submarines' working lives.
- Australia has a reputation as a country with the tightest security controls on nuclear material (ranked first on the NTI Nuclear Materials Security Index), which should limit proliferation fears.[133]

Export or proposed export of SSNs to nations like Australia is not unknown either—Canada considered acquiring SSNs in the 1980s and again discussed the option recently.[134]

This objection to nuclear power lacks a sound legal basis but shows the underlying ideological drive. The arguments are only surface deep and used to obscure an unreasoned opposition to nuclear power, particularly by the Labor government.

Industrial policy

It is often argued that defence policy has a necessary industrial policy component. Leaving aside arguments about self-sufficiency, this has been a thin veil for protectionism, as if defence industry has a unique character that belies the fundamental economic flaws of all protectionist arguments. However, even if this economically flawed argument is accepted, industry policy must still run second to the consideration of the potential costs and risks of manufacturing platforms in Australia.

Rear Admiral Rowan Moffitt, head of the Future Submarine project, has been quoted as saying that the '$36–40 billion figures that commentators have publicly stated does not adequately quantify the scale of [the Future Submarine project] as it is a long-term project that seeks to establish a submarine building industry in Australia.'[135] This echoes a comment in the RAND report on the Collins Class:

> A key lesson is that a new submarine development program produces more than a strategic military asset; it also contributes to domestic economic goals and is one part of a long-range operational and industrial base strategy.[136]

These arguments cannot be accepted—not only are they economically unsound but they also are logically flawed. Any submarine design industry developed in Australia will have limited export appeal for the very reasons used to justify development of a bespoke design in the first place—Australia's 'unique' demands. A similar argument was used to justify the development and manufacture of the Collins Class submarines in Australia, but no submarine-building industry was established in Australia. So why would the Future Submarines be different?[137]

A far better way of supporting local defence industry is be to push for a reduction in the global protectionism of defence markets.

As can be seen from the extremely limited success in supporting the Australian automotive industry, subsidies are rarely effective in maintaining the health of an industry. They also cost the government a significant amount of money—taxpayers are always the invisible losers in protectionism.

Instead of attempting to shield defence industry from competitive forces, a far better way of supporting local defence industry is to push for a reduction in the global protectionism of defence markets. Opening up further opportunities in Asia in particular would be a much better policy than sustaining inefficient companies for political (rather than strategic) purposes.

The other key factor in supporting the defence industry is to encourage communication between Defence and industry (and the public as well). Defence needs to articulate its needs better (where it can) and engage more proactively to ensure that these needs are being met. This engagement will encourage innovative companies to develop solutions to problems and allow competitive defence companies in Australia to thrive. This engagement should also include a review of the cumbersome defence procurement model.

Skilling up local supply chains for domestic production of a MOTS design for its own sake would be a costly error and will generate little benefit (other than profits for a select group of companies). If a MOTS or an FMS solution is viable, the government must consider the cost-benefits of using existing supply lines.

Conclusion

To date, the selection process for the Future Submarines has not been handled well. Defence has not articulated (or seemingly even developed) the capabilities needed by the Future Submarine and has not made a sufficient case for a greatly expanded submarine force. Nor has it made any substantial decisions on buying the Future Submarines—this delay may have created a capability gap in the years to come.

The Future Submarine project is moving inexorably on the same path as its predecessor, yet substantial issues with the Collins Class submarines are yet to be resolved and have the potential to seriously inhibit the capabilities and increase the costs of the Future Submarines. Maintenance costs for the Collins Class submarines are likely to exceed $1 billion a year by 2021, and the submarines are struggling to meet even modest readiness targets. These systemic issues are likely to infect the Future Submarine project.

The costs of the Collins Class submarines are abnormally high for an SSG. The Virginia Class submarines are likely to be a cost-competitive option. Their maintenance costs would be up to three-quarters of a billion dollars a year less than a force of 12 Future Submarines with similar costs to the Collins Class. Their acquisition costs would be $10 billion lower than some estimates of the Future Submarines, and their capabilities, particularly their range, endurance, sensors and systems, are superior to any of their conventional rivals.

Objections have been raised to an Australian SSN program on the basis of defence independence. However, similar arrangements for offshore maintenance support have been made for platforms in the past and the Australian defence industry is functionally reliant on global defence primes regardless of the location of maintenance facilities. Any extra loss of independence would be slight. Moreover, Australia's policy of defence self-sufficiency itself may need to be revisited, given increasing defence complexity and the potential capability impact of ongoing reductions in defence spending.

The decision to exclude SSNs from even the most basic consideration in the Future Submarine project is a mistake that should be corrected.

Similarly, other arguments against a nuclear option and in favour of an Australian-developed SSG—for example, those aimed at protecting Australia's domestic defence industry—are ill founded and economically unjustified.

On that basis, the decision to exclude SSNs from even the most basic consideration in the Future Submarine project is a mistake that should be corrected. The need for a rational debate on defence acquisitions policy is long overdue. The off-hand dismissal of SSNs is merely one of many flaws in the initial planning of the Future Submarine project.

Australia cannot afford to pay unreasonable additional costs in homage to the twin-flawed models of industry policy and defence self-sufficiency. It should not sacrifice value for money for political gain. This report has demonstrated that a Virginia Class SSN might represent value for money while achieving Australia's capability goals and must be considered for the Future Submarine project on that basis.

Endnotes

1 Time spent at periscope depth, close to the surface—especially by a diesel submarine that needs to recharges its batteries by snorting (taking in air via a snorkel). This is especially risky because submarines on the surface are much more vulnerable to discovery and attack.

2 White Paper, *Defending Australia in the Asia Pacific Century: Force 2030* (Government of Australia, Department of Defence, 2009).

3 As above, 70.

4 As above, 70.

5 As above, 70.

6 John Kerin, 'Defence cuts a "threat" to US alliance,' *The Australian Financial Review* (24 May 2012).

7 The designations SSN, SSG, etc. refer to the statistics line for the vessel in the *Dictionary of American Naval Fighting Ships*. The SS refers to submarine and the final letter(s) denote the type of submarine. Hence, SSBN is a SS (submarine) B (ballistic missile capable) N (nuclear-powered submarine). SSN is therefore a general purpose nuclear-powered attack submarine. SSK is a designation for a diesel-powered ASW submarine, while SSG is a diesel-powered submarine capable of launching guided missiles (like cruise missiles) – see Ship nomenclature and ship types, *Dictionary of American Fighting Naval Ships*.

8 A MOTS acquisition is the purchase of military equipment, typically in use by a foreign country, from a defence supplier with minimal adaptation.

9 A Foreign Military Sale is the acquisition of military equipment directly from a foreign government.

10 See 'India to buy 6 Scorpene submarines,' *Rediff India Abroad* (12 September 2005); Moin Ansari, 'Pakistan's 214 Submarines made in Karachi with German help,' *RupeeNews* (26 November 2008).

11 Senator Chris Evans in response to questions on Notice 644 and 646, *Hansard* (13 October 2011).

12 Hugh White, 'Submarine shopping should start with a few key questions,' *The Age* (7 February 2012).

13 The Collins Class is classified as an SSG, though in some places it is referred to as an SSK. Depending on the design choice of the Future Submarines, it could be an SSG or an SSK. For example, the Scorpene submarines are designated as SSKs, but if they were redesigned for the Future Submarine Project and equipped with guided missiles, then the new class of Future Submarines would be SSGs. For simplicity, this paper uses SSG to refer to generic diesel-powered submarines being considered for the Future Submarine Project

14 Brendan Nicholson, 'Nuclear or not, we'll need prefab subs,' *The Australian* (9 February 2011).

15 Andrew Davies and Mark Thomson, 'Mind the Gap, Getting Serious About Submarines,' *Strategic Insights* 57 (The Australian Strategic Policy Institute, 2011).

16 See John Birkler, et al., 'Australia's Submarine Design Capabilities and Capacities: Challenges and Options for the Future Submarine' (California: RAND Corporation—National Security Research Division, 2011) for a discussion of the gap in capability.

17 Air Independent Propulsion is a system of extending the range of a diesel-powered submarine through the use of a secondary power generation system (typically fuel cells or other technology) that does not require regular intakes of oxygen (unlike a diesel engine).

18 Reuters, 'Japan drops ban on military exports,' *The Guardian* (27 December 2011).

19 Hamish McDonald, 'Navy eyeing off new Japanese submarines,' *The Sydney Morning Herald* (9 July 2012).

20 'SS-501 Soryu /16SS / SS 2900 ton class,' *Global Security*.

21 Senator John Faulkner, response to Senate question on Notice 2557 (25 February 2010).

22 As above.

23 Brice Pacey, *Sub Judice: Australia's Future Submarine,* Kokoda Papers 17 (Canberra: Kokoda Foundation, 2012).

24 Time on station is the portion of a deployment (time spent at sea) that is spent carrying out the required mission (i.e. time spent on patrol in the operational area). The United States refers to mission days, which is a similar concept.

25 CBO (Congressional Budget Office), *Increasing the Mission Capability of the Attack Submarine Force* (1 March 2002).

26 Ronald O'Rourke, *Navy Attack Submarine Procurement: Background and Issues for Congress,* Congressional Research Service (CRS) Report for Congress (22 May 2008) citing a 2007 naval briefing

presented to the CRS and CBO that stated a force of 44 SSNs primarily composed of Virginia Class submarines could provide 10 day-to-day deployed submarines from 2020 to 2033, provided that a quarter of all deployments were lengthened by 15%.

27 Joint Committee of Public Accounts and Audits, 'Review of Auditor-General's Report No. 34 1997–98, New Submarine Project,' tabled in the House of Representatives and the Senate (11 June 1999).

28 Originally called the Australian Submarine Corporation, ASC was a joint venture by Swedish Kockums and the Australian government to build the Collins Class submarines. Kockums' shareholding in ASC was bought out by the government in 2000, and it remains a wholly government-owned enterprise.

29 'New Submarine Project,' Audit Report no. 34 (Canberra: Australian National Audit Office, 1998), 123.

30 'Unit-ready' days are the days when submarines are not undergoing major maintenance and can be assigned tasks.

31 See responses to Senate questions on Notice 2077 (28 October 2009); 2539 (23 February 2010); 108 (9 February 2011); 482 (17 August 2011); 758 (22 August 2011); 1600 (8 May 2012); and 2057 (10 October 2012).

32 As above.

33 See Malcolm McIntosh and John Prescott, *Minister for Defence: Collins Class Submarine Report 1 July 1999* (Canberra: Department of Defence, 1999) or Patrick Walters, 'Engine problems cripple Collins-class submarines,' *The Australian* (21 October 2009).

34 Rowan Moffitt, *Submarine Workforce Sustainability Review* (Department of Defence, 31 October 2008).

35 Brice Pacey, *Sub Judice: Australia's Future Submarine*, as above.

36 Also known as major depot maintenance—a complete overhaul and refurbishment of a submarine (typically takes several years to finish).

37 John Coles, *Collins Class Sustainment Review, Phase 1 Report* (Department of Defence, 13 December 2011), 19.

38 As above, 2.

39 Paul Rizzo, *Plan to Reform Support Ship Repair and Maintenance Practices* (Department of Defence, July 2011), 7.

40 As above, 8.

41 John Coles, *Collins Class Sustainment Review, Phase 1 Report*, as above, 12.

42 'Orphan equipment' or an 'orphan class' is a defence platform that is unique to a particular country or platform—for example, the Collins Class submarines are only operated by Australia, and the Hedemora V18 diesel engines are used only in the Collins Class submarines.

43 Response to Senate question on Notice 1595 (10 May 2012).

44 Response to question 73 to the Senate Standing Committee on Foreign Affairs, Defence and Trade, Senate Supplementary Estimates (19 October 2011).

45 Response to question 31 to the Senate Standing Committee on Foreign Affairs, Defence and Trade, Senate Supplementary Estimates (19 October 2011).

46 Minister for Defence, *Defence Portfolio Budget Statements 2012–13*, 18.

47 Defence Capability Plan 2012 update (Department of Defence), 10.

48 Defence Capability Plan 2012 update, Project Sea 1439 Phases 3, 5B and 6 (Department of Defence).

49 Sean Costello and Andrew Davies, 'How to Buy a Submarine: Defining and Building Australia's Future Fleet,' *Strategic Insights* 48 (The Australian Strategic Policy Institute, October 2009).

50 One advantage of an FMS purchase or lease is the potential option to purchase sustainment from an established supply line—relying on the competitive tendering processes of the FMS seller.

51 The United States uses International Traffic in Arms Regulations (ITAR) restrictions to limit access by people of certain heritage to US defence technology.

52 '43rd Report from Common's Select Committee on Public Accounts,' UK House of Commons (21 July 2004).

53 CBO (Congressional Budget Office), *An Analysis of the Navy's Fiscal Year 2013 Shipbuilding Plan* (July 2012).

54 Ronald O'Rourke, *Navy Attack Submarine Procurement: Background and Issues for Congress,* as above citing Navy testimony to the Projection Forces subcommittee of the House Armed Services Committee in 2006 and the Seapower subcommittee of the Senate Armed Services Committee in 2006.

55 For the United States, see Ronald O'Rourke, *Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress* (Congressional Research Service, April 2012); for the United Kingdom, see 'Astute SSN Program History,' www.globalsecurity.org; for France, see 'French Audit Report Reveals Weapon Prices, A400M details,' www.defense-aerospace.com (18 March 2010).

56 For the United States see, 'Virginia Class, Nuclear powered attack submarine,' *Military Today*; for the United Kingdom, see Andrew Preston, 'Defender of the realm: Britain's £1.2bn submarine—and typically, we can't afford it …,' *The Daily Mail* (22 March 2010); for France, see, 'France's Future SSNs: The Barracuda Class,' *Defense Industry Daily* (21 December 2011).

57 'SSN Barracuda Nuclear Powered Attack Submarine, France,' www.naval-technology.com.

58 Andy Miller, 'How Safe Are Our Subs?' *Navy News* (14 December 1998).

59 CBO (Congressional Budget Office), *An Analysis of the Navy's Fiscal Year 2013 Shipbuilding Plan* (July 2012).

60 A copy of treaty can be found in the United Nations Treaties Database (Article 3 contains the provisions for transfer of nuclear submarine propulsion).

61 Gerald L Brubaker, *Taking a Dive for a Friend—The Decision to Transfer Nuclear Submarine Technology to Canada* (National War College, 10 December 1990).

62 *Challenge and Commitment: A Defence Policy for Canada* (National Defence, June 1987).

63 Gerald L Brubaker, *Taking a Dive for a Friend*, as above.

64 As above.

65 Address by US Secretary of Defense, Leon Panetta, at the 11th IISS Asia Security Summit (2012).

66 John Kerin, 'US floats nuclear subs option,' *The Australian Financial Review* (22 February 2012).

67 Minister for Defence and Minister for Defence Materiel, 'Acquisition of Growler electronic attack capability' (23 August 2012), 'New Naval Combat Helicopters' (16 June 2011), 'purchase of additional C17,' joint media releases (19 March 2012).

68 Larry Abramson, 'Defense cuts: How do you buy 1.8 submarines,' NPR (23 July 2012).

69 The Virginia Class submarine can travel at 32 knots submerged. 'SSN774 Virginia-class fast attack submarine,' www.military.com.

70 Rex Patrick, 'A range of submarine options,' *Asia Pacific Defence Reporter* (12 May 2011).

71 'Hotel load' is the on-board electricity requirements of the submarine.

72 Hamish McDonald and Deborah Snow, '*Submarines no longer all at sea*,' *The Sydney Morning Herald* (9 July 2012)

73 'Ships, Sensors and Weapons—Undersea Warfare Programs Target an Expeditionary Future,' *Undersea Warfare* 3:3 (Spring 2001).

74 For example, the United Kingdom is actively developing UUVs for anti-submarine warfare and possible missile attacks. Nick Hopkins, 'Ministry of Defence plans new wave of unmanned marine drones,' *The Guardian* (2 August 2012).

75 Compare the 32-knot speed of the Virginia Class ('SSN774 Virginia-class Fast Attack Submarine,' www.military.com) with the estimated transit speed of the Future Submarines (Brice Pacey, *Sub Judice: Australia's Future Submarine*, as above).

76 John B Padgett III, 'Projecting Power: The Case for Maintaining an All-Nuclear Fleet,' *Armed Forces Journal* (September 2011).

77 In Ronald O'Rourke, *Navy Attack Submarine Force-Level Goal and Procurement Rate: Background and Issues for Congress,* Congressional Research Service (CRS) Report for Congress (18 January 2006), he cited a 2004 interview with former Director of Navy's nuclear propulsion program who noted that a force of 54 primarily Los Angeles Class submarines was sufficient to provide nine submarines continuously on deployment. However, Ronald O'Rourke, in *Navy Attack Submarine Procurement: Background and Issues for Congress* (Congressional Research Service Report for Congress, 22 May 2008), cited a 2007 Naval briefing presented to the CRS and CBO that stated a force of 44 SSNs primarily composed of Virginia Class submarines could provide 10 day-to-day deployed submarines from 2020 to 2033, provided that a quarter of all deployments were lengthened by 15%.

78 See endnote 26.

79 CBO (Congressional Budget Office), *Increasing the Mission Capability of the Attack Submarine Force* (March 2002).

80 Ronald O'Rourke, *Navy Attack Submarine Procurement: Background and Issues for Congress*, as above.

81 As above.

82 The actual number needed would be 8.25—so in theory, a fleet of eight boats could surge six 75% of the time, but would be limited to five 25% of the time. In reality, these figures are not as clear cut as they seem due to maintenance overruns, crewing issues, and other real-world complications.

83 Ronald O'Rourke, *Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress* (Congressional Research Service, April 2012).

84 As above, 6.

85 Allan Hawke, *Independent Review of the Potential for Enhanced Cruise Ship Access to Garden Island Sydney* (Department of Defence, 1 February 2012).

86 David J Berteau, Michael J Green, Gregory Kiley, and Nicholas Szechenyi, *US Force Posture Strategy in the Asia Pacific Region: An Independent Assessment* (Washington, DC: Centre for Strategic International Studies, June 2012), 75.

87 Francis Logan, 'AMC welcomes multi-million-dollar submarine facility,' media release (2 May 2008); 'Wavelength,' *ASC News* (Australian Submarine Corporation, Autumn 2012); and Brendon Grylls and Troy Buswell, 'Western Australia's new floating dock a world first,' media release (9 February 2010).

88 Jay Weatherill and Jack Snelling, 'Keeping SA at the forefront of the nation's defence,' media release (1 June 2012).

89 Australian Submarine Corporation Pty Ltd, Annual Report 2011.

90 For example, see Brice Pacey, *Sub Judice: Australia's Future Submarine*, as above, iv.

91 The CAIG (Cost Analysis Improvement Group) within the US Office of the Secretary of Defense publishes guidelines to allow comparison of operating and support data across multiple platforms. The US Navy system is called the Visibility and Management of Operating and Support Costs (VAMOSC).

92 US Department of Defense, Selected Acquisition Report SSN 774 (Defense Acquisition Management Information Retrieval, as at 31 December 2011), 38.

93 According to the x-rates website, the average exchange rate between AUD and USD over 2011 was 1 USD = 0.97 AUD. However, it should be acknowledged that the Australian dollar is trading at a much higher level than its average since floatation, so a more conservative estimate might be 0.75 AUD = 1 USD.

94 US Department of Defense, Selected Acquisition Report SSN 774, as above, 38.

95 CAIG (Cost Analysis Improvement Group), *Operating and Support Cost-Estimating Guidelines* (Office of the US Secretary of Defense, October 2007), 6–10.

96 Brice Pacey, *Sub Judice: Australia's Future Submarine*, as above, vi.

97 See for example Prime Minister, Minister for Defence, and Minister for Defence Materiel, 'Next stage of future submarine project announced, joint media release (3 May 2012).

98 Andrew Davies and Mark Thomson, 'Mind the Gap, Getting Serious About Submarines,' as above, 15; Brice Pacey, *Sub Judice: Australia's Future Submarine*, as above.

99 Senate Standing Committee on Foreign Affairs, Defence and Trade, *Visits to Australia by nuclear powered or armed vessels: contingency planning for the accidental release of ionizing radiation* (Australian Government Publishing Service, 1989).

100 World Nuclear Association, 'Nuclear-Powered Ships' (August 2012).

101 Nuclear Energy Institute, 'U.S Nuclear Power Plants.'

102 Чорнобильська АЕС (SSE Chernobyl NPP), 'Background.'

103 Obtaining verifiable data on reactor operations is an exceedingly difficult task—especially for the current Virginia Class submarines. Consequently, the actual output of the submarine may be higher or lower than is quoted here.

104 Magdi Ragheb, *Nuclear Naval Propulsion, Nuclear Power—Deployment, Operation and Sustainability* (InTechOpen, 2011).

105 An inter-departmental committee, the Visiting Ships Panel (Nuclear), oversees the arrangements for visits to Australian ports by Nuclear Powered Warships. These include the Commonwealth Plan *OPSMAN1* dealing with visits by nuclear-powered warships, and the associated *Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports* and the Department of Defence document, *Environmental Radiation Monitoring During Visits by NPWs to Australian Ports: Requirements, Arrangements and Procedures*.

106 Australian Radiation Protection and Nuclear Safety Agency, 'Nuclear Powered Warships Visit Planning.'

107 Department of Defence, *Visits by Nuclear Powered Warships to Australian Ports, Report on Radiation Monitoring During 2010* (Department of Defence, 2011); Department of Defence, *Visits by Nuclear Powered Warships to Australian Ports, Report on Radiation Monitoring During 2009* (Department of Defence, 2010).

108 This is considered the most serious accident that is likely to occur. In testimony to the 1989 Senate Standing Committee on Foreign Affairs, Defence and Trade review into visits to Australia by nuclear-powered or -armed vessels, ANSTO (Australian Nuclear Science and Technology Organisation) estimated the risk of a contained accident would be 1 in 10,000 reactor hours and the risk of an uncontained accident was 1 in 10,000,000 reactor hours. Given the improvements in reactor technology since then, it is likely that these figures are overly conservative.

109 ARPANSA (Australian Radiation Protection and Nuclear Safety Agency), *The 2000 Reference Accident Used to Assess the Suitability of Australian Ports for Visits by Nuclear Powered Warships* (Regulatory Branch ARPANSA 2000).

110 As above.

111 As noted in endnote 103, these figures are not verified and represent ARPANSA estimates. Also note that to compare power output from the Los Angeles Class and the Virginia Class, MW(t) should be converted to MW(e)—for power output for the Virginia Class, see endnote 104.

112 Australian Radiation Protection and Nuclear Safety Agency, *The 2000 Reference Accident Used to Assess the Suitability of Australian Ports for Visits by Nuclear Powered Warships,* Regulatory Branch ARPANSA (2000).

113 As above.

114 TJ Mueller, FL Lentz, J A Brann, and JW Waldrep, *Occupational Radiation Exposure from U.S. Naval Nuclear Propulsion Plants and Their Support Facilities,* Naval Nuclear Propulsion Program (US Navy, 2011).

115 Naval Nuclear Power Training Command, 'Nuclear Power School.'

116 US Navy, 'Submarine Officer (Nuclear Submarines).'

117 For example, see Commander James Lybrand, an experienced Collins Class submarine commander.

118 Seth Robson, 'Serving Down Under: Australia Offers Military Jobs to US Troops Facing Separation,' *Stars and Stripes* (8 May 2012).

119 Auditor-General, *Management of the Collins-class Operations Sustainment*, Audit Report No. 23 (Canberra: Australian National Audit Office, 2009), 17.

120 Steve Ludlam, 'We should build on our 30-year submarine experience,' *The Australian* (26 January 2012).

121 ANSTO (The Australian Nuclear Science and Technology Organisation), 'About IME.'

122 AINSE (The Australian Institute of Nuclear Science and Engineering), 'Missions and Goals,' www.ainse.edu.

123 ANSTO, 'OPAL: ANSTO's research reactor.'

124 Minister for Defence, transcript of press conference (23 April 2012).

125 White paper, *Defending Australia in the Asia Pacific Century*, as above, 12.

126 For example, see John Kerin, 'Defence cuts a "threat" to US alliance,' as above.

127 See Boeing Australia Integrated Logistics Division, 'C-17 Globemaster III Logistics Support,' and DSCA (Defence Security Cooperation Agency), 'Australia—Sustainment for MH-60R Multi-Mission Helicopters,' media release (2 February 2011).

128 Mark Thomson, *Cost of Defence: ASPI Defence Budget Brief 2012–13* (Canberra: Australian Strategic Policy Institute, May 2012).

129 Andrew Davies and Mark Thomson, 'Mind the Gap, Getting Serious About Submarines,' as above.

130 James Clay Moltz, 'Viewpoint: Closing the NPT Loophole on Exports of Naval Propulsion Reactors,' *The Nonproliferation Review* (Fall 1998).

131 Articles I and II, Treaty on the Non-Proliferation of Nuclear Weapons (1970).

132 Draft for discussion prepared by the International Panel on Fissile Materials, A Fissile Material (Cut-Off) Treaty, article-by-article explanation (5 February 2009).

133 Nuclear Threat Initiative, 'NTI Nuclear Materials Security Index.'

134 Greg Weston, 'Canada may buy nuclear submarines,' CBC News (27 October 2011).

135 Quoted in Nicole Brangwin, 'Australia's Future Submarines,' *Foreign Affairs, Defence and Security* (Parliamentary Library, 24 May 2012)

136 John F Schan, et al., *Learning from Experience: Lessons from Australia's Collins Submarine Program*, Vol. IV (Santa Monica, California: RAND Corporation—National Defense Research Institute, 2011).

137 Derek Woolner, 'Procuring Change: How Kockums was Selected for the Collins Class Submarine,' Research Paper 4 (2001–02) (Canberra: Department of the Parliamentary Library, 18 September 2001).

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