Submission

Submarine Institute of Australia

19/SUB/0913

A SUBMISSION BY THE SUBMARINE INSTITUTE OF AUSTRALIA

TO THE HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON THE ENVIRONMENT AND ENERGY INQUIRY INTO THE PREREQUISITES FOR NUCLEAR ENERGY IN AUSTRALIA

13TH SEP 2019

Issue:	1
Date:	13 Sep 19
Number of Pages:	14

Prepared for:

The House of Representatives Standing Committee On The Environment And Energy: Inquiry Into The Prerequisites For Nuclear Energy In Australia

	Name	Position	
Prepared By: **Approved By:**	David Nicholls Mark Sander	Executive Director President	

Introduction. The Terms of Reference for this inquiry are focused on nuclear power as a potential source of electricity generation, however there may be broader justification for a nuclear industry in Australia. This submission addresses one possible requirement not directly related to electricity generation, being nuclear power for the propulsion system of – and power generation for - future submarines for the Royal Australian Navy (RAN).

Executive Summary

The Submarine Institute of Australia (SIA) recommends the committee notes:

1. Despite slow progress, the SIA fully supports the Australian Government's decision to build a new design of 12 Attack class submarines in Adelaide. The SIA understands that the design and configuration of these submarines will be in 'batches' and hence, subject to change to accommodate technological advances. The Government's Naval Shipbuilding Plan states that the 12 new Attack class submarines are to be the first phase of a rolling acquisition program of submarines, effectively a continuous building program. A rolling acquisition program should give serious consideration to nuclear power as a propulsion option for future submarines.
2. The power source of conventional submarines is inferior to nuclear powered submarines. Nuclear propulsion allows a submarine to proceed at high speed without endurance constraints and frees it from having to expose itself to recharge its batteries. Nuclear propulsion confers critical mobility that allows a submarine to respond quickly (a particular advantage in the short-notice contingencies which are expected to arise in Australia's region) and, with no requirement to expose snorkel masts to charge the battery, this greatly reduces the risk of counter detection of the submarine.
3. Although there are no current government or defence plans to acquire nuclear powered submarines, the SIA is strongly of the view that these will be essential for Australia for our future submarine capability.
4. It would probably take at least 15 years to develop an Australian nuclear industry to an appropriate level, were Australia to decide to acquire nuclear powered submarines.
5. The future submarine technology review foreshadowed in the 2016 Defence White Paper to occur in the late 2020s should be brought forward to the early 2020s – not later than 2023 – to inform government decisions regarding future Australian submarines. This review should include the investigation of the early introduction of nuclear propulsion for a new class of nuclear-powered submarines. The Department of Defence and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) should examine the nuclear safety organisation structures for submarines in the US, UK and France to determine a potential model for Australia.
6. Legislation prohibiting nuclear power in Australia should be overturned.
7. The case for an Australian nuclear industry is stronger if both the potential civil and naval applications of nuclear power are considered.
8. A uranium enrichment facility and a nuclear waste storage facility would support both civil and naval nuclear application.
9. The Government should support the expansion of tertiary education in nuclear science and training in nuclear engineering, via the funding of appropriate university science and engineering faculties.

10. The Government should consider funding one small nuclear power reactor, as close as possible to Australia's Nuclear Science and Technology Organisation (ANSTO), primarily for training purposes, but capable of providing power for the electricity grid.

About the Submarine Institute of Australia (SIA)

The Submarine Institute of Australia (SIA) is the premier southern hemisphere organisation for promotion of informed discussion and research in the fields of submarine operations, engineering, history and commercial sub-sea engineering, otherwise known as submarine matters. The SIA has over 400 members from around the world. The SIA Executive Committee comprises office-bearers and members from many major defence industry companies.

The content of this submission is drawn on the deep knowledge base that the SIA Executive Committee and SIA members have of submarines and submarine matters, both in Australia and on a global basis.

Why are Submarines Important?

To Australia's north lies the South China Sea, part of the relatively newly-termed Indo-Pacific, a region through which around 65% of Australia's exports and imports are carried. It is also an area where multiple nations are jockeying for position in the struggle to exploit the resources that lay beneath it. It is not a coincidence that those nations who hold claims to those areas are also the ones who are contributing to the emergence of the Indo-Pacific as 'home' to more than 50% of the world's submarines.

It is the possession of a credible submarine capability that grants a nation a 'place at the table'. A frigate or fighter jet capability has its merits but, realistically, the only platform capable of independent operation in an area where its own nation does not control the sea or air is a submarine. It is that capability which provides a Government options for strategic consideration, hence it is critical that such a capability is clearly recognised by politicians, defence professionals and all those with an interest in the security of Australia.

This doesn't mean that any submarine operating in such an area is going to be focused on hostile operations. Submarines offer a whole spectrum of strategic options of which they are capable. The presence of a submarine in an area gives the Government a number of choices in how it can influence activities in that area and, in so doing, contribute to an environment through which Australia's trade can freely pass. Such options might be particularly relevant should a further decline in the strategic environment in the region become apparent.

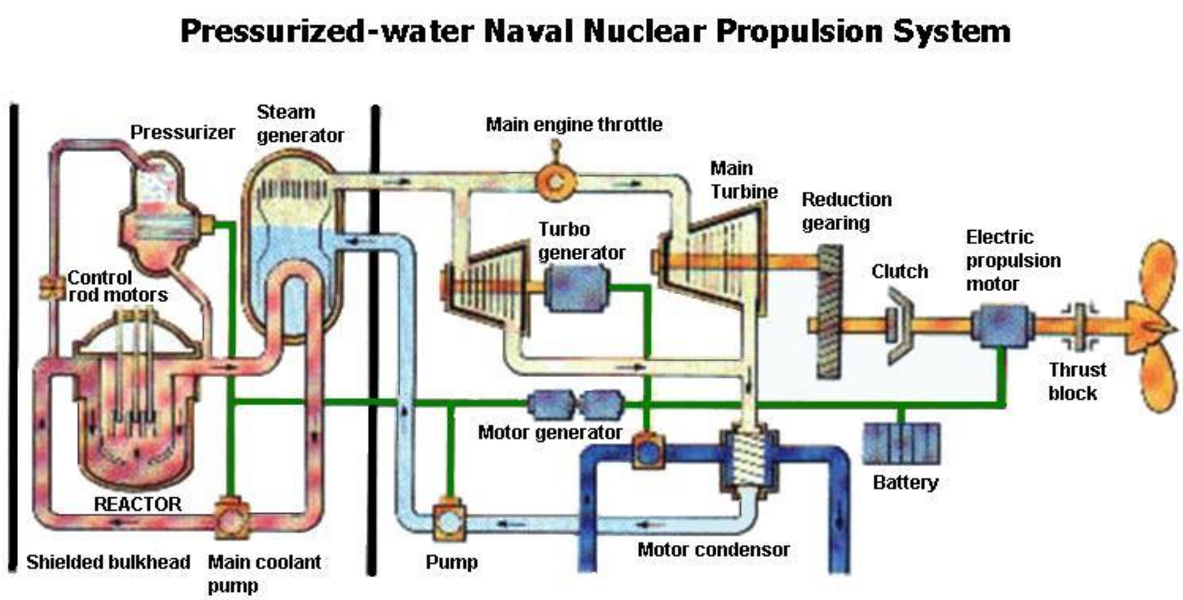
It is a question of geography that imposes long transit times upon Australia's submarines. The speed and endurance offered by nuclear-powered submarines radically reduces the time taken to make those transits and be available in areas of interest in our region.

Advantages of nuclear power in submarines

Nuclear propulsion allows a submarine to proceed at high speed without endurance constraints and frees it from having to expose itself to recharge its batteries. Nuclear propulsion confers impressive mobility that allows a submarine to respond quickly (a particular advantage in the short-notice contingencies which are expected to arise in Australia's region) and, with no requirement to expose snorkel masts to charge the battery, this greatly reduces the risk of counter detection of the submarine. While non-nuclear air independent propulsion technologies, such as fuel cells, are available and being introduced in regional submarines, these are of limited power and endurance, restricting the submarine's mobility when using this energy source and limiting the submarine's range because of the space required for oxygen storage. Non-nuclear, air independent propulsion is generally used while a submarine is loitering in an operating area to reduce the risk of counter detection; it does not improve the submarine's mobility on long transits, or overall endurance, without refueling. It also does not remove the ultimate reliance on the atmosphere to run diesel generators to charge the battery.

Nuclear power should not be confused with nuclear weapons

Nuclear power for submarine propulsion should not be confused with nuclear weapons. The nuclear power discussed in this submission merely generates steam to drive turbines that produce electricity for the motor connected to the propeller shaft or pump jet to propel a submarine through the water. The steam also drives turbo-generators to supply systems other than the main propulsor.



On 2 October 2019, in an attempt to stimulate discussion to better inform future policy decisions, the SIA, in conjunction with the University of NSW, is convening a seminar in Canberra titled '*A Nuclear Industry Future for Australia? Starting the Conversation'*.

Nuclear Power – Civil and Defence Application

As a developed western economy, Australia has traditionally been an early adopter of new and innovative technology. Nuclear power for both civil and defence use is a stand-out exception. On the civil side, 17 of the 20 countries in the G20 and a majority of OECD (Organisation for Economic Co-operation and Development) countries derive some of their electricity power generation from nuclear reactors, but not Australia. There are currently 451 nuclear reactors in power stations around the world, with at least a further 55 planned or under construction. Australia has the world's largest reserves of exploitable uranium, is the third-largest producer of uranium oxide and does not use any of it to generate electricity. Instead, Australia primarily relies on coal (which has associated carbon emissions).

Australia is the only known country in the world with legislation which prohibits the use of nuclear power.

On the defence side, the first nuclear powered warship, the submarine USS Nautilus, was launched in 1954. Several hundred nuclear powered vessels have since been produced, primarily submarines, where nuclear power is a natural fit, allowing submarines to remain submerged almost indefinitely. The US, Russia, China, UK and France all build and operate nuclear powered submarines. India has leased a Russian nuclear powered submarine since the 1980s and is now developing an indigenous nuclear submarine. Brazil and South Korea are developing nuclear powered submarines. Because nuclear powered propulsion for submarines is so superior to power sources for conventional submarines, the US, UK and France do not operate any conventional non-nuclear submarines. The US has not built a conventional submarine since the 1950s.

Australia's submarine fleet

Australia currently operates six ageing Collins class conventional diesel submarines. These are to be replaced by 12 Attack class submarines. Under the current plan, Australia will still be building conventional submarines 100 years after construction commenced on USS NAUTILUS, the first nuclear powered vessel; despite the reality that the power source of conventional submarines is inferior to nuclear powered submarines. However, the SIA recognizes that the design and configuration of the Attack class submarines will be in 'batches' and hence, subject to change. The Government's Naval Shipbuilding Plan states that the 12 new Attack class submarines are to be the first phase of a rolling acquisition program of submarines, effectively a continuous building program. A rolling acquisition program should give serious consideration to nuclear power as a propulsion option for future submarines.

Nuclear propulsion allows a submarine to proceed at high speed without endurance constraints and frees it from having to expose itself to recharge its batteries. Nuclear propulsion confers critical mobility that allows a submarine to respond quickly (a particular advantage in the short-notice contingencies which are expected to arise in

Australia's region) and, with no requirement to expose snorkel masts to charge the battery, this greatly reduces the risk of counter detection of the submarine.

One of the key tenets of the Attack class is that they will be a regionally superior submarine, but there is a significant risk that they will not live up to this potential.

It is frequently argued that Australia has not adopted nuclear power for submarines because it has no civil nuclear power industry. That position has not been substantiated by any serious review of what options would be available for Australia to acquire nuclear powered submarines or exactly what aspects of civil nuclear industry would be essential, if any, for Australia to have nuclear powered submarines. It appears that whenever nuclear power is considered in Australia, the civil need, such as electricity generation, and defence need, such as for submarine propulsion, are considered in isolation, whereas if considered holistically, the case for a nuclear industry is likely to be stronger. The Terms of Reference for the 2015/2016 South Australian Royal Commission into the Nuclear Fuel Cycle explicitly excluded consideration of any defence need for nuclear power.

The 2009 Defence White Paper stated: *"The Government will double the size of the submarine force (12 more capable boats to replace the current fleet of six Collins class submarines)"*. The quantum of future submarines did not vary from 2009 to the 2016 Defence White Paper, however the 2016 policy document called for the new submarines to be, *"….regionally superior submarines with a high degree of interoperability with the United States….".* There is no further qualification as to which countries this 'regionally superior' capability applies.

Where is Australia's region? The 2016 Defence White Paper frequently referred to the Indo-Pacific region and implies that the entirety of that region applies to Australia. For example: *"Our security and prosperity depend on a stable Indo-Pacific region"* and *"In the Indo-Pacific region Australia must continue to work with the United States and regional partners to make a positive contribution to security".* It also stated: *"In order for Australia and other countries to take advantage of the unprecedented economic growth of the Indo-Pacific region and beyond, we must be willing and able to meet the threats to the peace and stability that has underpinned these positive developments".*

In clarifying why Australia needs submarines, the White Paper stated: *"By 2035, around half of the world's submarines will be operating in the Indo-Pacific region where Australia's interests are most engaged. Australia has one of the largest maritime domains in the world and we need the capacity to defend and further our interests from the Pacific to the Indian Oceans and from the areas to our north to the Southern Ocean. Submarines are a powerful instrument for deterring conflict and a potent weapon should conflict occur."*

It is noteworthy that the security time horizon for the White Paper is only out to 2035 and the first of Australia's 12 new conventionally powered Attack class submarines will not enter service until the early 2030s, with the last boat entering service in the early

2050s and remaining in service until about 2080. Although Australia's submarines are conventionally (diesel and battery) powered, the RAN is not without reasonable knowledge of nuclear power. Many former British Royal Navy nuclear-trained submariners transferred to the Australian submarine service. Australian submarines frequently exercise with and against US nuclear submarines and all Australian submarine Commanding Officers are trained in Europe and are assessed when, among other situations, operating against nuclear submarines. As a result of this experience, it is unlikely any current or recent Australian submarine Commanding Officer has any doubt about the superiority of nuclear submarines over conventional submarines of similar vintage.

The limitation on sustained high speed on current and future Australian submarines imposes significant restrictions on the area of operations of conventional submarines. The 2016 Defence White Paper stated: *"The key capabilities of the future submarine will include: anti-submarine warfare; anti-surface warfare; intelligence, surveillance and reconnaissance; and support to special operations".*

Whereas nuclear powered submarines are largely effective anywhere, conventional submarines, to be effective, need to be pre-positioned (after potentially very long transits from Australia) in areas known to offer opportunities to counter the activities of adversaries (a 'focal point'). Invariably, this is a time-consuming operation.

World War II demonstrated that submarines are best used offensively, far from home and adjacent to enemy bases. The Germans, Americans and British all ran highly successful submarine campaigns by adopting an offensive strategy, whereas the large submarine forces of Japan and Russia were effectively wasted with too much time spent on a defensive posture. Any expectation that Australia's new Attack class submarines will be effective in their roles when operating defensively near Australia is unrealistic. They will be most effective operating adjacent to hostile bases or at a focal choke point through which the enemy must pass.

Without some radical discoveries and developments in removing the opacity of the sea, submarines will, for the foreseeable future, continue to hold the upper hand in undersea warfare. The physical characteristics of the water column (in relation to radio frequency (RF)/acoustic communications and constantly changing conditions affecting the acoustic path of active and passive sonar system performance) dictate that submarines hold a significant advantage over other maritime warfare platforms in the covert conduct/ execution of undersea operations. But the power-generating advantages of a nuclear-powered submarine over a conventionally powered submarine, are of an order of magnitude greater.

The following areas are relevant.

Anti-submarine warfare (ASW): When conducting anti-submarine operations, conventional submarines lack the sustained speed necessary to act in direct support, defending a surface force against hostile submarines. They would be most effective operating in the vicinity of an enemy submarine base where their opposition must, by necessity, conduct indiscreet activities for sea trials and training. Once an enemy submarine is clear of its home port focal area and transiting in open ocean, manned or unmanned maritime patrol aircraft are more effective ASW platforms than conventional submarines. Nuclear powered submarines, however, can operate in direct support of an allied surface force to counter enemy nuclear or conventional submarines.

Anti-surface warfare: When conducting anti-surface warfare, conventional submarines lack the sustained speed necessary to pursue enemy surface forces in open ocean. As with anti-submarine warfare, conventional submarines will be effective against surface forces when they are in a confined focal area, whereas nuclear powered submarines are effective in both focal areas and open ocean.

Intelligence, surveillance and reconnaissance (ISR): The advantage of using a submarine for ISR is that it can covertly go where other assets cannot. Control of the maritime air and surface environment is not necessary. As long as the submarines remain undetected, the observed targets are likely to continue the activities that most require intelligence collection and/or monitoring. The activities usually occur in an area near the coast of the country that is the ISR target. In periods of tension, a submarine can covertly conduct ISR without escalating the situation, while simultaneously being in a position to take action if hostilities eventuate. If, however, the presence of the submarine is detected, a conventional submarine is much more vulnerable to counter measures than a nuclear submarine, which has the speed and endurance to rapidly evade and clear away from the area.

Support to special operations: The term ‘Special Operations’ refers to delivering or recovering Special Forces, such as Special Air Service troops, behind enemy lines. If Special Forces are confined in a submarine for a long period of time, they can lose fitness. A critical advantage of nuclear power is that a submarine can transit to and from the target location relatively quickly, thus radically reduce the time on transit and increase the time on task.

The nature of Special Operations is such that they may occur in relatively shallow coastal waters. One of the myths often heard about nuclear powered submarines is that they can’t operate in water depths as shallow as a conventional submarine. It is the size of a submarine, not the type of propulsion that determines the minimum depth of water in which a submarine can operate. Australia’s new Attack class submarines will be of similar dimensions to British and French nuclear submarines and are, therefore, as restrained in shallow water operations as a nuclear submarine of similar size.

Nuclear industry for submarine construction and support

There has been no credible review of what development of civil nuclear industry would be necessary if Australia acquired nuclear powered submarines. Much would depend upon the source of those submarines, particularly whether or not they were to be constructed in Australia. The acquisition/support of nuclear submarines would not be reliant upon an Australian civil nuclear power generation industry. Such an industry could, however, add mass to the overall body of nuclear expertise, with both the defence and the civil sectors gaining collateral benefit from each other.

In the US and UK, civil and defence application of nuclear power capability occurred in parallel, not sequentially.

Assuming that, at some point, Australia would choose to build nuclear powered submarines locally, then some domestic nuclear industry would be desirable. This would include uranium enrichment and refining to the grade necessary for reactor fuel, nuclear fuel processing when replaced or removed from the submarine and the ability to decommission and dismantle nuclear submarines, with long-term storage or the resulting residual nuclear waste. The need to produce fuel for reactors, dispose of life expired reactors and long-term storage of nuclear waste is a requirement that would be common to both naval and civil power station application.

Characteristics of submarine nuclear reactors

The reactors in current nuclear power stations typically generate power in the order of 1000 megawatts. There is now considerable development in progress in several countries regarding Small Modular Reactors (SMR) for electricity generation. SMR are envisioned to generate power from a few megawatts up to 300 megawatts, but on average around 100 megawatts. Currently small nuclear reactors in submarines generate about 100 megawatts and are, therefore, comparable in output to the SMRs. The fuel used in the vast majority of nuclear reactors, including all known submarine reactors, is made of ceramic uranium oxide (UO_2)

The US and UK have a adopted a similar approach to submarine reactors. France has adopted a different approach. The US and UK use fuel containing a higher percentage of uranium 235, that is, uranium enriched to a higher level, than the fuel used in French submarines. The primary reason the US and UK have used the more refined nuclear fuel is that they have evolved their reactor designs so that the fuel core does not need to be replaced throughout the life of the submarine. Their reactors have welded joints and seals, which prior to the current long-life fuel fuels cores, required extremely costly and time consuming nuclear refueling a few times during the life of the submarine.

French submarines, with their less refined uranium fuel, require refueling about once every 10 years. The French submarine reactors have bolted joints and seals, which makes replacing the nuclear fuel core less complex, cheaper and much quicker than the method the Americans and British used prior to full life cores. There appear to be differing benefits to the nuclear technology models used by the western allies: a detailed study of the options would be appropriate for any consideration of nuclear powered submarines for Australia.

Education and training

If nuclear power is adopted for either submarine propulsion or for civil electricity generation, Australia's tertiary education capability will need to establish more suitable schools for training nuclear engineers and scientists, as well as to conduct ongoing nuclear research and development. Currently, only UNSW offers appropriate courses. The case for a greater number of tertiary institutions offering appropriate courses is stronger if nuclear power is adopted for both naval and civil application.

To achieve the best nuclear education and training, a small nuclear power reactor could be established, possibly close to ANSTO, at Lucas Heights, NSW. Only a small reactor would be required, possibly a SMR. While primarily for engineering training and nuclear research and development, it could produce power to be sold into the main electricity grid, thereby offsetting some of the cost of establishing and running the facility.

For many years, the Royal Navy (RN) ran a 'cold' reactor (code named 'Jason') at the Royal Naval College at Greenwich in the heart of London, for the nuclear training of Executive Branch officers, prior to taking up their appointments to nuclear propelled submarines. Specialist degree courses in nuclear engineering are undertaken by RN engineer specialists appointed to nuclear submarines. In the US, all officers volunteering for submarines undertake a degree in nuclear engineering.

Regulatory regime

Nuclear safety in Australia currently falls within the remit of ARPANSA. Were Australia to adopt nuclear power for submarine propulsion, ARPANSA would need to be strengthened and its remit broadened. Additionally, a nuclear safety management organisation would need to be established within the RAN.

Safety organisations would need to be involved in all facets of nuclear power, including construction, auditing training curricula, skills assessments, at-sea emergency procedures and maintenance. The nuclear safety organisation structures of the US, UK and France should all be studied to inform the best model for Australia.

Time scale for nuclear submarines for the RAN

It is too late to consider nuclear power for submarines to replace the existing Collins class submarines. It would likely take at least 15 years and more likely 20-plus years to develop the infrastructure required in Australia to support nuclear submarines. It is a national strategic imperative that Australia proceeds with the conventionally-powered Attack class submarines for now.

The 2016 Defence White Paper foreshadowed a review of future submarine technology to be conducted in the late 2020s. The Government's Naval Shipbuilding Plan stated that the 12 new Attack class submarines are to be the first phase of a rolling acquisition program of submarines, effectively a continuous building program. Given the reasons outlined above, among others, the future technology review should give serious consideration to nuclear power as a propulsion option in the rolling acquisition program for future submarines. To achieve this, ideally the future submarine technology review would be brought forward to occur in the early 2020s, to enable a nuclear industry to commence functioning by the late 2030s.

Recommendations for the circumstances and prerequisites to be considered by government:

a. **Waste management, transport and storage:** Waste management will be a major factor in gaining approval for a nuclear submarine program. The lessons learned from other countries on defueling, decontamination and disposal of radioactive waste from decommissioned submarines must be fully resolved at the start of the program;

b. **Health and safety:** Health and safety of the workforce is essential for a nuclear submarine program and therefore, this must be paramount. This applies to construction, operation and sustainment of the submarines;

c. **Environmental impacts:** The environmental impacts of nuclear submarines are an important consideration that has already been addressed in the procedures that must be followed for visits to Australia by nuclear powered vessels from other navies;

d. **Energy affordability and reliability:** Energy affordability is applicable to nuclear submarines but in a different manner to civil electric power demand. The overall cost of ownership must be considered against the greatly enhanced utility of a nuclear powered submarine. Reliability is an absolute priority as the safety of the submarine and her crew is utterly dependent on this energy;

e. **Economic feasibility:** The construction of submarines is already undertaken in Australia and the acquisition of the reactor section – as a cylindrical section of the pressure hull, approximately 10m long, to be welded into the mid-section of the pressure hull – is already feasible. Major investments will need to be made in shore facilities to support nuclear submarines, such as a gas-tight refuelling enclosures;

f. **Community engagement:** Community engagement is increasing and will be greatly enhanced by full disclosure of all facets of a proposed nuclear propulsion program;

g. **Workforce capability:** The workforce will be an initial challenge for a nuclear power program but will attract many new entrants once the commitment is made to undertake the program;

h. **Security implications:** Security will be mainly determined by the source of the reactor, but is not expected to be any greater than other sensitive technologies adopted for defence materiel; and

i. **National consensus:** There is a growing move for acquisition of nuclear powered submarines and this will continue to increase as the economic feasibility and safety are explained.

Conclusion

By the 2040s, in the Indo-Pacific region the totality of maritime nations will not only have numerical submarine superiority over the US, they may well have closed - and possibly eliminated - many areas of the submarine technology gap. In the 2040s, the power source for Australia's conventional submarines will be become increasingly challenged in sustaining a regional capability advantage. While the SIA fully supports the current plans to develop and build the conventionally-powered Attack class submarines, the SIA concludes that, to maintain 'regional superiority' in submarine capability in the future, Australia will need to consider acquiring nuclear powered submarines.