Parliamentary Inquiry on the Prerequisites for Nuclear Energy in Australia

Submission

by

Submarines for Australia

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EXECUTIVE SUMMARY

This submission to the Parliamentary Inquiry into nuclear energy is made by Submarines for Australia, an entity with a website owned and operated by Gary Johnston, the owner of Jaycar Electronics and a number of other businesses. He has no commercial interest in naval shipbuilding industries.

Since the announcement in April 2016 that the government-owned French company, Naval Group, had been selected as the design partner for Australia's future submarine, Mr Johnston has supported significant research by Insight Economics and other groups into whether or not this decision will provide the RAN with the advanced operational capability that it will require in the future. Over time, a reference group composed of distinguished Australians has developed in support of Mr Johnston, including four retired RAN officers of flag rank with substantial submarine experience.

While the main focus of this submission is on the need for the RAN to acquire nuclear powered submarines, we also consider Australia's position in the nuclear fuel cycle more generally. The two issues are related. Without a much greater development of competencies in nuclear physics and engineering, Australia will not be able to develop the extensive hard and soft infrastructure required to acquire, operate and sustain nuclear submarines, even if this becomes a strategic necessity.

Australia and the nuclear fuel cycle

With the world's largest reserves of economically recoverable uranium, Australia has a strong global position in the nuclear fuel cycle. Yet in terms of production, the uranium mining industry punches below its weight, with new mines having been banned for a lengthy period of time. Two States, NSW and Victoria, still ban uranium mining and Victoria even prohibits exploration for uranium.

In addition, despite Australia's strong reserve position, no further processing of uranium occurs domestically. One view is that because of concerns about how its uranium will be used, rather than exporting yellowcake, over which it can exercise limited control, Australia should instead undertake the leasing of processed nuclear fuel, which when exhausted would be returned to Australia for disposal. Apart from the potential for major economic benefits, this approach would offer significant advantages in terms of being able to be assured that Australian uranium was not been used for weapons production or proliferation.

Australia does have a small nuclear reactor, located in the suburbs of southern Sydney, that is an important producer of essential isotopes used in nuclear medicine – Australia is one of only 11 countries in the world that produce these isotopes. But despite the acceptance of nuclear medicine, nuclear power has been banned in Australia since 1999 as a result of a specific clause in the Howard government's Environment Protection and Biodiversity Conservation Act 1999.

Australia's energy policy is in a mess. It is dominated by ideological positions on the left (the worship of renewable energy as providing a complete and universal solution) and on the right (the glorification of coal). It is extraordinary that a conservative government brought about the legislative prohibition on nuclear power. But if Australia is to develop an energy strategy that is based on cost-effectiveness, reliability and appropriate concern for the environment, ideology will need to be left behind.

In this context, there is an urgent need to develop a plan for how a cost-effective, reliable electricity supply system will be sustained in the future. One major issue is how reliability will be maintained in a world where interruptible power is providing more and more of the overall supply and Australia's ageing fleet of coal-fired generators is approaching retirement. There is no commercial appetite to invest in more coal, while as yet battery technology is far from

being able to offer a cost effective back up in any substantial depth. We believe proponents of small modular reactors (SMRs) should be invited to offer proposals for providing future supplies of base load power. These proposals would need to offer a competitive price as well as safety guarantees and be able to satisfy all the criteria in the EPBC Act apart from the specific ban on nuclear power. The Act should first be amended to remove this clause.

Does the Royal Australian Navy need nuclear powered submarines?

The RAN Submarine Force constitutes the ADF's only substantial power projection capability.

At a cost of $79 billion in terms of future dollars, Defence is working with the French company Naval Group to design the *Attack* class, 12 diesel-electric submarines (SSKs) that will be commissioned between 2035 and the early 2050s and replace the *Collins* class.

The main task of Australian submarines is to undertake anti-submarine warfare (ASW) in wartime and intelligence gathering, surveillance and reconnaissance (ISR) in peacetime. Their main area of operations (AO) is the South China Sea, 3,500 nautical miles from their base in Fremantle. No other conventional submarines around the world undertake 70-day operations of which time half is spent in transit to and from their areas of operations (AOs). When they finally reach their AO, RAN submarines operate in what is globally the most highly contested sub-surface environment, with half the world's submarines forecast to be operating in the Asian region by 2030. With the US now using the term 'new cold war' and China commissioning new ballistic missile submarines to provide a second nuclear strike capability, the operating environment in the South China Sea is becoming increasingly intense.

This will cause some significant problems for Australian conventionally powered submarines.

The first problem is in regard to the submarine capability that the RAN can deploy on station at any time. Currently, with six *Collins* class submarines, even with world best practice levels of availability, the very long transits mean that only one submarine can be on station in the South China Sea for around half of the time. Doubling the size of the force to 12 means that one *Attack* class submarine could be on station all the time, but only after 2050 when all the new submarines have been delivered. One submarine on station is not a substantial force and at a whole of life cost of over $250 billion, including through life sustainment, it is open to question as to whether the rather modest bang justifies the very substantial bucks.

With a fleet of twelve nuclear powered attack submarines (SSNs), on the other hand, their high speed would enable three or four to be deployed on station at any time – a much more powerful force. This constitutes a strong strategic argument for SSNs.

In operational terms, a major problem relates to the RAN submarines' indiscretion ratio, or the proportion of time on an operation that a conventional submarine has to spend 'snorting' near the surface so as to run its diesel generators and re-charge its batteries. When a submarine has to snort, it becomes more liable to be detected and, in wartime at least, attacked. It also loses some of its ability to detect an attacker because its own sonar becomes less effective due to self-noise. Technology is constantly moving forward, making it ever harder for submarines to avoid detection while snorting. It is not only the additional noise of the diesel generators and the radar reflection off the snort mast that will attract attention. Magnetic anomaly detectors and wave anomaly detectors, deployed by aircraft and satellites, are much more effective when a submarine is operating close to the surface.

Again, a nuclear powered submarine does not have the problem of having to snort. Its dived endurance is virtually limitless on an operation. In the highly contested waters of the South China Sea a nuclear submarine is much less likely to be detected than a SSK that needs to snort every few days.

A second operational problem for a SSK relates to its inability to sustain a high speed. If a submarine is detected, the ability to depart the scene at a sustained speed of 30 knots gives

the submarine a much better chance of breaking contact and withdrawing in good order. A high speed also provides a better chance of evading weapons should the submarine be under attack.

For all these reasons, a fleet of nuclear powered submarines would provide the RAN with a more effective submarine capability. In strategic terms it would be able to deploy a much stronger force in its AO 'up threat'. If the role of RAN submarines changed to a more self-reliant strategy of denying access to hostile incursions in the waters to Australia's north, a fleet of SSNs would also be much more effective. Finally, the increased level of survivability provided by a SSN, particularly in a heavily contested operational environment, is of very great importance.

Conclusions

It will not be easy to acquire nuclear powered submarines for the RAN. We would need six new conventional submarines first, as well as six life extended *Collins*, and the number of personnel in the Submarine Force would need to increase by a factor of three. We would need the assistance of the US and other friendly nations. Most importantly from the perspective of this Inquiry, in order to be able to acquire, operate and sustain SSNs, we would need to substantially increase our competencies in nuclear engineering and physics at scale and in depth.

We suggest the Parliamentary Committee consider making recommendations that would be supportive of:

- Amending the EPBC Act 1999 so as to remove the prohibition on nuclear power
- A discussion of how Australia could better leverage off its potentially strong strategic position in the nuclear fuel cycle – this should include an assessment of the proposition that a leasing process for nuclear fuel rods would carry with it both economic benefits and ethical advantages around nuclear safety and proliferation
- Undertaking an in-depth review of future base load options, including nuclear power, for Australia's electricity supply
- A strategic approach to increasing Australia's nuclear science and engineering competencies more generally
- A review of the FSM project to determine whether, on the basis of strategic need, operational effectiveness and survivability, there is a case for acquiring nuclear powered submarines for the RAN.

Foreword

This Submission to the Commonwealth Parliamentary Inquiry into Nuclear Energy is made by *Submarines for Australia*, an entity with a website owned and operated by Gary Johnston, founder and CEO of Jaycar Electronics Pty Ltd.

Over the last three years, Mr Johnston has generously supported significant research by Insight Economics Pty Ltd and others into Australia's future submarine project, SEA 1000. As both a substantial Australian taxpayer and a supporter of the ADF, he is motivated by two overriding considerations:

- The need to acquire a powerful but cost effective submarine capability for the RAN in an acceptable timeframe
- While accepting that all ADF personnel undertake a certain level of personal risk in the course of their duties, to seek to ensure that Submarine Force personnel go into harm's way on platforms that both incorporate the most advanced level of technology that Australia can afford and offer them the highest possible level of survivability in what is often a dangerous operational environment.

Mr Johnston considers that the way in which SEA 1000 is being delivered addresses neither of these criteria in a satisfactory manner.

Mr Johnston is pleased to acknowledge Insight Economics' significant contribution to this submission. He also greatly appreciates the contributions from the members of a reference group that has developed around this project, distinguished Australians with strong relevant expertise and/or experience who have joined the group voluntarily and contributed their time and expertise in the national interest.

For the purposes of this submission, this reference group includes four highly distinguished retired naval officers of flag rank from the Royal Australian Navy (RAN):

- Rear Admiral (Retired) RAN, Peter Briggs AO, former commanding officer of *Oberon* class submarines and CO of the Submarine Force, Director of Submarine Warfare and Head of the Submarine Capability Team
- Rear Admiral (Retired) RAN, Rowan Moffitt AO, former Deputy Chief of Navy, Fleet Commander, Deputy Chief of Joint Operations and Director of SEA 1000
- Commodore (Retired) RAN, Paul Greenfield AM, former Engineering Officer in the Submarine Force, *Collins* Project Director (the two fast-track submarines) and a principal of the Coles Review into *Collins* class sustainment
- Commodore (Retired) RAN, Terence Roach AM, former commanding officer of two *Oberon* class submarines, former Director Submarine Policy and Warfare, Director, Director General Naval Warfare and Director General Maritime Development

All four of these officers consider it desirable that the RAN acquire nuclear-powered submarines as soon as it is practicable to do so. Not only is this very challenging step necessary in terms of the strategic need and operational effectiveness, but also, given an increasingly intensely contested tactical environment for our submarines, in the interests of crew welfare and survivability.

While these experts have been extremely generous in contributing their views and expertise, the responsibility for the material contained in this submission lies with *Submarines for Australia* and Insight Economics Pty Ltd.

1. Introduction

This submission from *Submarines for Australia* is divided into two parts. First we look at the case for repealing the current legislation banning civil nuclear power and at least allowing potential investors in small modular reactors to put a business case to government. But many other experts will no doubt make this case as well as us. This is not a complicated argument to prosecute and, provided we approach the issue from an intellectual rather than an ideological perspective, the case seems difficult to refute.

Secondly, where we believe we can make an important and rather different contribution is in relation to submarine propulsion technologies. Extensive research commissioned by Submarines for Australia, and supported by four retired naval officers of flag rank, has convinced us that the strategic and operational case for the Royal Australian Navy (RAN) acquiring and operating nuclear-powered submarines is compelling. In an increasingly uncertain strategic environment, this could well be an important element in Australia's future national security. In our view, it is important that the Committee understands the merit of this case but also the significant challenges this poses for the Australian community. Apart from repealing the legislative prohibition on nuclear energy, which for a sophisticated developed economy we consider absurd, there are a number of other recommendations that the Committee could make that, if adopted, could mitigate some of these challenges and open the door to the acquisition of much more powerful submarines with the added benefit of greater survivability for the crews.

It is now 65 years since the first nuclear-powered submarine, USS *Nautilus*, was commissioned. That breakthrough technology has changed little through the years. In 2019, it should not be considered in any way to be a new technology. Yet although they are not prohibited under the Nuclear Non-Proliferation Treaty (NPT), nuclear submarines are still operated by only six countries in the world, namely the five permanent members of the United Nations Security Council (US, China, UK, France and Russia) together with India.

Were Australia to acquire nuclear powered attack submarines (SSNs), therefore, we would be joining a fairly exclusive club. All the other members have considerably larger economies than Australia and, in military terms, are great rather than middle powers. These countries all possess nuclear weapons. At present, perhaps none of them with the exception of France (and then only on the basis that the RAN would acquire a French-designed nuclear submarine) would support Australia if the government sought to acquire SSNs.

The important additional point, which could be a focus for this inquiry, is that those six great powers all have significant civil nuclear industries, which provide a strong industrial base for the safe operation and sustainment of nuclear powered submarines. Australia does not. Australia is one of only three countries in the G20 without a nuclear power industry. While this does not make the acquisition of nuclear submarines impossible, it does mean that some important competencies will need to be developed in depth and at scale in Australia before the Navy could acquire, operate and sustain SSNs. This Committee could make an important contribution to the future defence of Australia if its recommendations took full account of this issue.

2. Is there a role for nuclear power in Australia?

The splitting of the atom and associated developments in nuclear science constitute one of the major technological achievements of the twentieth century. Of course, nuclear weapons pose a significant danger, but otherwise nuclear energy has provided significant benefits to the global community. Around 16 per cent of the world's electricity is provided safely, reliably and economically by nuclear power, while nuclear medicine provides an important healthcare resource.

No developed countries other than Australia have imposed a legislative blanket ban on nuclear power. One view is that this was a necessary idealistic gesture to demonstrate a rejection of nuclear weapons. A more rational view is that legislating to ban nuclear weapons is one thing but to reject the peaceful applications of nuclear science is an immature action to take. Indeed, it is akin to banning the internal combustion engine on the grounds that its introduction led to more traffic accidents and deaths.

Ideology in energy policy: a recipe for bad ideas

Australia's energy policy is a mess. We are an energy rich nation that once had very low energy costs by global standards. Now our electricity and gas costs are among the highest in the world. In terms of the impact this is having on the competitiveness of industry, we are shooting ourselves in the foot.

Much of the reason for these sub-optimal outcomes lies in the fact that both sides of the argument in energy policy are dominated by ideologically based views. This is particularly the case in relation to electricity supply. On one side, the government finds it impossible to integrate energy policy with climate policy. There is a view held by some in the Coalition that all that is good in power generation lies in coal. This ignores the fact that the last coal generator, Kogan Creek in Queensland, was commissioned twelve years ago and there is absolutely no commercial appetite in business to invest in new coal generation plant.

On the Green side, ideologues demonise coal and suggest that all that is good in power generation lies in renewable energy, which should provide 100 per cent of our electricity. This fails to recognise that renewables, while their costs are coming down, are highly subsidised and quite unreliable when the wind doesn't blow and the sun doesn't shine. Australia will continue to have a substantial requirement for base load power. At this stage, at least, battery back up for renewables can provide only so much support, while its costs are relatively high.

As energy expert Matthew Warren has said:

> We are, by default, attempting to build a renewables-based grid but we don't have a blueprint for what it will look like when completed, how we plan to get there and how much this will all cost. … But there is nothing else: no policy to ensure there is adequate and flexible storage or peaking capacity to complement the gigawatts of intermediate generation. No scheme for the orderly exit of coal and its timely and complete replacement.[1]

This is sobering but true. The last sentence demonstrates the potential opportunity for this Committee to break through the ideology and make some recommendations that could help to establish the basis for a cost effective, sustainable and reliable electricity network in the future.

Just about the only area in which the various ideologies come together is in their deeply flawed tacit agreement, on the basis of zero evidence, that there is no room for nuclear power in Australia's electricity generation system. The left clearly believes this for ideological reasons, although it is not always clear what they are. Indeed, it was deeply discouraging that the ALP's reaction to the establishment of this inquiry was to produce a juvenile "Gotcha" point – to demand that the government reveal where ten or twelve nuclear power plants would be built. It would be depressing if, as it seems, the Opposition no longer believes in the desirability of evidence-based policy. Yet on the right, no doubt for political reasons, it was the Howard coalition government that introduced the legislative prohibition on nuclear power in the Environment Protection and Biodiversity Conservation Act 1999. Wariness of the politics of the 'N' word in Australia suggests there is a limited political appetite to challenge this position, at least for as long as the cost of nuclear power makes it an unattractive proposition.

[1] Warren, Matthew (2019), "The hollow energy superpower", *Australian Financial Review*, 12 September, page 50.

There are a number of points to be made here.

In instances where new technology gives rise to what economists call negative externalities or spillovers, the policy implication is not that the government should ban the technology, and thereby eliminate any of the benefits it can provide, but rather that it should regulate its use in the best interests of the community. This is how governments managed the introduction of the motor car. This is the solution to living with the nuclear industry provided it can deliver electricity cost-effectively.

If the ban were removed, the government should allow the market to select electricity generation technologies on the basis of their economics, including taking full account of their social costs and benefits including environmental impacts. While the main criteria should be cost and reliability, this does not mean that other issues are not important. As suggested above, the market also needs to take account of externalities (social costs), such as pollution, greenhouse gas emissions and safety. In the case of nuclear power, for example, this might mean that beyond considerations of cost and zero carbon emissions, only technologies with fail-safe systems should be allowed to compete. The designs of the new small modular reactors (SMRs), for example, generally allow for a complete shutdown as soon as any problem arises.

New nuclear plants would need to be regulated for their safety by Australia's nuclear regulator, ARPANSA. The project proponents would also be responsible for the disposal of waste and ultimately the decommissioning of plant and these costs would need to be included in the price charged for the supply of electricity. Failure to do this has given rise to a massive contingent liability in the UK, particularly for Sellafield. Had the decommissioning costs been included in the costs of the power supply from the very beginning, however, this would not have been a problem.

That said, there is no argument to subsidise nuclear energy, just as there is no argument to subsidise renewable energy or coal. The straightforward answer for all generation technologies is to impose an appropriate cost on the externalities, such as carbon emissions, nuclear waste disposal, the decommissioning of generation plant of all descriptions and, where they exist, safety issues. In the future this would allow market forces, appropriately regulated to incorporate the cost [and benefits] of negative [and positive] spillovers, to determine the technologies that in the future provide for the generation of electricity in Australia.

We would not necessarily expect large Gen III or Gen IV nuclear plants to be viable in Australia. Producing up to 2,000 MW, such plants are likely to be too big and too inflexible for Australia's uniquely long and skinny grid system with its substantial and increasing contribution from renewables. Very high capital costs and issues such as the cost of insurance would also cause major difficulties to the extent that large nuclear generators would almost certainly need to be government owned. For example, the projected cost of electricity from the UK's new large-scale nuclear plant (3,260 MWe) being constructed at Hinkley Point looks to be extremely high.

But the possible future contribution from scalable and flexible SMRs, providing between 50 and 700 MW of power, should be very carefully examined as soon as commercial applications are available. Unlike large-scale generation plant, SMRs have a relatively small physical footprint and are not generally water-cooled. Therefore the potential to situate such plants underground in more remote areas and away from water offers great flexibility in terms of location. Given that Australia's only nuclear reactor is situated in the leafy southern Sydney suburb of Lucas Heights and is seemingly well accepted by local residents, this flexibility should minimise concern in the community. SMRs share many characteristics with small nuclear reactors used in naval applications (submarines, aircraft carriers and cruisers). Since

1954, tens of thousands of service personnel have served in these vessels in western navies (primarily the USN) and the safety record has been exemplary.

It is also instructive to recognise that in France, where around 60 per cent of the electricity supply is provided by nuclear power and electricity prices are well below the EU average, local communities have been known to compete with one another to attract investment in a new nuclear power station. For regional Australian communities, a new SMR could be attractive in terms of job creation.

The nuclear fuel cycle more generally

Even if it does not embrace nuclear power, Australia could benefit by understanding that the nuclear industry may very well be at the beginning of an expansion phase globally. By contrast, the government could recognise at least the possibility that the thermal coal industry globally may have already have reached its peak and is likely to decline in the future as nations around the world switch to more sustainable fuels. Major mining companies are running down their coal businesses and banks are increasingly reluctant to finance it. So rather than banging on about the benefits of coal, the government should begin to look at how other industries may start to increase their contribution to exports and compensate for the likely future decline in the thermal coal industry. In this context, Australia has a very strong position in the nuclear fuel cycle even if governments find it politically convenient not to recognise it.

EXHIBIT 1: GLOBAL URANIUM RESOURCES BY COUNTRY (2017)

Country	Tonnes Uranium	% of World Resources
Australia	1,818,300	30
Kazakhstan	842,200	14
Canada	514,400	8
Russia	485,600	8
Namibia	442,100	7
South Africa	322,400	5
China	290,400	5
Niger	280,000	5
Brazil	276,800	5
Uzbekistan	139,200	2
Ukraine	114,100	2
Mongolia	113,500	2
Botswana	73,500	1
Tanzania	58,200	1
USA	47,200	1
Jordan	43,500	1
Other	280,600	4
WORLD TOTAL	6,142,600	100

Source: World Nuclear Association, https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production.aspx

First of all, Australia has a much higher share of the world's uranium resources than coal. Although Australia is the leading exporter of coal, its coal resources account for only 14 per cent of the world's reserves (the US leads the field with 24 per cent of the global total).[2] The latest data on global uranium resources are presented in Exhibit 1 above. The data in Exhibit 1

[2] BP, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-coal.pdf

show that, at 30 per cent of the global aggregate, Australia's share of economically recoverable uranium resources is by far the highest in the world, being over twice as high as the next country, Kazakhstan. Yet in terms of production, Kazakhstan produces the largest share of world supply of uranium from mines (41% of world in 2018), followed by Canada (13%) and Australia (12%).[3] Clearly Australia has not leveraged its very substantial resource position in uranium to nearly the same extent as it has in coal.

For many years, Australia had a policy of not allowing the development of new uranium mines. Uranium mines are still proscribed by State government legislation in NSW and Victoria. There is a great potential here for Australia to lift its game. Although uranium prices are low at present – due mainly to the slow development of new nuclear generation opportunities and the continuing availability of nuclear fuel from secondary sources including warhead reduction – this may well be a winner industry in the future. Yet the government appears to have little interest in it. Ironically, the only courageous decision in this area in recent years was made when the Gillard government agreed to supply uranium to India, which is a non-signatory to the NPT and was therefore contrary to established Australian government policy.

Moving on from mining, the beginning of the nuclear fuel cycle, we also need to look at secondary processing, namely the enrichment of uranium. The further processing of Australian mineral resources in-country has always been an aspiration informing the industry policy both of the Coalition and Labor and an export industry based on unprocessed yellowcake, particularly at current prices, is not particularly attractive. Yet the only real interest in this potential opportunity was displayed by the South Australian Labor government that established a Royal Commission. Without bipartisan support, this aspiration will never be realised.

To be sure, the economics of the nuclear industry worldwide at present suggest that further investment in enrichment plants is not currently commercially attractive. Yet if the International Energy Agency is right and nuclear power is going to make a major contribution globally to decarbonising electricity supply in the future, the outlook for the industry may be much brighter. Surely, if a global investor approached the Australian government with a proposal for enrichment, it should be seriously considered? At present, it is not clear that it would.

There would be strategic benefits for Australia if it processed its uranium into nuclear fuel rods for export. If a leasing scheme were implemented, so that used fuel rods were returned to Australia for disposal with a strict accountability regime, we could be sure that Australia's uranium was used for peaceful purposes agreed by the Australian government and that it would not be used for weapons production and further proliferation. This would provide Australia with far greater control over how its uranium is used than only allowing the export of yellowcake.

Finally, at the end of the nuclear fuel cycle, the issue of nuclear waste disposal has never been seriously discussed at the political level in Australia. At present, around the world, high and low level nuclear waste is stored in above ground repositories, regarded generally as an interim solution. With its ancient rock formations, stable geology and vast remote areas supporting only a very small population, Australia offers the most prospective opportunity globally for permanent underground storage. In 1998-99, the British company Pangea Resources put forward a proposal to build such a repository in remote central Australia. Regardless of the potential substantial economic benefits to the Australian community and with no serious analysis, this was almost instantly dismissed by both sides of politics. The Howard government Industry Minister, Senator Nick Minchin, stated that "the Pangea

[3] World Nuclear Association, https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production.aspx

proposal will go nowhere".[4] And it did. Yet if the leasing approach outlined above for processed fuel were adopted, the disposal of nuclear waste in Australia would constitute an essential element of that policy.

While the economic benefits of waste storage could be enormous, the politics of this issue are clearly difficult. But the ethical arguments are not confined to the naysayers. They include the case for Australia doing its bit for supporting the welfare of the global community when it is best placed to do so and, particularly, when it makes good economic sense. Irrespective of whether or not this should have occurred, the storage of increasing amounts of high-level nuclear waste in some countries in what amounts to little more than reinforced 40-gallon drums constitutes a major health and safety risk to the global community, including Australia. This also constitutes a strong argument for the leasing strategy outlined above. The ethical arguments for this are surely worthy of consideration.

3. Does the RAN need nuclear submarines?

The Royal Australian Navy's Submarine Force constitutes the only significant power projection capability in the Australian Defence Force (ADF). Because of the covert nature of their operations and the power embodied principally in their Mk 48 CBASS torpedoes, they have the potential to conduct asymmetric warfare successfully against a much stronger adversary. Ideally, this offers a strong deterrent effect and can provide Australia with the military capability to punch above our weight. In the event that in the future circumstances dictate that the ADF will need to prioritise self-reliance over coalition operations with the United States, the Submarine Force can also offer a potent asset in support of that strategy.

This deterrent effect is the most important strategic argument for Australia to maintain a submarine capability that is as powerful as we can afford. The weight of this argument has increased markedly in the last few years as the power balance between China and the US in our region has shifted. As Paul Dibb stated recently:

> Above all else, we must recognise that we now face the prospect—for the first time since the Second World War—of a potential major power adversary, with whom we do not share fundamental values, operating in our neighbourhood and capable of threatening us with high intensity conflict. To counter this eventuality, we must develop a stronger defence force capable of denying our approaches to a well-armed adversary."[5]

Both the Rudd and Abbott government briefly considered whether the Future Submarine (FSM) should be nuclear-powered. For whatever reason, both concluded that it should not. The question is whether that issue should be revisited in the light of the greater challenges in the strategic and operational environment for RAN submarines that have emerged over the last decade.

The strategic requirement for RAN submarines

In strategic terms, while the *Collins* class submarines are highly effective SSKs, Australia does not possess a sufficiently powerful submarine force to deter a significant adversary.

Although they are capable in a number of military applications, the main role for RAN submarines is anti-submarine warfare (ASW). The successful interdiction of hostile submarines is most likely around their base; submarines are still extremely difficult to detect in the commons of the open ocean or around their destination, since we do not know where that is. Together with the fact that the main peacetime role of the submarines is intelligence gathering, surveillance and reconnaissance (ISR), the ASW task means that their main area of

[4] *Senate Debates*, 18 October 1999, page 9814.
[5] Dibb, Paul (2018), "Why we need a radically new defence policy", *The Strategist,* https://www.aspistrategist.org.au/why-we-need-a-radically-new-defence-policy/, 29 September.

operations (AO) is in the South China Sea, approximately 3,500 nautical miles from Fleet Base West near Fremantle.

No country other than Australia requires conventionally powered submarines (SSKs) to operate 3,500 NM from base. Yet 70-day operations are standard for RAN submarines, of which about 35 days are accounted for by transits in both directions leaving a maximum of 35 days for patrols in the AO. There are a number of problems with this. First of all, the operations are intense and extremely demanding for crews. Living in a cramped space, never seeing the sky for 70 days, and being out of contact with social media and the Internet in a non-wartime environment can be difficult to accept. At the least, this will make the recruitment and retention of highly skilled personnel more problematic.

But the more important strategic problem is that with the six-boat Submarine Force that the RAN currently deploys, even when availability is consistent with world best practice as it now is, only one submarine can be on station in its AO for around half the time in any year. By doubling the size of the Force to 12 submarines with the new *Attack* class, this will allow one submarine to be operating on station in the South China Sea at any time. But this will not occur until the 2050s, over thirty years from now, when both the strategic situation may be very different from what it is today and there may have been profound and unforseen developments in technology. The length of RAN submarines' transits means that the deployed capability, in terms of time spent on patrol in the AO, is lacking and its deterrent effect must therefore be relatively low.

If the RAN were to acquire twelve nuclear-powered attack submarines (SSNs), the productivity and strategic effectiveness of the Submarine Force would be transformed. With transit times more than halved, three or four submarines could be on station 'up threat' in the South China Sea at any time. A force of that size could provide a significant deterrent, with the potential to create havoc around an adversary's naval bases, not just by attacking hostile submarines but surface ships as well. Also, the deterrent effect of twelve SSNs compared to twelve SSKs would be much greater than is implied by the significantly larger number of submarines deployed on station, because of their greater operational effectiveness.

In the context of the strategic contest between the US and China for hegemony in the Asia-Pacific region, as Hugh White and others have suggested, there is a material possibility that in the next two decades the US may withdraw from the regional contest and focus on sustaining its strategic position globally. If that were the case, Australia may be required to focus on a more self-reliant strategy that would involve, *inter alia*, pursuing an anti-access and area denial (A2/AD) policy in the extensive waters to our north. The *Attack* class would be sub-optimal in this role mainly because of the submarines' limited sustainable speed. In order successfully to pursue high value targets and be able to interdict a seaborne attack on Australia by a fleet that may feint its advance in one direction and then change course to another, a fleet of SSNs would be required because of their much higher speed speed.

From a strategic perspective, therefore, irrespective of whether Australian submarines will operate up threat as part of a coalition involving the US or in a self-reliant, defence of Australia role, there is a need for nuclear-powered submarines in the future. This need is made greater by the more threatening strategic circumstances that Australia now faces. Since the decision on the FSM was announced in April 2016, the strategic contest between the US and China in the Asia-Pacific has become more intense, with the American Vice President referring to a "new cold war". At the same time, Australia's relationship with China has become more strained.

The operational requirement for RAN submarines

There are two factors that significantly restrict the operational effectiveness of Australian SSKs, as well as compromising their survivability.

The first problem is the '**indiscretion ratio'**, or the proportion of time on an operation that a conventional submarine has to spend 'snorting' near the surface so as to run its diesel generators and re-charge its batteries. When a submarine has to snort, it becomes much more liable to be detected and, in wartime at least, attacked. It also loses some of its ability to detect an attacker because its own sonar becomes less effective due to self-noise generation. The much greater noise signature of diesel generators relative to the main motor means that the submarine becomes more exposed to detection from seabed hydrophone sensors and sonar employed by surface ships, other submarines, sonobuoys dropped from maritime patrol aircraft (MPA) and helicopters. The snort mast is also liable to be detected by radar deployed on MPAs, surface ships and helicopters. All these detection technologies have improved significantly in recent years. The same can be said for magnetic anomaly detection, undertaken by MPAs and also satellites, a technology that is far more effective in the ASW role when the submarine is operating close to the surface. Finally, wave anomaly detection is also a contemporary ASW technology deployed by satellites that is becoming more effective, again particularly when a submarine is snorting close to the surface.

Australian submarines exhibit a high indiscretion ratio relative to many other SSKs. This is because of the challenging nature of their operations, which have some unique characteristics compared to the tasks undertaken by other conventional submarines, and partly because of their lack of air-independent propulsion (AIP). Most diesel electric submarines are designed in Europe where operations are short, AOs are close to home and patrols are often undertaken dived throughout, using AIP. They do not undertake operations lasting for longer than about three weeks. In the Asian region, Japanese submarines of the Soryu class generally undertake 14-day patrols, also dived throughout, using AIP or, more recently, energy intense Lithium-Ion batteries.

By contrast, Australian submarines typically spend around the first 17 days of an operation in transit to their AO. They generally average about ten knots on these transits, which is very challenging for a conventional submarine. This high speed also feeds back into the indiscretion ratio, which can be up to 25 per cent while in transit. Although contested transits have not been common, the growing potential for Chinese satellites and MPA to detect Australian submarines in transit and even to track them to their destination cannot be ignored. One tactical scenario is for an adversary's SSN to loiter around the choke points in the Indonesian archipelago that a RAN submarine must transit so as to interdict it before it reaches its AO.

Once they reach their AO in the South China Sea, RAN submarines will be operating in perhaps the most heavily contested, high intensity sub-surface environment in the world. Over half of the world's submarines are projected to be operating in the Asian region by 2030, many of them nuclear-powered. The main contest is being played out by China's PLA Navy (PLAN) and the US Navy in the South China Sea. China's strategy of seeking to enforce A2/AD on and above the surface of the South and East China Seas, with the militarisation of disputed islands and the installation of advanced anti-shipping missile batteries, is now being matched in the sub-surface domain. Only recently, the PLA's capability in ASW was rated as relatively poor. Now ASW capability is an evident priority and apparently is improving rapidly. The Chinese media highlights the construction of an underwater 'Great Wall' aimed at denying access to allied submarines. Seabed sensors are being installed, along the lines of the US SOSUS network. New destroyers and frigates with advanced sonars are joining the fleet at a rapid drumbeat as are helicopters optimised for ASW. One reason for this emphasis on A2/AD in the sub-surface domain is the fact that the PLAN is now deploying ballistic missile submarines (SSBNs) that provide China with a credible second-strike nuclear deterrent. A prime objective will be to protect them against detection by the US Navy.

At the same time, the US Navy is clearly highly competitive in the sub-surface domain, having developed a tried and tested operational approach in the North Atlantic during the Cold War.

It will contest China's A2/AD strategy and, if previous form is any guide, will be particularly focussed on detecting and tracking the PLAN's SSBNs. The US now deploys more than half of its fleet of nuclear submarines in the Asia Pacific and has shifted many of its submarine detection assets to that theatre. All the US Navy's cruisers and destroyers are now being equipped with advanced towed array sonars in the interests of detecting PLAN submarines. Yet with the retirement of older boats, the US Navy is facing an increasing shortage of SSNs just as the intensity of the contest in the South China Sea is increasing. As the Commander of the US Submarine Force has stated, "we also integrate with our … allied Navy undersea forces – including ASW aircraft and ships – that have vital undersea warfare roles".[6]

Australian submarines have the great benefit of access to the advanced and multi-layered American command, control, communications and intelligence (C3I) infrastructure as well as the Integrated Undersea Surveillance System (IUSS). Nevertheless, with operations in the South China Sea becoming increasingly intense, a rapidly developing ASW capability on the part of the PLAN will make life much more difficult for allied submarines, particularly those with limited dived endurance and a significant indiscretion ratio. The weakness of Australian conventional submarines on patrol in the South China Sea – their requirement to snort in a restricted and highly contested battlespace – cannot be countered by the support of the US Navy. When they snort, they are effectively on their own. As a former RAN submarine commanding officer (CO) has stated:

> Dived endurance, the ability to remain submerged without having to expose the submarine by recharging the battery, is a critical (I would say life or death) characteristic of submarines, particularly to meet Australia's requirements to operate in areas where the sea and air space isn't under our control. It improves tactical mobility, effectiveness, flexibility and survivability in both transit and patrol area operations.[7]

It could well be argued that operational conditions in the South China Sea have already reached a level of intensity that make it more challenging to continue to deploy *Collins* class submarines in their principal AO. Without AIP, their indiscretion ratio will have the effect of compromising not only their operational effectiveness but also their survivability in any conflict. Yet, similar problems loom for the *Attack* class, which are intended to supersede the *Collins* class and be deployed between 2035 and the early 2080s. As presently designed, they will have neither AIP nor modern, energy-intense batteries that provide superior dived endurance.

For Australian submarines, the benefits of AIP are regularly debated. A system that can provide dived endurance of perhaps 18 days in tropical waters in an 70-day operation would provide considerable benefits for those 18 days but for the rest of the operation represents a significant dead weight, increasing snorting time in transit and the rest of the patrol. Expert naval opinion suggests that, given the unique nature of RAN operations with SSKs, the net benefits of AIP are unproven, although it is difficult to find a former submarine commanding officer who wouldn't want it. Defence has stated that the Attack class "may" incorporate AIP, but it is not clear it is being included in the initial design.

With a zero indiscretion ratio, clearly SSNs would provide great advantages in these circumstances. Their operational effectiveness would be greater because they would not have to withdraw from the main patrol area so as to find a quiet spot in which to snort for several hours. In addition their survivability would be greater because they would be less liable to detection.

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[6] *Commander's Intent for the United States Submarine Force and Supporting Organisations,* March 2018, https://www.public.navy.mil/subfor/hq/Documents/Commanders%20Intent%20March%202018.pdf, pages 1-2.
[7] Briggs, Peter (2016), "SEA 1000: the importance of dived endurance (part1)", *The Strategist*, 2 March, https://www.aspistrategist.org.au/sea1000-the-importance-of-dived-endurance-part-1/

The second problem with SSKs is their **limited sustainable speed**. Together with unlimited dived endurance on any operation, this is the major advantage enjoyed by a SSN. The first important benefit here would be in regard to transits, with a SSN being able to reach the Submarine Force's far distant AO in less than half the time taken by a SSK and with far less stress. This would raise the Force's productivity – in terms of capability deployed on station – by a factor of perhaps three for a similar sized fleet of submarines. Given Australia's unique operational requirements, the value of this should not be underestimated.

In an offensive role, unlike a SSK, a SSN can chase down high value targets, including aircraft carriers, other nuclear submarines and major surface units at 30 knots for as long as it takes. It can also operate with a surface task force or battle group, albeit appropriately at some distance from it, while SSKs can't keep up. It can deploy to new trouble spots at an exceptionally high speed – as demonstrated by Royal Navy SSNs during the Falklands War.

In more defensive mode, when needing to withdraw from a challenging situation – perhaps being detected in confined waters – a SSN can wind up the speed and have a better chance of breaking contact and escaping than a SSK, which cannot sustain a high speed. A SSN also has a better chance of avoiding counter-detection after it has detected an adversary and has a better chance of evading or outrunning weapons directed towards it.

A fleet of SSNs would constitute a far more powerful force than a similar sized fleet of SSKs. Given Australia's deteriorating strategic circumstances and the long transits to and from our submarines' AOs, there is a clear strategic need for a powerful force of fast submarines, which effectively means a requirement for SSNs. We need to be able to put a greater submarine capability on station for a substantially greater length of time. There is also a strong operational requirement for a submarine that can undertake missions in high intensity tactical environments without having to expose itself to detection by snorting and with the speed not only to be more effective in offensive missions but also with a better ability to disengage when required and withdraw in good order. Finally, the issues around survivability and a reduced risk of attrition are of critical importance. These operational imperatives also point to a requirement for SSNs.

Yet acquiring nuclear-powered submarines will not be easy. Even if we started the process now, it would take between 15 and 20 years to see the first SSN in the water. We would need to acquire a minimum of six new SSKs first to build the Submarine Force up to 12 boats including six life-extended *Collins*. The number of personnel in the Submarine Force would need to grow by a factor of at least three. The recruitment and training task would be prodigious, with all submarine personnel needing to be nuclear qualified to a greater or lesser degree. In addition, the through life support of nuclear submarines in Australia, which would be essential if a sovereign submarine capability was to be sustained, would require a whole new infrastructure designed to ensure nuclear engineering of the highest order supported by world class safety protocols. Australia's engineering capability is often underrated, but very substantial enhancements in the area of nuclear engineering and nuclear science and safety would be required.

Australia's lack of a nuclear industry is sometimes cited as a reason why we cannot acquire nuclear powered submarines. But this can be exaggerated. We do have a nuclear industry, if small and underdeveloped. As we have seen, Australia is a major exporter of uranium. The Australian government owns and operates a small experimental nuclear reactor in the leafy southern Sydney suburb of Lucas Heights. It seems to be well accepted by the local community and is now moving into a new commercial market, namely the production of medical isotopes for domestic and export markets. Australia is one of only 11 countries in the world that produce the isotopes that are vital components of certain medical processes. If there is an ethical argument for employing a nuclear reactor to produce medicines but not to produce electricity its intellectual basis is not immediately clear. In addition, Australia's nuclear regulator ARPANSA is well credentialed and provides a solid base for future growth.

4. Conclusions

Since the Rudd and Abbott governments rejected nuclear propulsion for the FSM in 2008 and 2013 respectively, circumstances have changed at both the strategic and operational level. The case for SSNs has increased substantially. In this context, the 2016 Defence White Paper (page 91) included the following statement:

> As part of the rolling acquisition program, a review based on strategic circumstances at the time, and developments in submarine technology, will be conducted in the late 2020s to consider whether the configuration of the submarines remains suitable or whether consideration of other specifications should commence.

Our interpretation of this statement is that the Turnbull government recognised that in light of a possible future deterioration in Australia's strategic circumstances there may be a need to re-consider whether the RAN required nuclear-powered submarines. But by the end of the 2020s the *Attack* class program will be well under way, at very great cost, and the pathway to acquiring a much more effective submarine will become far more difficult. In any case, we would argue that the foreshadowed deterioration in Australia's strategic circumstances has already occurred, about a decade earlier than forecast, and that the review needs to be held now.

Nevertheless, Australia will need the support of the US and other friendly nations such as Britain and France if we are to acquire SSNs. One of the US Navy's previous concerns has been Australia's lack of a nuclear industry and a general lack of extensive competencies in nuclear science and engineering. The USN is strongly focussed on nuclear safety and spends enormous sums of money on supporting it. The fact of Australia's legislative ban on nuclear energy may also have suggested that we are not a serious player. If we are to acquire nuclear powered submarines, as our strategic circumstances dictate, Australia will need to seriously lift its game in these very challenging disciplines.

We suggest the Parliamentary Committee consider making recommendations that would be supportive of:

- Amending the EPBC Act 1999 so as to remove the prohibition on nuclear power
- A discussion of how Australia could better leverage off its potentially strong strategic position in the nuclear fuel cycle – this should include an assessment of the proposition that a leasing process for nuclear fuel rods would carry with it both economic benefits and ethical advantages around nuclear safety and proliferation
- Undertaking an in-depth review of future base load options, including nuclear power, for Australia's electricity supply
- A strategic approach to increasing Australia's nuclear science and engineering competencies more generally
- A review of the FSM project to determine whether, on the basis of strategic need, operational effectiveness and survivability, there is a case for acquiring nuclear powered submarines for the RAN.