NUCLEAR-POWERED SUBMARINES FOR AUSTRALIA
November 2010

Three members of the Navy League of Australia, retired Rear Admirals Andrew Robertson, David Holthouse and Chris Wood (ex RN), gave a presentation in late November 2010 on the above subject to the Nuclear Panel of Engineers Australia (NSW Branch). They emphasised that in no way did they represent Defence or Navy views, but spoke as concerned citizens from their own experiences. They acknowledged that they were long retired and not up-to-date in technical advances but would address principles and information already available in the public domain.

The main address was given by Rear Admiral Wood, a former commander of British submarines including the nuclear-powered attack boat HMS WARSPITE. He outlined, with many interesting slides, submarine developments since World War 2, including the six RAN OBERON class boats, showing:

- first, that until the end of the Second World War and for many years thereafter, submarines like these were powered by diesel-electric propulsion systems which were reliable and effective, but which were nevertheless limited operationally in terms of their range, speed, self-protection and counter-detectability by an enemy. Their primary tasks had been the destruction of enemy naval and merchant shipping carrying fuel, food, vital raw materials, troop reinforcements and armaments, all of it essential to any enemy's war effort;

- second, that the RAN of today is capable of operating modern submarines with panache, skill and technical ability. For all their current difficulties, the COLLINS Class submarines are at the peak of conventional submarine technical and operational achievement and the people who crew them are similarly endowed. If the necessary national investment in schooling, support and commercial cross-fertilisation to achieve adequate trained manpower was in place, the RAN's transition to nuclear-powered variants would in his view be perfectly feasible.

Rear Admiral Wood then outlined developments during the cold war with land and sea-based nuclear deterrents and nuclear propulsion being introduced.

The submarine's prime tasks now became surveillance and intelligence-gathering so as to enable threat assessment of the potential opposition, and ultimately to prepare for the destruction of its surface warships and submarines. In the latter case, the most effective counter to a modern, fast, stealthy and deep-diving opponent is another submarine which is capable of detecting, stalking and attacking from deep – and they need to be nuclear powered to be able to do that.

The first allied nuclear-powered submarine, USS NAUTILUS, was commissioned in 1954 and with her later Westinghouse S5W PWR (pressurised water reactor) she had a range of 158,000 nautical miles!

USS *Nautilus* (US Dept of Defense)

Here at last, with its high speed and virtually unlimited submerged endurance, was the first true submarine. She had been developed by the Naval Reactors Branch of the US Atomic Energy Commission under the, then, Captain Hyman G Rickover whose fame and influence were to become legendary.

USS NAUTILUS went on to break all existing endurance and speed records and, in 1958, became the first vessel to reach the geographic North Pole en route to the UK, and in due course she went on to travel over 1800 nm under the ice – a major achievement, given the future importance of the Polar region for strategic ballistic missile submarine operations.

She also created the need for engineers and shipbuilders to adopt greatly improved quality control programmes for future design and construction – engineering disciplines which subsequently influenced and benefited marine shipbuilding standards across the board.

Later in 1960, the USS TRITON circumnavigated the world without once breaking surface, in a 3 month deployment. It was an astonishing achievement by any standard and one which initiated a full scale programme of building and improvement thereafter.

HMS *Dreadnought* (RN S/M Museum 1963)

The first British nuclear-powered submarine, built with much co-operation from the US, was HMS DREADNOUGHT which commissioned in 1963. In most respects she was a direct copy of the US Navy's new SKIPJACK Class of attack submarine (or SSN) and was fitted with an advanced 2nd generation Westinghouse S5W PWR and a complete set of propulsion machinery driving through ahead and astern turbines to a single propeller.

Buying American enabled Britain to get her first nuclear to sea 3 years earlier than had been anticipated and importantly led to successful completion of a British shore-based prototype propulsion plant.

In addition to mastering the nuclear plant itself, new pressure-hull welding techniques to guarantee watertight integrity of the reactor compartment had to be learned, together with those for ventilation, air-conditioning, air purification, and waste disposal. A constant supply of pure air had to be provided by electrolysers extracting oxygen from seawater. High voltage precipitators were needed to keep dust out of the submarine's atmosphere which had itself also to be closely and continuously monitored for any radiation content. Other units were needed to remove CO2 from the air. The learning curve was steep.

HMS DREADNOUGHT's distinctive whale-shaped hull gave reduced drag and emphasised speed rather than stealth in those early days. She was actually quite small – at 3000 tons, only a third bigger than contemporary diesel boats – but with a larger complement of 113 men.

One major impact of her introduction was the need for comprehensively re-organised recruitment, training and re-training necessary to prepare the crews and shore bases for the operation and support of these revolutionary new boats. Furthermore the unique qualities of life onboard required personnel of proven ability and leadership, capable of operating for long periods underwater.

The RN's second SSN, HMS VALIANT, had a British front half and part-British rear end. The third, HMS WARSPITE, was the first all-British nuclear submarine from one end to the other, and constructed with the first Rolls-Royce PWR1 reactor.

She was followed by a succession of evermore sophisticated and costly, but increasingly effective, hulls – initially an interim class of three CHURCHILL Class, followed from 1973 onwards by the first of 14 larger and greatly improved and deeper diving SSNs of the SWIFTSURE and TRAFALGAR classes which bore the brunt of Cold War operations.

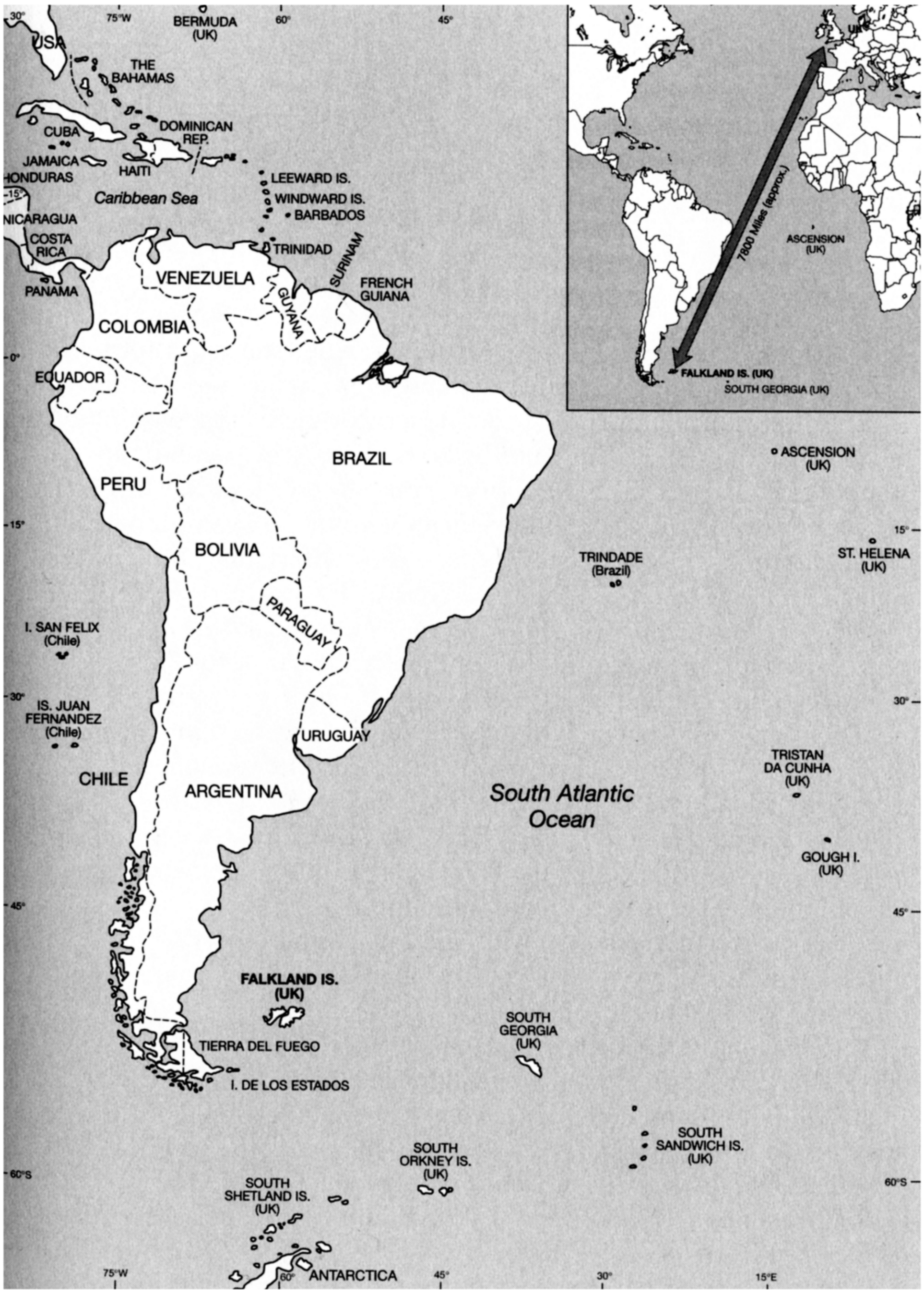
These boats would typically submerge as soon as they left their home base and, if necessary, remain dived for the duration of their operational patrol until surfacing outside that home base once again. Crews might go for weeks without seeing daylight or having any contact with the outside world. Most onboard would not have the slightest idea of their whereabouts, the time zone they were in, or even whether it was day or night.

Two or three month, and even longer, dived patrols were perfectly feasible so aspects of crew welfare became a priority in both selection and training. From early American experience, and as repeated in Britain, it was evident that prospective crews needed careful screening for temperament, intelligence and stamina, as well as operational competence. Social misfits in particular could not be countenanced and were rejected.

This, then, was the scene for the 30 years of Cold War operations during which, in close co-operation with our American allies, surveillance patrols were conducted against Soviet surface and underwater activity in the far reaches of the North Atlantic and elsewhere (including under the Arctic ice) so as to constantly monitor and assess the maritime threat.

Professionally they were valuable years which provided challenging technological and operational experience for crews, planners and analysts alike - but perhaps above all it was this eyeball to eyeball confrontation that confirmed the need for high sustainable power and lengthy dived endurance together with increasing stealth and reduced vulnerability to counter detection by an opponent, which defined the classic attributes offered by nuclear power.

Admiral Wood then went on to outline the British submarine involvement in the Falklands Campaign in 1982 which, until only a few years ago, had been kept under security wraps. He pointed out some significant problems which had to be faced, including:



Falklands **(Official History of the Falklands Campaign – Freedman 2007)**

- The 8000 miles separation between the UK and Port Stanley.
- The surface warship refuelling problem down to the South Atlantic, requiring the pre-placement of 40+ commercial tankers taken up from trade to act as petrol stations along the route.
- Ascension Island, the nominated Forward Logistics Support Base, was itself over 3000 miles from the Falkland Islands.
- South Georgia, where things started, was also a long way from the Falklands.
- And finally, the worrying proximity of Argentinian shore-based air cover and aircraft equipped with anti-ship weapons sitting only a few hundred miles away on the mainland.

Six UK submarines, five of which were SSNs, were deployed in late March 1982, well before the developing crisis was generally acknowledged and broadcast to the British Nation. Two of these were of the fairly new SWIFTSURE Class (SPARTAN and SPLENDID), 2 middle-aged (CONQUEROR and COURAGEOUS), and an elderly SSN (HMS VALIANT).

In addition, one modern conventionally-powered diesel-electric submarine, HMS ONYX, was deployed for specialist shallow water and inshore operations.

Two of the nuclear boats were on station on surveillance patrol off Port Stanley and the Falklands Sound within a matter of days –and well before the Naval Commander in Chief in Britain needed to establish an Exclusion Zone around the islands.

The CinC's difficult task was to deliver an initial assault of about 7000 troops onto hostile shores 8000 miles away with only minimal air cover, and in increasingly foul weather. His only forward logistics support base was at distant Ascension Island.

For air cover, at least at the start, the only fixed wing aircraft capable of air defence and direct support of landing operations were the handful of Sea Harriers embarked in the two carriers HERMES and INVINCIBLE – whereas the Argentineans could deploy an airforce of considerable strength from safe shore bases on the mainland, and also from their own aircraft carrier the VIENTICINCO DE MAYO.

From the start, intelligence sources suggested that much of the Argentine fleet was at sea in the vicinity of South Georgia whilst other heavy units posed a direct threat to the Falklands from the west. But nothing was known of the whereabouts of their two small modern German-designed and very capable conventional submarines.

Early priority was given to establishing clandestine eyes and ears throughout the area, plus secure communications to and from UK and within Task Force ships, so the speedy SSNs became an obvious first choice for deploying those capabilities.

Emphasis upon their non-detectability and covertness was paramount and strictly maintained until circumstances in early May led to the incident which left the Argentines in no doubt whatsoever about the seriousness and determination of the UK response – namely the sinking of the elderly Argentine cruiser GENERAL BELGRANO.

HMS *Conqueror* **(RN S/M Museum 1983)**

CONQUEROR's attack on the GENERAL BELGRANO south of the Falklands was the first and only revelation of the presence of any of the British submarines, nuclear or otherwise, but it was not a demonstration to frighten off the opposition.

It resulted from the Battle Group Commander's assessment that his ships, and his 2 crucially important carriers in particular, were in jeopardy from threat of an Argentine Navy pincer movement by the aircraft-carrier DE MAYO Group on one edge of the declared Exclusion Zone and the BELGRANO Group on the other – with a further big question mark concerning their small, fast submarines which remained undetected and therefore a permanent threat.

The Battle Group Commander, Admiral Sandy Woodward's naval and military conviction was "Lose INVINCIBLE and the operation is severely jeopardised, lose HERMES and the operation is over".

Either way the tactical importance of the BELGRANO sinking was that it nipped in the bud any co-ordinated attack on the UK Battle Group, whilst the longer term strategic benefit was the withdrawal of all Argentine surface units to their home bases – never to emerge again for the duration of the conflict.

It was a significant military necessity clouded only by the failure to find and sink the aircraft carrier 25 DE MAYO instead. Her destruction would have removed many dangerous aircraft from the Argentine order of battle because later her brave pilots, operating from mainland bases, were to inflict heavy losses upon the British ships in the Falklands San Carlos amphibious landing area.

Separately from CONQUEROR, all the other four SSNs were employed covertly during the entire campaign. Their wide area surveillance and close contact monitoring ensured enforcement of the UK Exclusion Zone – and this was important because it not only established clear boundaries in fighting terms but it also created scope for further possible diplomatic options with continuing discussions at high level.

Next in importance came their constant tasks of locating, reporting and reconnaissance which revealed amongst other things, minelaying off Port Stanley (which was immediately surveyed and reported) and further attempted activity off South Georgia where the Argentineans were trying to decoy our forces off to the south east.

An obvious SSN role was to patrol and sanitise the entire sea area around the Falklands so as to protect and clear the way for the eventual British amphibious approach.

Another new role was the close inshore visual and electronic spotting identification and reporting of enemy aircraft as they took off from mainland airfields en route for the Islands. This early warning enabled the Landing Force to shorten its readiness time, prepare its defences and significantly reduce the potential for surprise attack.

The invisible presence of the British submarines (only ever guessed at by the Argentineans, and wrongly as it turned out because they assessed twice as many submarines were out there) – coupled with their later-revealed disbelief that the British would actually use such expensive assets as nuclears – meant that the deterrence effect worked successfully in two quite different but equally effective ways.

Coming to the present day, the British Defence Review in November 2010 indicated that all the remaining TRAFALGAR Class SSNs will now be withdrawn from service. In their place the ordering of six (or maybe 7) of the very latest ASTUTE Class SSNs is confirmed. The first batch of these large submarines is estimated to cost £3.6bn – (ie £1.2bn – about A$2bn per copy).

The ASTUTE Class has a dived displacement of over 8000 tonnes, length over 100m, a 50% greater weapon load than any previous SSN, a crew of only 98 (compared with TRAFALGAR's 118) and the latest Rolls Royce PWR2 reactor which is designed to last for the full 25 year life of the submarine and thus obviate the need for any lengthy and expensive refuelling refits. Add to that a weapons and communications suite to surpass any other currently at sea, and she becomes the ultimate nuclear submarine for the Royal Navy.

HMS *Astute* and HMS *Dauntless* **(RN S/M Museum 2010)**

Following Admiral Wood's outline of some operational experiences with British nuclear-powered submarines in the Cold War and the Falklands War, Admiral Robertson gave his view of an Australian perspective in the case of a major war involving Australia.

He argued that of all world countries few would benefit more, in terms of national defence, from the possession of such submarines than would Australia. This was due to a number of factors – primarily our maritime geographical position, our vast distances and the fact that we are a democracy, slow to see a threat developing, and slow to react. So speed of deployment would be of considerable importance.

Any major threat to the survival of our nation itself must come from a powerful maritime nation, for armies cannot walk upon water and need huge support, particularly when deployed over great distances.

Arguably, noting our large island continent and small population, the best deterrent and defence capability we could possess would be an offensive capability which could be deployed indefinitely near an enemy's homeland. This would divert huge enemy resources into his local defence. The destruction of his shipping would have a major effect on any enemy's economy. Attack by submarines using accurate long-range weapons, such as the American Tomahawk, would pose a great threat to an enemy's centres of production, transport, command and Government, as was so vividly displayed on our TVs in the early stages of the Iraq War.

There seems a strong case that the most effective deterrent Australia could have would be some nuclear powered submarines armed with the latest conventional weapons, noting:

- Nuclear submarines can get to their operational areas submerged and stealthy in about one third of the time required by conventionally-powered boats.
- They can stay longer in the operational area than can conventional boats due to their high transit speed and endurance, limited only by food and crew fatigue. They can search out electronically vast areas of ocean, pursue, hunt and intercept targets much more effectively than can conventional boats.
- Operational areas can be changed swiftly.
- Refuelling would not be needed for the whole life of the latest boats, and there would be no call on maybe scarce oil supplies.
- They have almost unlimited power for propulsion and electricity generation.
- They can help in the escort of convoys and naval Task Forces (conventional submarines can't, due to lack of endurance at speed).
- Due to their stealth and speed, nuclear boats are probably more survivable.
- Australia having its own nuclear powered boats would greatly assist in the training of our own anti-submarine forces.

And the disadvantages?

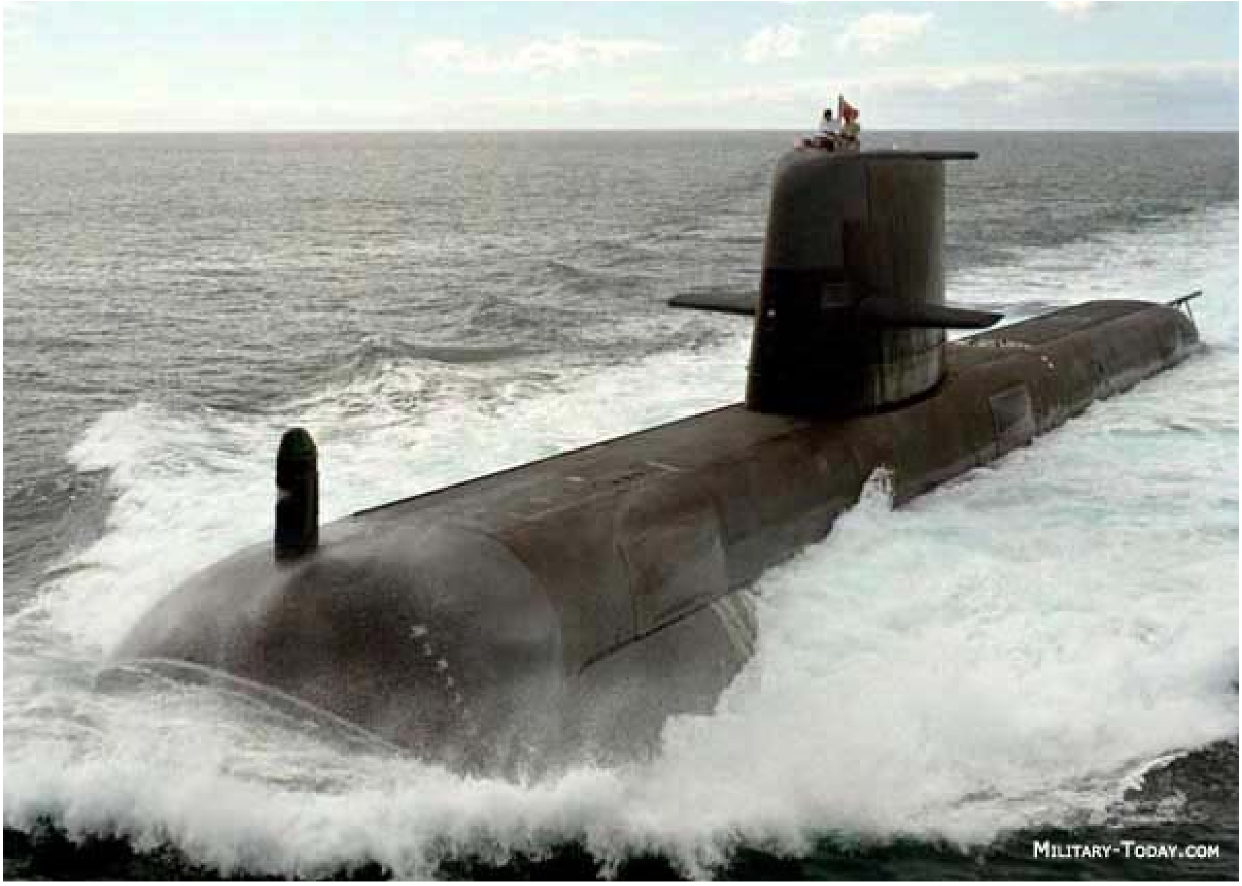
- Larger and more skilled crews would be required (offset by the probability that fewer boats would be needed).
- Major training and considerable infrastructure would be needed (offset somewhat by the extra required for the projected future large conventional boats).
- Probable limitations in peacetime flag-showing cruises due to reluctance by some other countries to receive such visits.
- Depending on size and design, in some situations in shallow water small conventional submarines may be more effective than large nuclear-powered vessels.

Admiral Holthouse, a naval engineer of over 40 years experience, trained in Britain in the mid 1960s at UKAEA Harwell, Winfrith Heath and Dounreay and at the Birmingham College of Advanced Technology. This was an indication of the RAN's vision for nuclear propulsion all those years ago.

He outlined further aspects of submarines emphasising that his nuclear expertise as a naval engineer was limited and much out of date. He stated that virtually the only work he did in the field after completion of his nuclear studies was to assess the likely fall-out from a hypothetical maximum credible accident occurring in a visiting nuclear powered warship in Sydney Harbour.

Interestingly, subject to selecting the right berth for the ship, the risk to the community was judged to be manageable.

The current COLLINS Class submarines, built in Australia, are as big as the French RUBIS class nuclear attack submarines. Despite some much-publicised early problems the COLLINS Class are a fine achievement, one in which Australia should take pride, and he considered that they make perhaps the most important contribution to Australia's order of battle.



RAN *Collins* class

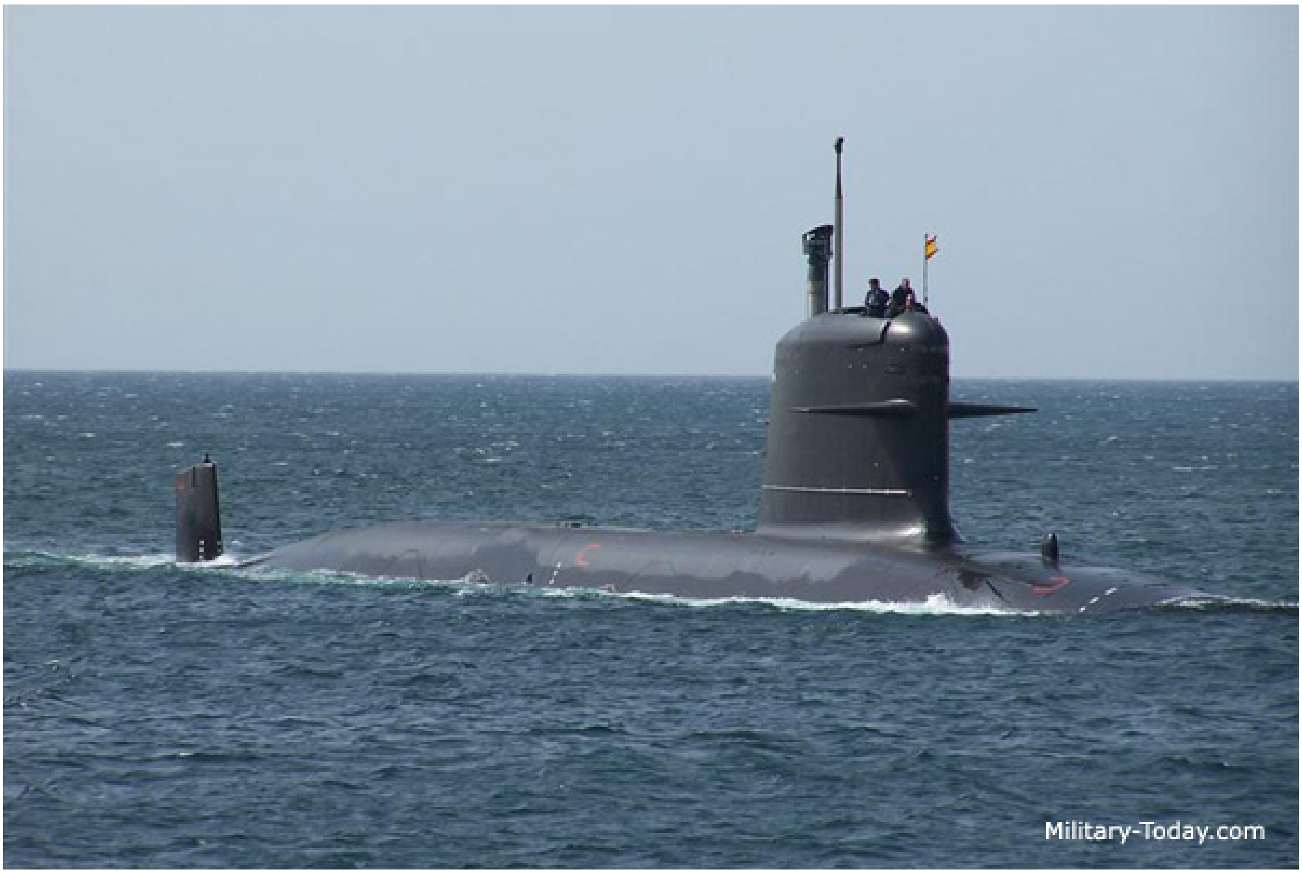
The announced eventual 12 replacements for the COLLINS Class, which will be very big boats, are the most significant element of the Rudd Government's Defence White Paper.

The size of these projected submarines is of importance not only because of the extra range, endurance, speed and payload that flow from size, but also, unfortunately, because Australia has nowhere to turn to but itself for expertise in designing and building such a large conventionally powered submarine. The US and the UK have no conventional submarines. Several European nations have them but they are too small to be extrapolated safely and economically.

The new submarine program has a high priority in the White Paper and enjoys bipartisan support. But it is a long way off, perhaps 10 years before the first steel is cut and 6 years more before commissioning the first boat. The twelfth boat is probably 25 years beyond that, putting the last of them in the water in 2045.

As warships are complex and take a long time to build the usual practice is to build them in flights, taking advantage of technological and strategic developments over time. The last flight is therefore likely to be very different from the first in terms of capability, weapons fit, even mission; and of course propulsion.

So if we start conventional, can we finish nuclear? Anything is possible: after all the French SCORPENE class is a conventionally powered design which it is rumoured may be redesigned for Brazil as a nuclear powered variant. The French offered Australia a conventional variant of the nuclear powered RUBIS class as a COLLINS class option.

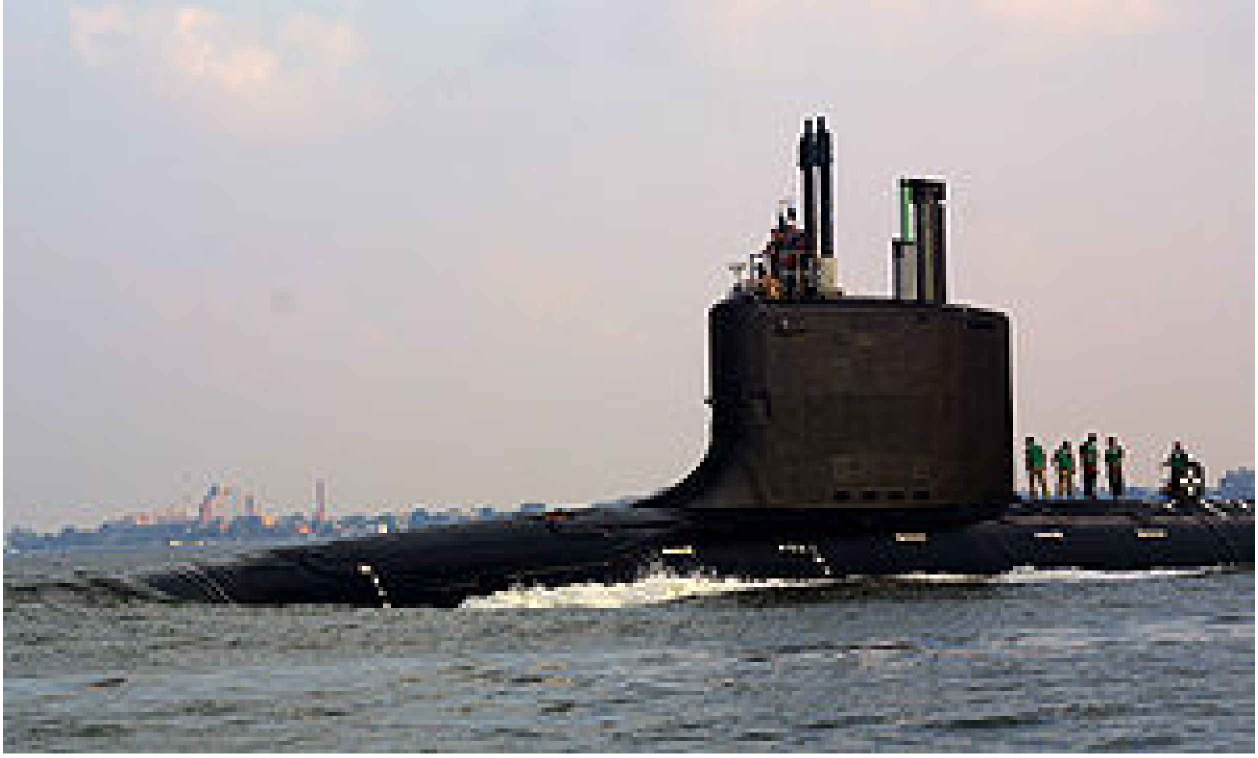


***Scorpene C* lass**

So it is possible but there has to be a will within government and there is presently none. Worse, in his view, is that there is simply no debate on the subject. One wouldn't expect Defence/Navy to take a different line from government about this but Admiral Holthouse expressed disappointment that the retired submarine community has apparently chosen to fall into line, too.

The publicly available reasoning for this stance includes:

Cost, covering both acquisition and through life costs. The generally accepted wisdom is that a nuclear submarine might cost between 1.5 and 2 times the cost of a conventional submarine and it is public knowledge that a USN VIRGINIA class attack submarine costs about US$2b in 2005 dollars.



USS *Virginia* (Wikipedia)

Source. Only a handful of navies presently have nuclear submarines: US, UK, France, Russia, China, India, and perhaps Brazil and Argentina on the way. For our own practical purposes though, only the US, UK and France are relevant as potential sources. The USN and RN share information and technology, and in the past, access to the RN's nuclear submarine world was controlled by the US. Admiral Holthouse postulated that the RN's privileged access to USN technology might possibly be compromised were the RN to set itself up as a source of submarine nuclear propulsion technology independent from the US. Which would leave the USN and the French.

Admiral Holthouse had a largely unrestricted tour of USS NAUTILUS including the propulsion plant, during a visit to Pearl Harbour in 1958 but it was to be almost 30 years before he was able to look around another USN nuclear submarine, in Seattle in 1986 during an official visit to the USN by our own Chief of Navy.

He opined that times have changed and that the USN would not reject an overture from us out of hand today, were we to determine to source nuclear submarines from them next time around. He felt they would be very discouraging about the difficulties and cost of doing so and that for a range of reasons they would prefer us not to, but he did not think we would be rejected.

One difficulty would be that US submarines are very big. Our COLLINS Class boats displace about 3000 tonnes and the planned conventional replacements might displace about 5000 tonnes, as compared to the US nuclear-powered VIRGINIA class of around 8000 tonnes and the SEAWOLF Class of over 9000 tonnes.

Seawolf Class

He considered that going elsewhere, to the French for example, was likely to be problematic. The USN might be concerned for permeability believing that an extended “family” including themselves, ourselves, the French and France’s other international customers would introduce just too many potential leakage paths for closely held information to be safe.

Industry infrastructure. Admiral Holthouse felt that the proposition that the Navy’s ability to own and operate nuclear submarines was governed by the availability of domestic nuclear infrastructure was often overstated. There were ways this perceived problem could be overcome.

During the RAN’s service with the US 7th Fleet in the Vietnam War, he had observed with amazement how reliant upon fly-in-fly-out commercial technical representatives the USN had become. The RAN does the same today and it works. 250,000 tonne merchant ships traverse the oceans with unmanned engine rooms and 18 souls on board, hooked up by radio link to monitoring stations ashore and the certainty of a technical response team meeting the ship at her next port of call in the event of a transducer somewhere in the system warning of an incipient problem.

He felt that were we to decide now that the next generation of submarine would be nuclear, entering service in 10 or 15 years’ time, we could handle it safely through a combination of immensely long refuelling cycles (minimum 20 years), return-to-builder for depot-level reactor and perhaps all primary circuit maintenance, and fly-in-fly-out technical representatives. The real issue for us would be whether the submarines would be alone in an otherwise still nuclear-free Australia or would the decision to acquire them provide the catalyst for other elements of a nuclear industry to emerge including ground-to-ground fuel cycling, nuclear waste processing and storage and even power generation in an era when fossil fuels are drying up and otherwise on the nose, and renewables are still an expensive luxury. He referred to the sometimes disputed Peak Oil element in the equation and made an interesting observation about how nuclear reactors in some commercial applications, for example as a power source in remote settlements and mining operations, are down-sizing. This opened up, he felt, the prospect of commonality between reactors for naval propulsion and civilian power generation.

National will. Conventional wisdom is that the Navy can do nothing about nuclear propulsion unless and until there is a domestic nuclear power industry to support it and that's a lot more than 10 years away. In his view it is a matter of how best to gain traction in a society which has become more willing than ever before to entertain the possibility of nuclear energy as a power source, since Prime Minister Howard floated it as a legitimate topic for discussion and since the community became more conscious of global warming and climate change.

What is needed is a champion, just as the then Defence Minister Kim Beasley was a champion for domestic building for the COLLINS class; and it may be easier to find a champion for nuclear propulsion for submarines than for a nuclear power generation industry ashore, in a timescale to suit the new submarine delivery.

The need is for a champion for nuclear propulsion this time, not for domestic building, which raises an interesting issue. Informed commentators have said that to build and support the new (conventionally powered) submarines would require a permanent workforce of 5000 and the involvement of 1000 Australian companies across the nation competing with the mining industry for critical engineering capacity and human resources. An overseas build would reduce the pressure on local industry and resources. However with a working population in excess of 12 million he felt that it has to be possible for Australia to find 5000 people for a submarine building industry, and the prospect of continuous work for decades.

Admiral Holthouse then summarised his views. The presently planned conventional replacements for the COLLINS class will still be with us in the 2070s, by which time, surely, concerns for the availability of fossil fuels and their impact on global warming will have bitten hard.

If we are to design and build conventional replacements ourselves we may be faced with capacity problems. Were we to opt for nuclear propulsion and an offshore build these problems could be substantially reduced.

Nuclear powered submarines are steam ships. Towards the end of the steam era in the RAN its three remaining (high end) steam plants became orphans. There was no longer a steam nursery in which to train the operators and offshore training became the order of the day. We could obviously do it again.

The Government closed down any conventional versus nuclear debate by plumping for conventional from the outset. It did so pretty much because it believed the nuclear option to be unacceptable to the general public and that, anyway, Australia would need an established power generation industry and associated infrastructure to support nuclear powered and conventionally armed submarines.

Yet Australia mines uranium and sends it overseas, in the process dividing public opinion over the underlying moral principles. Some fresh impetus for ground-to-ground handling of the lifetime fuel cycle is needed to move this divisive debate forward. Australia's entry into the fuel cycle through the acquisition of nuclear powered submarines might just do it.

Options for the acquisition of nuclear powered submarines come down to probably two potential suppliers and both present difficulties. But just how serious these difficulties are will remain matters for conjecture until a champion emerges at the political level. Someone to carry the discussion overseas and to ask the question of potential supplier navies: what would it really take to persuade you to give us access to nuclear propulsion for our next generation of submarines?

Admiral Robertson concluded the presentation by outlining some of the factors governing the practicability of introducing nuclear-powered submarines.

Costs. Assuming that one or other of our allies would be prepared to sell us such boats, how would costs probably compare with the local production of the proposed conventional boats? Admirals Wood and Holthouse had already given some rough costs of US submarines. The cost of a British Astute submarine (which does not have to be refuelled in its entire life and therefore considerably reduces running costs and increases operational availability) built in Britain has been quoted at about £1.2 billion. At present exchange rates this is about $A2 billion Australian dollars. Costs would seem to be similar for US boats built in the USA. The only known rough estimate of our proposed 12 future conventional submarines is $36 billion – about 3 billion each. Allowing for hidden costs, infrastructure etc the costs involved for conventional built here and nuclear built overseas would probably compare.

Crews. The problem may not be significant as, though individual crews would be greater for nuclear boats, less submarines may be required.

Training. Probably greater for nuclear-powered boats, though offset by less crews being needed for fewer boats.

Infrastructure. This will be considerable, but offset a little by the need for extra infrastructure for the currently proposed large conventional boats.

Can Australia introduce such submarines? It is still about 14 years before the first conventional boat is due to be completed. This would seem to be enough time to make the necessary arrangements. After all Australia in the past introduced:

- Aircraft Carriers in about 3 years from the decision to acquire without previous experience in carriers, though with much help from Britain.
- Submarines in about 5 years although it was some decades since we had last possessed such vessels.
- US Guided Missile Destroyers in about 5 years from decision, though this involved buying our first large American warships with entirely new equipment of all types including Australia's first large guided missiles, 3 dimensional radars and very high-pressure steam systems. This involved a huge recruiting, training, dockyard, infrastructure and logistic effort at the same time as submarines and other new ships and aircraft were being introduced into the RAN.

Political. This seems to be the main hurdle. A national debate on nuclear power and nuclear-powered submarines is needed to inform the Australian public. It should be remembered that the proposed conventional submarines will be in service from 14 years until about 50 or more years time in a very different world. Long-range decisions are required in the national interest, and unshackled by present perceived prejudices.

Four nations in our general area operate nuclear-powered boats today. Sixteen nations in our region have nuclear power stations. Australia is drifting behind in technology and in maritime defence and it would seem of importance for the nuclear option to become a national issue.

In thanking the three Admirals for their presentation a representative of Engineers Australia confirmed that a new small reactor/engine system was under development and that this could be fitted in both small nuclear power stations and as the propulsion system for nuclear-powered submarines. Clearly this would have great potential advantages for countries such as ours.

The Navy League of Australia has for some years supported consideration of nuclear propulsion for at least a proportion of Australia's future submarines. Given the uncertainties of the strategic future as the balance of economic and military power moves slowly to East and South Asia it would seem in Australia's defence interest to consider seriously this form of propulsion for some, at least, of our future submarines.

Surely our brave youth, operating in this exacting and dangerous environment, so important to our national defence, should be equipped with the most effective, efficient, and survivable boats in the world. They deserve nothing less.