AUKUS: a tripartite foundation for Indo-Pacific security

A paper based on a presentation to the Institute in Sydney on 18 April 2023 by

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AUKUS is an agreement among Australia, Britain and the United States to enable Australia to acquire nuclear-powered submarines (Pillar 1) and to undertake research and development of novel defence technologies (Pillar 2). This paper describes the AUKUS tripartite relationship; outlines the eight AUKUS Pillar 2 technology and collaboration initiatives; and looks in detail at the planning for Australia's acquisition of nuclear-powered attack submarines under AUKUS Pillar 1. Strategic implications for Australia and the Indo-Pacific region are noted and the author concludes that AUKUS will provide a foundation for enhanced national and regional security.

Key words: AUKUS; nuclear-powered submarines; Pillar 2 technologies.

The AUKUS Tripartite Relationship

The tripartite AUKUS agreement was announced on 15 September 2021 in a joint virtual presentation by the leaders of Australia, United Kingdom and the United States of America. The announcement mainly focused on the agreement to facilitate Australian acquisition of nuclear-powered attack submarines – a class of submarine commonly referred to as an SSN. This formed the so-called Pillar 1 of the agreement.

There is a symbiotic relationship among the three AUKUS participants (Figure 1). Each brings historical experience and capability to contribute to a combined strength in building up Australia's defence capabilities, especially in the step up to nuclear-powered submarines. The British Royal Navy has provided the cultural basis for the Australian Navy in all respects, including in submarine operations and sustainment, and in naval workforce development, for over a century and continues to do so. The United States (U.S.) Navy has provided technical and operational leadership ever since Australia acquired ships and aircraft from America and this continues in the collaborative development of submarine combat systems and undersea weapons.

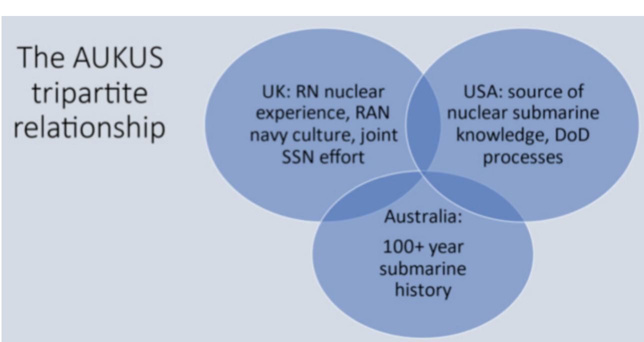

***Figure 1**: The AUKUS tripartite relationship.*
[Source: the author]

AUKUS Pillar 2 Technologies

Pillar 2 comprises several areas of advanced technology that are significant in ongoing development of defence and national security capability (DPMC 2023). A separate working group is addressing each of the following eight advanced technology areas.

- ***Undersea capabilities***, especially sensors and undersea communications: undersea uncrewed vehicles (UUV) of all sizes and endurances are becoming more available, from extra-large UUV, through large UUV, to smaller drones that can intercommunicate and hence operate in swarm or tandem.
- ***Quantum technologies***, still in advanced development but already demonstrated to perform computational feats beyond what is possible with existing conventional digital processors based on discrete states of 1 and 0. Quantum is being directed towards highly secure communications, sensors and very fast digital data processing.
- ***Artificial intelligence*** (AI) technology and automation is everywhere and over the last six months has taken a dramatic further advance, being developed and deployed in products such as ChatGPT that have caused a reactive movement to consider dangers to human existence and to the ethics of AI.
- ***Advanced cyber*** is continuing a steady advance in wider and more effective application of cyber technologies; and cyber has been identified as a fifth warfare domain along with Air, Land, Sea and Space.
- ***Hypersonic and counter-hypersonic capabilities***: the ability of airborne missiles to reach high Mach numbers has greatly increased the challenges for air defence to detect, track and engage such weapons.
- ***Electronic warfare*** is always advancing due to its own inherent technological advances and to the demand to detect, monitor and, as necessary, disrupt electro-magnetic emissions of all kinds.

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- ***Innovation*** is included as a dedicated working group in order to enhance the innovation processes.
- ***Information sharing*** to ensure all states and forces that co-operate do so effectively.

Nuclear-Powered Submarine Task Force

The detailed planning for the Pillar 1 nuclear submarine programme primarily rested with the Nuclear-Powered Submarine Task Force[2] headed by Vice Admiral Jonathan Mead AO RAN. The Task Force's initial role and responsibilities when announced on 16 September 2021 were to work with our American and British partners over the subsequent 18 months to identify the optimum pathway to acquire the submarines. The Task Force examined the requirements that underpinned this pathway, including nuclear stewardship, safety, security, capability, programme management, industrial base, non-proliferation, disposal, regulation, environmental protection, training facilities, basing, workforce and force structure.[3] The Task Force rapidly grew into a comprehensive new organisation of some 350 people and operated via nine working groups.

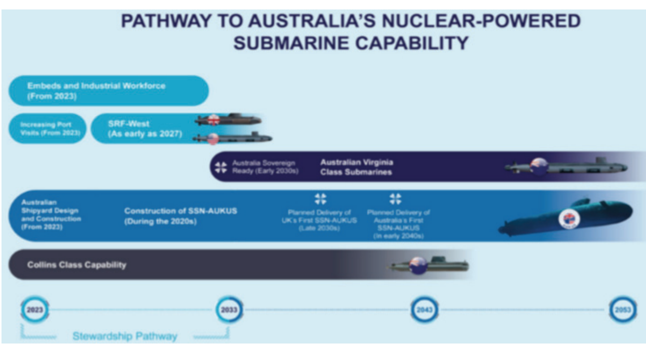

***Figure 2**: AUKUS phased timeline as announced by the three leaders on 13 March 2023. [Source: U.S. Navy undated]*

The findings of the AUKUS Pillar 1 Task Force were announced by the three AUKUS national leaders from the U.S. Navy submarine base in San Diego, California, on 13 March 2023. The Australian nuclear-powered attack submarine (SSN) capability was to be acquired in three stages (Figure 2):

- the basing of US Navy and Royal Navy SSNs in Australia at Fleet Base West near Fremantle, Western Australia, from 2027, thereby enabling Australian submariners to gain experience that is essential before the following stages;
- the sale of three US Navy Virginia-class SSNs to Australia, with a possible further two, to cover the period between the decommissioning of the current Australian conventionally-powered Collins-class submarines following their planned 10- year life extension and the commissioning of the AUKUS SSNs; and
- for Australia to join the British SSN (Replacement) programme to replace the current Royal Navy Astute-class SSNs with submarines designed in Britain and constructed in both Britain and Australia.

Submarine Nuclear-Propulsion Technology

Nuclear-propulsion confers superior endurance, sustained speed and agility on a nuclear-powered submarine by comparison with a conventionally-powered one. It also avoids the need that conventionally-powered submarines have to periodically spend several hours at periscope depth 'snorting' (*i.e.* taking in air for the diesel-powered electrical generators to recharge batteries) – this periodic snorting gives rise to much greater acoustic signals that render the conventionally-powered submarine much more detectable.

The most important advantage, though, that virtually unlimited power confers on an SSN is in transiting time to an operational area, which is greatly reduced, resulting in much greater time on station. Further, the greater speed of an SSN is such that it can often overtake a surface ship and always possesses a tactical advantage that conventionally-powered submarines lack.

Submarines depend for their superior operational advantage on their much lower detectability by opposing forces. Being largely undetectable, they are considered 'stealthy'. As a consequence, opposing forces are uncertain of the presence of a submarine and hence must continuously search for an SSN which, until it chooses to take explicit action, probably will remain undetected.

The submarine nuclear reactor and primary cooling circuit (Figure 3) are confined entirely in a single compartment that is shielded from other compartments and is uncrewed. Steam is produced in the heat-exchanger with the secondary circuit that powers the primary propulsion and other auxiliary steam turbines, a technology that has been in use for over a century.

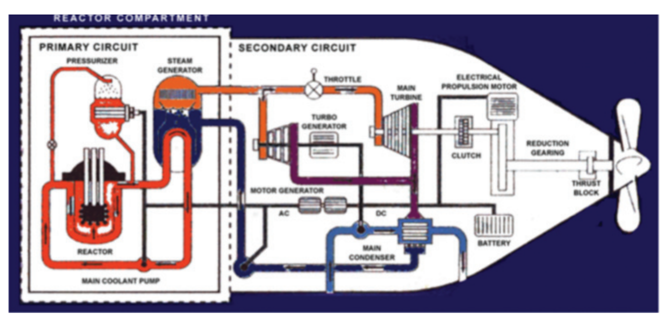

***Figure 3**: The submarine nuclear-propulsion plant – schematic. [Source: U.S. Navy undated]*

The Nuclear Fuel Cycle Applicable to Submarine Propulsion

Australia must consider the full cradle-to-grave life cycle of the nuclear fuel to be employed in an Australian SSN. The steps involved in the uranium nuclear fuel cycle involve:

- mining the uranium ore followed by its milling for ease of transport;
- processing the ore to separate the uranium from the ore;

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[2]The Task Force was superseded by the Australian Submarine Agency on 1 July 2023 and the newly-created Australian Nuclear-Powered Submarine Safety Regulator.

[3]Quoted from Department of Defence job vacancy advertisement dated 24 September 2021.

- enrichment of the uranium (U) fuel to increase the proportion of U_{235}, the isotope that undergoes the fission process;
- manufacture of fuel assemblies as small cylindrical shapes that are inserted into fuel rods and then into the reactor core structure – the fuel rods are the first level of containment of the radioactive fuel material and the core permits control and effective flow of purified water as both a coolant and a moderator to slow the neutron stream such that each fission produces further neutrons in a balanced manner;
- construction of the reactor core and the surrounding reactor containment vessel that acts as the second line of containment of radioactive material, with the submarine reactor compartment providing a third; and
- operation of the reactor, noting that once fission has been initiated there is a continuous need for cooling even if the reactor is shut down – this is due to the ongoing heat and radiation that arise from the continuing decay of the fission products which lasts for several years.

Some reactors require to be refuelled periodically when the fuel has been depleted. This is achieved by removing some fuel rods or assemblies and replacing them with new rods or assemblies. However, the U.S. Navy and Royal Navy submarine reactors now use highly-enriched uranium fuel which can operate effectively for the planned life of the submarine and this simplifies the full-cycle maintenance routines.

Eventually the reactor is decommissioned and the fuel assemblies removed to be placed in cooling ponds for several years for decay heat and radiation to dissipate sufficiently for careful handling. Fuel assembles are then transported to a reprocessing plant where unexpended fuel material is extracted to be used in new fuel assembles and the remaining radioactive waste, now reduced to a lower (intermediate) level waste, is stored and ultimately placed in an approved long-term repository (probably a geologically-stable underground facility) to be stored there potentially for several hundred years.

There are some additional complications for Australia that have to be taken into account. Australia has a series of legislative bans on several steps in the nuclear fuel cycle at federal, state and territory levels that arose from a period when the world had emerged from the Cold War and took into account the implications of the nuclear-power accident at Chernobyl in the Ukraine in 1986.

Australia also has only a single nuclear reactor, a research and medical isotope production reactor which is located at the Australian Nuclear Science and Technology Organisation (ANSTO) at Lucas Heights, New South Wales. Hence, Australia lacks any form of nuclear industry or workforce beyond the ANSTO staff. Previously, this was believed to preclude any consideration of nuclear-powered submarines. This view changed after a workshop conducted by the Submarine Institute of Australia in Canberra in October 2019 (Frame 2020).

Finally, Australia was an original signatory to the Nuclear Non-Proliferation Treaty (NPT) and has pledged that the AUKUS programme for SSN acquisition will not be permitted to compromise Australia's adherence to the NPT.

The Infrastructure Needed for Nuclear Submarines

The most demanding aspects of nuclear propulsion (or of any other use of nuclear energy) are an exemplary safety and security culture and a risk-management approach to protection from all conceivable hazards and possible failures. The infrastructure required for the operation, sustainment and eventual construction and delivery of nuclear-powered submarines is extensive and must meet the most stringent safety criteria including 'safety cases' to be formally approved, licensed and implemented, always subject to independent regulation and oversight.

The infrastructure for nuclear submarines must provide for multiple-redundant cooling for the primary circuit of the reactor, which even when shut down will continue to generate heat from continuing decay of fission products. Overheating of the reactor core will result in irreversible physical damage and *in extremis* the release of radioactive materials. This must be prevented 24/7 in spite of all possible failures of supplies and connections.

Further, the infrastructure must provide a safe environment for the workforce to conduct routine repair and maintenance tasks. And finally, there must be effective physical management of all radioactive materials at all times.

The Nuclear-Qualified Workforce

A very challenging aspect of the AUKUS SSN programme is building up the workforce, both naval and civilian. The civilian workforce must cover all aspects of research, development, design, construction and delivery, sustainment, fuel management, and overall independent regulation.

Australia has only two undergraduate-level nuclear courses: one in nuclear science at the Australian National University in Canberra; and one in nuclear engineering at University of New South Wales in Sydney. These courses must be replicated and expanded such that the workforce is dramatically increased – with full oversight and attention to formal assessment, qualification and licensing as required for the many functions to be performed.

United States Nuclear Submarines in Australia

The U.S. Navy has been acquiring Virginia-class SSNs since 1998 and continues to order their construction at a rate of two per year. Basing a small number of these SSNs in Western Australia will require some additional infrastructure.

To permit Australian submariners to serve in the American boats will require formal training, qualification and licensing of the Australians to U.S. Navy standards. This process has already started with Royal Australian Navy (RAN) personnel already enrolled at the U.S. Navy Nuclear-Power School, an intensive six-month programme with formal assessment. Already, three RAN officers have graduated from this school.

When the time comes in the early 2030s for Australia to take delivery of the three (possibly five) Virginia-class SSNs for the RAN, then all the prerequisite infrastructure and workforce will need to be in place. Since this is slated to start in 2033, a decade from now, there is no time to lose.

Design and Construction of the AUKUS-class SSNs

Britain will complete its current Astute-class SSN contruction programme in 2026 and has already begun work on the following class, now renamed as SSN AUKUS-class, which has been identified as the basis for Australian participation (Figure 2). Australian personnel with be involved in the design and development of the SSN AUKUS-class. That will rest on a number of assumptions that will need to be validated and delivered, including the delivery to Australia of the complete PWR3 nuclear reactor module from Rolls Royce Submarines in Derby, United Kingdom.

This process is not expected to create any special difficulties as it is normal practice in both Britain and America for submarine nuclear reactors to be fuelled and transported in an inert state to a submarine integration site where submarine construction is completed, and, only when all prerequisites are in place, for the nuclear reaction to be initiated.

AUKUS as a Foundation for Indo-Pacific Security

The underlying thrust of AUKUS is to augment a multilateral foundation for safety and security in the Indo-Pacific region. Australia's acquisition of a nuclear-powered submarine capability would provide a powerful maritime regional defence capability and so would project strong deterrence.

Australia projects its commitment in several ways. It has a global perspective overall but with a special focus on the Indo-Pacific region – including the Pacific, Indian and Southern Oceans, all the archipelagic countries therein and all the continental countries adjoining these oceans. This is a region with a recognised potential for conflict, with most attention on Taiwan but with other possible conflicts also.

The AUKUS partners share a deeply historical connection with long-standing shared culture and vision. The three countries are dispersed more or less equally around the globe. This gives them the perspective of widely different time zones and hence 24-hour alertness.

Britain closely follows America in most technological areas and Australia is well-practised in learning from them both. This past experience has contributed to American and British confidence that Australia is competent and committed to the effective transfer of valuable technology with full attention to safety and security of the intellectual property that is made available by them.

More broadly, there is a growing trend for countries to co-operate and make formal agreements to build more powerful and effective alliances and partnerships to resist coercion and confrontation with inimical powers, especially China, but also Russia, North Korea and others. Notably NATO countries have acknowledged the importance of the Indo-Pacific region for their own security based on extensive trade and transport with the region.

Conclusion

AUKUS is a fundamental gamechanger for Australian national security and Indo-Pacific regional security. At the same time, it provides a powerful basis for the engagement of the AUKUS partners, America and Britain, in the world's most dynamically changing region in which China is rapidly expanding its influence.

AUKUS has provided the key to Australia acquiring a nuclear-powered submarine capability that had previously been discounted due lack of a nuclear-power industry. There is a great deal to be done to make this happen, but already there is commitment from government and industry to make this feasible.

The most significant contributions to national security that will flow from the adoption of submarine nuclear propulsion are a much increased capability for intelligence gathering, surveillance and reconnaissance, coupled with enhanced deterrence arising from the potential of the attack submarines for land strike and maritime interdiction within the Indo-Pacific region. This collectively provides a foundation for enhanced national and regional security.

The Author: Chris Skinner, a retired Royal Australian Navy captain, was a weapons and electrical engineering officer who served in six surface warships. His involvement in submarine matters is more recent and he is currently chairing the technical committee for the 7th Submarine Science, Technology & Engineering Conference in Adelaide in September 2023. [Photo of Captain Skinner: the author.]

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