Progress in Implementation of the AUKUS Agreement

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The tripartite technology information agreement between Australia, the United Kingdom and the United States of America (AUKUS) was announced on 15 September 2021 and was discussed in an earlier article[1]. This article provides an update and interim progress commentary on AUKUS and the technology aspects mentioned in the announcement and in the more recent progress report, the further implications of the use of highly enriched Uranium (HEU) as submarine nuclear reactor fuel, and the broader geopolitical implications of AUKUS as it relates to the Nuclear Non Proliferation Treaty.

Key words: AUKUS; nuclear submarines; nuclear proliferation; nuclear fuel cycle; cyber warfare; artificial intelligence; quantum computing; undersea technology; hypersonic missiles; highly enriched uranium; nuclear waste.

The AUKUS Agreement announced by the leaders of USA, UK and Australia on 15 September 2021, covers the sharing of technical information and experience on cyber security, artificial intelligence (AI), quantum computing and undersea technology, especially enabling Australia to acquire nuclear powered submarines. The Australian Prime Minister expanded on the latter to state that this would be a program of at least eight nuclear powered submarines (SSN) to be built in South Australia starting in 2030, with the delivery of the first submarine by 2040. The process for this SSN program is under joint development over 18 months within a Nuclear-Powered Submarine Taskforce (NPSTF) with a deadline of March 2023.

In a six-monthly review of AUKUS, four further technology areas were added: hypersonic missiles; electronic warfare (EW); information sharing processes, and innovation approaches. In the same period the formal tripartite agreement on information sharing has entered into force.

This paper reflects the extraordinary level and diversity of ongoing public discussion on AUKUS and especially nuclear technology that has erupted since the first announcement, both domestically and in the broad international geopolitical domain. There remain several significant challenges before the program is assured, notably the nuclear-powered submarine core of AUKUS.

Further developments relating to the AUKUS Agreement

The most recent development since the election of the Australian Labor Party to government is the establishment of a Defence Strategic Review to report at the same time as the Nuclear-Powered Submarine Task Force (NPSTF) in March 2023. The need for this new review has been generally accepted reflecting the growing global impact of the Russian invasion of the Ukraine, and the most recent aggressive moves by China against Taiwan following the visit there by US House of Representatives Speaker Nancy Pelosi.

This paper covers several recent developments relating to the AUKUS Agreement, and indirectly to the continuing unfolding of the consequences of the Russian invasion of Ukraine, the effective repulse by Ukrainian forces with significant material support from NATO and other sympathetic liberal democratic nations including Australia.

The AUKUS Agreement and the follow-on 16-page Agreement between the three governments for the 'Exchange of Naval Nuclear Propulsion Information'[2] specifically reaffirms the commitment to the obligations under the NPT, including the application of International Atomic Energy Agency (IAEA) safeguards on all peaceful nuclear activities in Australia. The latter proviso, the strict rejection of nuclear weapons and the agreement not to pursue a nuclear power industry were the conditions to the prompt support for AUKUS by the then federal opposition party, the Australian Labor Party, since elected to government.

The announcement specifically mentions several disruptive technological development areas for the three-way sharing of information discussed individually, concluding with an overview of nuclear propulsion technology, as they are expected to contribute to the capability of the Australian Defence Force (ADF).

Highly Enriched Uranium Nuclear Reactor Fuel

The implication of an Australian SSN program for the wider aspects of Australia's engagement with nuclear science, technology and engineering, and related legal and international frameworks is profound. This applies especially to the use of HEU nuclear fuel in both US and UK submarines in current production, which is at the level

[1]SKINNER, Christopher, (2022), Nuclear powered submarines and other AUKUS technologies for the Australian Defence Force. *United Service*, RUSI NSW, Vol. **73** No.1, March 2022.

[2]Agreement between The Government of Australia, The Government of the United Kingdom of Great Britain and Northern Ireland, and the Government of the United States of America for the Exchange of Naval Nuclear Propulsion Information executed in November 2021. See: https://www.defence.gov.au/sites/default/files/2022-01/Information-Agreement_0.pdf .

of enrichment used in nuclear weapons. The possible avoidance of HEU in the next generation of nuclear attack submarines by USA and UK is relevant but not yet assured and the projected programs are many years away from commitment.

Other International Developments

There have been a number of key visits directly related to AUKUS and nuclear submarines by overseas principals including the IAEA, US Department of Defence, and UK military leaders.

In the USA, Congressional action is underway to facilitate the onboard nuclear training of Australian submariners in US Navy nuclear submarines. The UK has proposed similar attention to nuclear training by basing UK nuclear submarines in Western Australia to provide onboard training there in a similar fashion.

The recent review conference on NPT[3] has occasioned notable AUKUS-related submissions by Indonesia, China and the joint AUKUS partners. AUKUS has become a *cause celebre* especially by China that argues that AUKUS is an indirect strategy for Australia to acquire nuclear weapons.

Hypersonic Missile Development

There has been growing interest in the advent of hypersonic cruise missiles especially for anti-shipping use and this has focussed attention on the recent commitment to the priority development of an Australian guided weapons and explosive ordnance development and manufacturing capability[4].

Other Added AUKUS Technologies

In the three other additional AUKUS technology areas of electronic warfare (EW), information sharing and innovation there has not been much to report over the past several months, except that their importance has been generally accepted.

Need for an Interim Conventional Submarine Program

Many commentators have suggested the need for an interim conventionally powered submarine program to cover the expected delay in delivery of the nuclear-powered submarine capability. This proposal is rejected by Defence who state emphatically that the nuclear program can be accomplished in a timely manner. This view has been debated openly including this author postulating that by choice of the UK ASTUTE design with minimal differences[5], and construction shared between South Australia and UK; then cutting steel in 2027 and first boat delivery in 2037 is feasible[6].

Some others agree albeit with concern that there must be a greater sense of urgency than has been applied to similar large complex defence programs in recent times. This is also an imperative for the concurrent Defence Strategic Review.

Nuclear Powered Submarine Capability for Australia

The dominant public discussion has focussed on the SSN capability, raising questions on the justification, selection of design and the strategic partner country, workforce development to meet onerous regulatory safety and non-proliferation concerns, and the inevitable cost and schedule challenges of the SSN acquisition program.

Emphasis on timing had been a contentious area even before AUKUS, with the current Collins-class submarines requiring major investment to extend their service life by a further decade, which even then fall short of the announced SSN delivery dates. A major challenge for the NPSTF will be to optimise the timing of SSN delivery dates with submarine force structure mandatory numbers[7].

The use by both the UK Royal Navy and the United States Navy in their current SSNs of HEU nuclear fuel which could be converted for use in nuclear weapons, requires stringent management of nuclear fissionable material to ensure adherence to the multinational NPT. However, Australia has experience of these processes from the operation of the former HIFAR[8] and current OPAL nuclear reactors by the Australian Nuclear Science and Technology Organisation (ANSTO).

The selection of the design from the two SSN designs currently in production, or a hybrid of the two, or inclusion in the follow-on design processes that have been initiated by each country, is moot. The NPSTF has this as an early consideration, as many of the acquisition processes are dependent on this choice. Thereafter there is need for detailed analyses and selection of preferred options to present to the three governments for their respective approval, not later than the March 2023 deadline for the NPSTF.

Options that have been considered for the AUKUS SSN

The most obvious choice for AUKUS is either of two designs in current production: Virginia-class for USA and Astute-class for the UK. In addition, there have been mentioned the successor programs for each country: SSN(X) for USA and SSN(R) for UK.

Each of these options has attractive features but they differ significantly in timeliness of availability which is therefore likely to rule out the later options from serious consideration.

Virginia program status

'The US Navy's Virginia class (SSN-774) program is currently scaled at 66 projected boats with 36 so far procured at a rate of two per year from two cooperating shipyards. The Virginia-class design has been updated multiple times since FY1998. Most Virginia-class boats

[3]Tenth Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons. (1 - 26 August 2022).

[4]https://www.defence.gov.au/project/sovereign-guided-weapons-and-explosive-ordnance-enterprise.

[5]Notably the use of the alternative Mk48 533mm heavyweight torpedo in place of the UK Spearfish torpedo.

[6]https://www.defenceconnect.com.au/key-enablers/10202-build-the-astute-class-in-osborne-and-barrow-for-fastest-delivery.

[7]See https://www.defence.gov.au/about/taskforces/nuclear-powered-submarine-task-force.

[8]HIFAR was initially fuelled with HEU then progressively changed to operate with fuel of lower enrichment.

procured in FY2019 and subsequent years are to be built with the Virginia Payload Module (VPM), an additional, 84-foot-long, mid-body section equipped with four large-diameter, vertical launch tubes for storing and launching additional Tomahawk missiles or other payloads'[9]. The Virginia program will continue until 2035 and possibly beyond.

Astute program status

The UK Astute program has seven boats is in its final stages with the last two boats currently under construction completing in 2026. The single shipyard at Barrow in Cumbria, UK, is beginning the transition to the Dreadnought Strategic Ballistic Missile Nuclear Submarine program (SSBN) which will use a later design nuclear reactor (PWR3) that requires a lager pressure hull diameter than the 11.3m of the Astute-class, which uses the Rolls Royce PWR2 nuclear reactor.

Development Program status

For USA, the next generation SSN program is called SSN(X) for which research and development began in 2016 with a projected duration of 15 years, hence completing in 2031, which aligns with the projected completion of the Virginia building program around 2035[10].

For UK the similar follow-on program known as the as SSN(R) or replacement SSN, is getting started but has not made much progress as yet.

A key issue for both programs is whether this will include a move away from use of HEU to low enriched Uranium (LEU), or even to an alternative reactor design to achieve other benefits. It is tempting for Australia to opt for one of these two approaches providing ample time to get up to speed including the development of the essential workforce skills and regulatory competence. However, this choice would confirm the need for the interim conventionally powered submarine program and blunt the impetus that AUKUS has provided in a world of growing geopolitical uncertainty.

Essential Areas for the NPSTF to Address

The NPSTF must address several essential areas of policy and technology that are inherent in the adoption of nuclear propulsion, as has been documented in several recent papers[11]. The major topics and the related key issues are:

The context for nuclear submarines in Australia

- What are the benefits of nuclear propulsion for Australia's submarine fleet?
- History of nuclear propulsion since its first introduction in 1955.
- Challenges in nuclear propulsion that are unique to Australia, a country without a general nuclear industry supporting electric power generation.
- The additional regulatory policy and organisational needs must be fully addressed at an early stage to provide the basis for all other work to proceed. If the practice of other western nuclear navies is followed, there will need to be an independent nuclear propulsion regulatory body established with reporting lines independent of the Defence portfolio, to ensure there is full objectivity and accountability in nuclear propulsion development in Australia.

The technology for nuclear propulsion

- The full nuclear fuel cycle and specifically the differences that apply to stages of the fuel cycle for a submarine nuclear reactor, compared with a civil reactor such as the ANSTO OPAL reactor. There is also the common requirement for permanent disposal of intermediate level nuclear waste material that results from spent nuclear reactor fuel after reprocessing to remove residual fuel and other products requiring explicit management such as Plutonium.
- The additional infrastructure needed for the safety and security of nuclear propulsion. This requires existing infrastructures to be reviewed and new facilities to be built to meet stringent standards to be approved by the Australian nuclear submarine regulatory body yet to be established.
- Construction of nuclear submarines, both in general, and specifically for construction in Australia. This is a complex question because the final assembly in Australia will necessarily include the integration of the nuclear reactor section or module with other sections and modules some of which may be constructed at the same site but could also be manufactured elsewhere at sites that are not necessarily nuclear licensed. The current submarine building and deep maintenance site at Osborne North in South Australia has not yet been assessed as meeting the safety and security criteria that have been mandated by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) for visits by nuclear powered warships, which may be expected to form the basis for extended rules for construction and reactor initiation after launching.

Program management issues

- Workforce development, both civilian and uniformed, will be a major challenge that will take several years to enable full Australian participation in the design and development work. In many respects this could be the critical path in the program. The leasing of one or more commissioned and crewed nuclear submarines from the source country for the Australian program is proposed as a practical means to raise the level of experience and on-the-job training with boats to be based at Fleet Base West, and to provide crewing spaces for Australian submariners to acquire nuclear submarine qualifications of that source navy.
- The engagement with the civil nuclear activities of ANSTO and the international community in matters such as the NPT must be fully agreed with all involved parties in all relevant portfolios, including Foreign Affairs and Science and Technology.

[9](2022). Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress. Congressional Research Service, Washington DC. Report: RL32418; 27 July 2022.

[10]There were media reports circa 2018 that Australia had been invited to join the SSN(X) program but had declined.

[11]TFor example: SKINNER, Christopher. *'Nuclear Propulsion Roadmap for Australia – 2021: Update to Reflect AUKUS.'* Australian Naval Review 2021, Issue 2. Australian Naval Institute, Canberra. 2021.

- The cost and time budget for all of the work to be undertaken are critical issues, especially with the looming end of service life of the current Collins-class submarine fleet, even with the commitment of the life-of-type-extension of a further decade for each boat. The NPSTF have a major challenge to advance the delivery dates for nuclear submarines, compared with the original announcement to avoid the possibility of a reduction in submarine force numbers.

Implications of AUKUS

How to contribute most effectively to the development and adoption of the AUKUS technologies, and how to do this in the manner identified in the RUSI Seminar of 23 November 2021[12], when it was concluded that RUSIDSS should imagine the future of defence and security confrontation in the light of advances in technologies and changes in societal values and resources. The rationale for this approach is to challenge the current thinking in Defence and ask what else needs to be done or avoided, based on the extraordinary accumulation of knowledge and experience within the RUSIDSS membership and its network of contributors.

Use of Highly Enriched Uranium (HEU) Nuclear Fuel

The global dialogue on AUKUS is continuing at a high level reflecting the significance of any country adopting nuclear powered submarines and especially a country that has formally proscribed the general use of nuclear energy for industrial purposes. This discussion is focussed especially on the risks inherent in the use of HEU nuclear fuel and the possible diversion of the HEU for production of nuclear warheads.

The ambitious timeline for SSN Acquisition

A second major challenge is the time factor for introduction of the SSN submarines to avoid any reduction in submarine capability following the decommissioning of the Collins-class after their life extension. A feasible way to address this and at the same time provide two further benefits is for the parent navy to base submarines of the same class in Western Australia. This would provide an enhanced geostrategic presence in the Indian Ocean and also closer access to the South and East China seas.

It would also provide a powerful means to provide at-sea training for Australian submariners in training billets in those submarines.

Legal and Regulatory Constraints

Legislative bans on nuclear energy apply in Australia at both the federal and state and territory levels but are not seen as directly applicable to acquisition of nuclear-powered submarines. However the acquisition of small modular nuclear reactors (SMR) for civil electrical power generation are prohibited. There is a possible synergy in the workforce development that would apply to both submarine and SMR introduction over a similar period and might therefore result in proposals for amendment of legislation to permit some aspects of the nuclear industrial work to become lawful.

Based on both US and UK practice, Australia will need to create an extended regulatory body such as the UK Office of Nuclear Regulation (ONR)[13] or US Nuclear Regulatory Commission (NRC)[14] empowered to examine all aspects of safety and security of the submarine program and the full extent of the selected nuclear fuel cycle.

Conclusion

The AUKUS Agreement is an extraordinarily significant event in Australia's geopolitical future and its execution will be regarded as a point of departure in our sovereign capability development, irrespective of the actual trajectory that is ultimately followed.

AUKUS may well have been mandated by the original agreement transferring nuclear propulsion information from USA to the UK requiring US approval for any further transfer but the over-arching significance of both UK and US leaders stating publicly their support for transfer of such information to Australia is of profound significance, as the wide-ranging global commentary on AUKUS has confirmed.

The result is the greatest technological challenge that Australia has ever faced to prepare for and execute the nuclear submarine program within a challenging timeframe that reflects the previous inattention to the ongoing maintenance of the Australian submarine force but also the decades-long false assumption of the necessity for a nuclear power industry when that is no longer asserted. The action taken in 2023 following the recommendations from the Nuclear Powered Submarine Task Force and the Defence Strategic Review will be a watershed for Australia's national security.

The Author

Christopher Skinner served 30 years in the RAN as a Weapons and Electrical Engineering Officer in six surface warships in the South-East Asia Treaty Organisation, the Vietnam War and North-West Indian Ocean surveillance. Shore postings included Superintendent of Missile and Torpedo Maintenance at the time of introduction of Mk48 torpedo and submarine launched Harpoon Anti-Ship Cruise Missile in the Oberon-class Submarine Weapons Update Project, secondment to the US Naval Sea Systems Command to conduct first-of-class trials of a joint frigate project, and initial Project Director for the ANZAC Frigate program of ten ships for Australia and New Zealand. His involvement in submarine matters is more recent. In 2019, he registered the business name 'Nuclear Propulsion Roadmap for Australia®'. The views expressed in the paper are his own.

[12]See https://rusinsw.org.au/site/VideoTheatre48.php.

[13]https://www.onr.org.uk/.

[14]https://www.nrc.gov/.