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Developing the Royal Australian Navy's Nuclear Powered Submarine Work Force

Lieutenant-Commander Stephen Miller, RAN

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Exercise Solo Flight

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INTRODUCTION

The Australian Government announced in September 2021 that it was to acquire nuclear-powered submarines by partnering with the United States (US) and the United Kingdom (UK) through an enhanced trilateral security partnership to be known as AUKUS.[1] Nuclear power provides the United States Navy's (USN) submarines and aircraft carriers unprecedented endurance and speed; it is a unique capability that the US has only shared with one other country, the UK.[2] The inclusion of Australia and the Royal Australian Navy (RAN) in this select group is extremely significant – the pressure to succeed will be immense. The integration of nuclear-powered submarines into the RAN will be difficult, summarised by the Australian Strategic Policy Institute (ASPI) as: "…probably the largest and most complex endeavour Australia has embarked upon."[3] Whilst there is much analysis and debate already as to what type of submarines Australia requires and where these submarines should be constructed; the generation of appropriately trained RAN officers and sailors to operate the capability will require an equal level of focus. Retired Australian submarine Rear Admiral Peter Briggs recently stated: "Of all the challenges to achieving the transition to this new capability, and there will be plenty, having the right people in place may prove to be the most important."[4]

Whilst the concept of operations for the new submarines is still to be determined fully, the present intent is that the submarines will be operated from Australia and crewed by officers

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[1] Prime Minister of Australia "Australia to Pursue Nuclear-Powered Submarines through New Trilateral Enhanced Security Partnership|," accessed April 2, 2022, https://www.pm.gov.au/media/australia-pursue-nuclear-powered-submarines-through-new-trilateral-enhanced-security.

[2] Julian Borger and Dan Sabbagh, "US, UK and Australia Forge Military Alliance to Counter China," *The Guardian*, September 16, 2021, https://www.theguardian.com/australia-news/2021/sep/15/australia-nuclear-powered-submarines-us-uk-security-partnership-aukus.

[3] Andrew Nicholls *et al*, "Implementing Australia's Nuclear Submarine Program," *The Strategist,* December 13, 2021, https://www.aspistrategist.org.au/implementing-australias-nuclear-submarine-program/.

[4] Peter Briggs, "Making the Shift to Nuclear-Powered Submarines: Safety First," *The Strategist,* October 25, 2021, https://www.aspistrategist.org.au/making-the-shift-to-nuclear-powered-submarines-safety-first/.

and sailors of the RAN.[5] Nuclear power has never been a part of Australia's industrial base and it possesses negligible nuclear expertise within industry or the RAN – it will need to build this workforce from its foundations.[6] Developing the RAN's people for nuclear-powered submarines represents a technological leap in levels of difficulty above conventional submarine operations; the complexity and safety requirements of nuclear-powered submarines will require very high levels of technical proficiency and training standards, in addition to the already stringent requirements of conventional submarines.[7] To understand the scale of this challenge, it is important to consider which areas of developing the RAN's officers and sailors will present the most difficulty and risk to creating competent nuclear-trained personnel.

This paper demonstrates that the risks in attracting, retaining and training the nuclear-qualified naval personnel required as part of creating an effective nuclear submarine capability are presently underappreciated, and will require significant participation by government, industry, AUKUS partners and the RAN to mitigate effectively.

To support this argument, this paper will first establish the context by describing the current RAN submarine capability and what a transition from conventional to nuclear propulsion will mean in terms of complexity. Next, it will analyse the manpower requirements for crewing, timelines for developing the requisite expertise, and attracting and retaining of personnel considerations. Finally, it will review the training requirements in broad terms by examining the approaches of AUKUS partners and then consider the opportunities and risks of developing the training program to produce the RAN's nuclear-powered submarine workforce.

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[5] Economics References Committee – *"Australia's Sovereign Naval Shipbuilding Capability."* Commonwealth of Australia, October 15, 2021, 34.

[6] Tanya Ogilvie-White, "Australia's Rocky Nuclear Past and Uncertain Future." *Bulletin of the Atomic Scientists* 71 (2015), 59. Australia has one nuclear reactor at Lucas Heights in Sydney, NSW. It was first commissioned in 1958 to support the development of nuclear power reactors which ultimately did not eventuate. It was replaced with a new reactor in 2007 and is now used primarily to generate radioisotopes for medicine.

[7] Conventionally-powered, also known as diesel-electric propulsion.

Background

Maintaining an effective submarine force of any type is difficult, and for over 100 years the RAN has pursued a submarine capability intermittently with varying degrees of success.[8] The conventional Collins Class submarines operated by the RAN are presently considered to be amongst the world's best in operational availability.[9] It has taken over two decades (the first commissioned in 1996), money (approximately AUD$1.2 billion per annum) and effort to build the RAN's submarine capability as it exists today.[10] There were periods early in the life of the Collins Class that submarine availability was low and facing significant technical difficulties, the submarine program became highly politicised, and was at risk of being cancelled.[11] Operating conventional submarines is challenging enough – nuclear-powered submarines will be significantly more so. The USN made this transition beginning nearly 70 years ago and found the technological leap difficult. A US nuclear submarine commander at the time described the challenge of the transition as follows:

> …the difference was as great as that between a bicycle and a modern automobile. The … diesel boat, like a bicycle, was slow, limited in range, and uncomfortable, but it was simple in design, easy to repair, and amenable to a display of individual dexterity and even daring by the operator. The nuclear submarine, like the automobile, was fast, capable of long-range operation, and comfortable, but it was an extremely complex and expensive vehicle requiring specialized skills and facilities for repair, and demanding caution and self-discipline more than flamboyance from the operator.[12]

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[8] John F. Schank *et al*, "Learning from Experience - Lessons from Australia's Collins Submarine Program" (RAND Corporation, 2011), 3.

[9] Finance Minister of Australia, "From Concern to Exemplar - Collins Class Submarine Sustainment," accessed January 22, 2022, https://www.financeminister.gov.au/media-release/2016/10/21/concern-exemplar-collins-class-submarine-sustainment.

[10] Marcus Hellyer, "What's the Real Cost of Australia's Submarine Capability?" *The Strategist,* August 23, 2021, https://www.aspistrategist.org.au/whats-the-real-cost-of-australias-submarine-capability/.

[11] Defence Connect "Trashing the Reputation of Collins a Political Mistake," Last Modified March 9, 2018, https://www.defenceconnect.com.au/maritime-antisub/2016-trashing-the-reputation-of-collins-a-political-mistake.

[12] Richard G. Hewlett, "Nuclear Navy 1946-1962." United States Atomic Energy Commission Historical Advisory Committee, 1974, 345.

Whilst conventionally powered submarine technology has advanced greatly, this analogy remains valid today and more so as safety standards and public expectations regarding nuclear power have risen. In addition, the RAN and supporting Australian civilian industry lack familiarity with nuclear power, which significantly compounds the scale of this challenge. The RAN is standing at the base of a Mount Everest when it comes to operating nuclear-powered submarines as it begins the steep uphill climb of developing its people for this new capability.

Operating Nuclear-Powered Submarines – People

Understanding how the RAN's uniformed workforce will complement this new capability is critical to ensure that risks to the development of the workforce are identified and appropriate mitigations applied. The Australian Defence Force's (ADF) *Defence Capability Manual* outlines the policy associated with taking the government's strategic intent and translating that into capability delivery. Key to this translation are the nine fundamental inputs to capability (FICs), which include: major systems, industry, supplies and so on.[13] Whilst all are deemed essential, one of the most critical for nuclear-powered submarines will be the "personnel" FIC that will make up the "competent workforce".[14] This workforce will be broad, consisting of uniformed personnel, public servants and defence contractors. The delivery of the first nuclear-powered submarines is not expected until the late 2030s, the development of this competent workforce will take time to establish and develop. The USN and UK's Royal Navy (RN) have world-leading experience with nuclear-powered submarine operation and excellent safety records of which they are proud.[15] The USN has accumulated over 7,100 years of reactor operation and 166

[13] Australian Defence Force. *Defence Capability Manual* (Defence Publishing, Library and Information Service), December 2020, 11.

[14] *Ibid*, 11.

[15] Department of Energy/Department of Navy "The USN Nuclear Propulsion Program Annual Report - 2020." Naval Nuclear Security Administration, 2020, 8.

million miles underway on nuclear power.[16] This safety record is underpinned by high-quality people and training. The RAN is about to join an elite group that on top of its AUKUS partners includes Russia, China, France and India. To best prepare for the introduction of nuclear-powered submarines, the RAN's future engineers and sailors will need to begin their training as soon as possible.

Workforce Development Requirement

The significant requirement for personnel to crew future nuclear-powered submarines risks placing strain on the ongoing requirement to crew the current capability, both of which must be carefully managed; it will be mitigated by treating this new workforce as a separate cohort from the current RAN submarine force. A recent analysis by ASPI mapped out the FICs associated with the project and highlighted: "Perhaps the most important of those [FICs] is the challenge of how the navy ramps up its uniformed workforce; solving that problem is just as crucial as delivering boats on time."[17] For the Collins submarines the RAN has expanded its workforce of qualified submariners from 540 in 2014 to 900 in late 2021, an expansion rate of approximately 50 per year.[18] The present intention is to grow the overall submarine workforce to approximately 2,300 personnel by the mid-2030s, in-line with the current growth rate.[19] The complex training requirements of nuclear-powered submarines will not facilitate the RAN simply transitioning its current uniformed workforce to the new submarines as they are being built, the training lead times are too long. The preparation of a new workforce, parallel to the existing capability, will need to begin many years in advance. Recently the RAN's Chief of

[16] Department of Energy/Department of Navy "The USN Nuclear Propulsion Program Annual Report - 2020." Naval Nuclear Security Administration, 2020, 1.

[17] Andrew Nicholls *et al*, "Implementing Australia's Nuclear Submarine Program," *The Strategist,* December 13, 2021, https://www.aspistrategist.org.au/implementing-australias-nuclear-submarine-program/.

[18] Economics References Committee – *"Australia's Sovereign Naval Shipbuilding Capability."* Commonwealth of Australia, October 15, 2021, 34.

[19] *Ibid.*

Navy has stated that is the intention.[20] There are two principal reasons for this separation; the first being the time required to build the necessary skill-sets. From the timelines described further within this paper, it becomes evident that the development of the right numbers of uniformed suitably-qualified and experienced personnel (SQEP) for conventional submarines can take up to ten years.[21] Training personnel for nuclear-powered submarines will take longer because of the additional layers of complexity and safety requirements involved. The second is that the current Collins uniformed workforce needs to be protected as part of the current submarine capability from the draw of personnel to the new program. Presently there are sufficient technical sailors and Marine Engineering officers (MEO) to crew the Collins submarines and work in supporting roles; however, this balance could be upset by this risk. Throughout the last decade, the RAN has been able to build its uniformed submarine workforce significantly with several carefully applied retention initiatives supported by high submarine availability; however, this has not always been the case. Throughout the 2000s, as the Collins submarines were coming into service, technical issues limited submarine availability resulted in a situation in which technical sailors and officers were leaving the service at an unsustainable rate.[22] Whilst historic workforce issues have been overcome for now, risks remain and the current capability must be protected as the new capability is developed.

Crew Size

The transition from conventional to nuclear-powered submarines means that the RAN's future submarine workforce will not only need to undertake longer and more complex training,

[20] Economics References Committee – *"Australia's Sovereign Naval Shipbuilding Capability."* Commonwealth of Australia, October 15, 2021, 38.

[21] Defencejobs.gov.au, "Marine Technician Submariner," accessed April 10, 2022, https://www.defencejobs.gov.au/jobs/navy/marine-technician-submariner.

[22] Cameron Stewart, "Critical Shortage of Crews Hits Subs," *The Australian*, March 10, 2008, https://www.abc.net.au/mediawatch/transcripts/1322_koch.pdf.

but it also will need to be larger. Larger, nuclear-powered submarines will require larger crews. The current intention is that there will be eight nuclear powered-submarines built for the RAN with the first one coming into service between 2035 and 2040 – 13 to 18 years from today.[23] At the time of this analysis, Australia is exploring nuclear-powered attack submarines (SSN) operated by the USN and the RN as possible candidate platforms. Whilst no decision is expected until approximately mid-2023, the head of Australia's Nuclear Powered Submarine Task Force recently stated that: "It is our intention that when we start the build program, the design will be mature and there will be a production run already in existence".[24] This situation will be driven primarily by a desire to minimise technical risk and to move into a construction program as soon as possible.[25] As a starting point, it is possible to make an approximation of what sized uniformed technical workforce the RAN will require based upon SSNs in-service with Australia's AUKUS partners. They are the UK's Astute Class and the USA's Virginia Class.[26] Both of these submarines are larger and displace at least twice as much of the 3,300 tons of Collins Class. The Astute is approximately 7,000 tons and the Virginia (Block IV) is approximately 7,800 tons.[27] Astute has a crew of 90 and Virginia a crew of 130 compared to the 60 of Collins.[28] Whilst these crew sizes are a big increase in terms of raw numbers, it is critical to understand what proportion will make up the nuclear engineering workforce to better appreciate the requirement.

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[23] Nigel Pittaway, "Australia Details Its Nuclear-Submarine Ambitions," *Defense News,* September 16, 2021, https://www.defensenews.com/global/asia-pacific/2021/09/16/australia-details-its-nuclear-submarine-ambitions/.

[24] "Nuclear Submarines for Australia – What Are the Options?" *Navy Lookout,* November 11, 2021, https://www.navylookout.com/nuclear-submarines-for-australia-what-are-the-options/.

[25] Charbel Kadib, "Weighing up the Options — Astute or Virginia Class?" *Defence Connect,* November 30, 2021, https://www.defenceconnect.com.au/maritime-antisub/9171-weighing-up-the-options-astute-or-virginia-class.

[26] Andrew Greene "Government Concedes Naval Ship It Promised to Build Will Now Be Bought from Overseas," *ABC News*, October 27, 2021, https://www.abc.net.au/news/2021-10-27/defence-scraps-local-ship-build-for-overseas-purchase/100572926.

[27] "Astute vs Virginia: Which Navy Has the Best Nuclear Attack Submarine?," *Naval Technology* (blog), April 15, 2019, https://www.naval-technology.com/analysis/astute-vs-virginia-best-submarine/.

[28] *Ibid.*

Submarine Engineering Departments Size

For eight nuclear-powered submarines, the RAN will require approximately four times the amount of technical sailors and Marine Engineering officers to crew the new class of submarines than its current capability. A Collins Class submarine with a crew of 60 can have up to a quarter of the crew belonging to the Marine Engineering Department.[29] Assuming the future Australian nuclear-powered submarine has a crew of approximately 120, that would equate to a Marine Engineering Department of 30 personnel based on conventional practice. Adding the additional watch-keeping and safety requirements associated with nuclear propulsion, it would likely be as high as 50 engineers and technical sailors per submarine. Eight new submarines would have an approximate total requirement of 400 engineering personnel compared to today's 90, an increase of over 300, which does not include the critical shore-based technical support or augmentation. Since the submarines are unlikely to come into service at a rate faster than one platform every three years, this transition and demand will build gradually; however, it is essential to understand the approximate scale of this increased demand. Attracting and retaining the necessary numbers of young Australians to develop this larger workforce will be challenging.

Attracting Talented Individuals

The transition to nuclear-powered submarines will amplify significantly the level of difficulty of developing the RAN's submarine technical workforce(s) – both because of the additional numbers of personnel required and the new training requirements. Attracting, and more critically, retaining submariners with the unique technical skills and temperament to operate and maintain conventional submarines are challenges that the RAN has done much to

[29] Royal Australian Navy "HMAS Collins," accessed April 25, 2022, https://www.navy.gov.au/hmas-collins.

address successfully over the last decade.[30] RAN submarine recruiting literature heavily emphasises the benefits of training, travel and camaraderie that the 'silent service' brings to its people. [31] For the transition to nuclear propulsion, the focus should be on technical proficiency and the opportunity to be involved in the pinnacle of Australia's emerging nuclear engineering capability.

The future employability and remuneration benefits must be an area of greater focus as the engineering levels of difficulty increase greatly with the complexities that come with nuclear propulsion. The RAN is going to need to recruit the 'best and the brightest' to ensure success in their training and they will need to work hard and be prepared to hold significant responsibility. The USN's Nuclear Power School leaves no doubt for potential candidates as to the challenge of their training program: "The naval nuclear program is widely acknowledged as having the most demanding academic program in the U.S. military. Academics proceed at a rapid pace with high academic standards enforced in all subjects."[32] The RAN will need to position itself as an employer of choice. This difficult task is compounded by Australia's labour market being at its most competitive in over 14 years – competition for the best will be fierce.[33] Next to consider is what sort of pre-requisite qualifications the RAN will be seeking from its future engineering officers and sailors.

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[30] "Economics References Committee – *"Australia's Sovereign Naval Shipbuilding Capability."* Commonwealth of Australia, October 15, 2021, 35.

[31] Defence Force Recruiting, "Experience a Unique Workplace," accessed April 10, 2022, https://navy.defencejobs.gov.au/submariners/overview.

[32] "Naval Nuclear Power Training Command - Nuclear Power School," Naval Sea Systems Command, accessed April 24, 2022, https://www.navsea.navy.mil/Home/NNPTC/powerschool.aspx.

[33] Peter Hannam and Paul Karp, "Australia's Unemployment Rate Falls to 4% – the Lowest since 2008," *The Guardian*, March 17, 2022, https://www.theguardian.com/business/2022/mar/17/australias-unemployment-rate-falls-to-4-the-lowest-since-2008.

Graduate Engineers Qualifications

The RAN will need to reassess the current pre-requisites for engineering officer entry in order to avoid unnecessarily constraining the field of potential applicants; the USN and RN provide informative case studies. Presently, RAN engineering officer applicants require a recognised engineering degree that qualifies for membership of Engineers Australia for entry.[34] The USN takes a different approach and does not make an engineering degree mandatory for entry, but rather:

> Candidates must be graduates or students of an accredited college or university in the United States or in a United States territory pursuing a BA, BS or MS (preferably major in mathematics, engineering, physics, chemistry or other technical areas)… and…one academic year of calculus… one academic year calculus based physics… and a minimum grade of "C" in all technical courses. [35]

In comparison, the RN does not consider applicants that do not hold a Bachelor's Degree that is not aligned to the science, technology, engineering, and mathematics (STEM) fields.[36] The approach taken by the USN is one worth considering that, by not making an engineering degree mandatory, but rather taking more aptitude based focus, it is broadening its recruiting base. This is an approach that should be considered by the RAN as it has found it challenging in recent years to achieve its submariner officer recruitment targets and will need to cast the net as widely as possible to build the future engineering workforce.[37]

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[34] "Mechanical Engineer Submariner," Defence Force Recruiting, accessed April 10, 2022, https://navy.defencejobs.gov.au/jobs/mechanical-engineer-submariner.

[35] United States Navy Careers "U.S. Navy Submarine Officer Careers" accessed May 4, 2022, https://www.navy.com/careers/nupoc-submarine-officer.

[36] Royal Navy Careers "Marine Engineer Officer Submariner," accessed April 11, 2022, https://www.royalnavy.mod.uk/careers/roles-and-specialisations/services/submarine-service/marine-engineer-officer-submariner.

[37] Australian Defence Force, "Department of Defence Annual Report 2019-2020," September 21, 2020. 98.

Remuneration for Uniformed Engineers

To attract some of the best and brightest university graduates to a career as a nuclear submarine engineer, the RAN will have to increasingly position itself as an employer of choice. Increased levels of technical expertise associated with the requirements of nuclear power will necessitate a commensurate rise in remuneration and employment conditions. Both will be necessary to attract and retain quality personnel in what will be a competitive labour market.[38] As the RAN embarks on the project to acquire nuclear-powered submarines, there is evidence it recognises the scale of this aspect of the challenge. The head of the initial Australian Nuclear Powered Submarines Task Force, Vice Admiral Jonathan Mead, AO[39] recently stated: "We are vigorously recruiting the sharpest minds in Australia to be part of the task force, so we can deliver on the government's commitment."[40] It is true the RAN will require many sharp minds as this endeavour expands. Whilst the RAN already offers an excellent remuneration package for graduates, it will be competing for some of the best graduates with Australian industry, and graduate engineering salaries in Australia average approximately $75,000 (AUD) per annum.[41] In comparison, the RAN offers what appears to be a far more attractive starting salary of $104,000 for engineering graduates.[42] One of the key competitors with the RAN for graduate engineers is the Australian mining industry, particularly in Western and South Australia where much of the mining and submarine industries are co-located. A mining engineering graduate's

[38] National Skills Commission "Skill Shortages and Labour Market Tightness: A Global Perspective" March 24, 2022, https://www.nationalskillscommission.gov.au/insights/skill-shortages-and-labour-market-tightness-global-perspective.

[39] Officer of the Order of Australia

[40] Economics References Committee – *"Australia's Sovereign Naval Shipbuilding Capability."* Commonwealth of Australia, October 15, 2021, 50.

[41] Talent "Graduate Engineer Salary in Australia - Average Salary," accessed April 11, 2022, https://au.talent.com/salary.

[42] Defence Force Recruiting, "Mechanical Engineer Submariner," accessed April 10, 2022, https://navy.defencejobs.gov.au/jobs/mechanical-engineer-submariner.

starting salary averages between $80,000 and $100,000 and "grows considerably with experience".[43] When the industry salaries are compared, there appears to be little difference. As part of a broader cost-benefit analysis for the future submarine program, the remuneration package must reflect the quality and commitment of what is required of the uniformed workforce to attract and retain the best. The USN offers a significant incentive to entice eligible graduates to join its nuclear program as explained in the following:

> There are also monetary benefits in being a part of the Naval Nuclear Propulsion Program. For example, those who are accepted in the Program can receive a generous entry bonus of up to $40,000. After joining, sailors typically advance rapidly and receive more income as a result. Sailors in the Program also receive special duty pay for their unique skills.[44]

Financial incentives could be one avenue that the RAN could utilise to attract candidates; however, it does have others.

Diversity as a Resource

Making engineering careers in submarines attractive to graduates of all backgrounds will be one of the key ways to expand the field of quality officer candidates. Engineers Australia reported in their 2020 analysis of engineering graduate statistics that: "Australia sources its engineering labour force from national engineering education programs and from permanent and temporary skilled migration programs. At present, the structural balance is weighted in favour of overseas-born engineers…"[45] While historically the ADF may have lacked diversity, this is no longer the case and it long ago recognised that this lack of diversity was negatively impacting the

[43] Graduates Australia "Salaries and Benefits for Graduates in the Mining Sector," August 18, 2019, https://gradaustralia.com.au/on-the-job/salaries-and-benefits-for-graduates-in-the-mining-sector.F

[44] Department of Energy/Department of Navy "The USN Nuclear Propulsion Program Annual Report - 2020." Naval Nuclear Security Administration, 2020, 28.

[45] Engineers Australia, "Australia's Next Generation of Engineers - University Statistics for Engineering" (Institution of Engineers Australia, 2020), 1.

organisation.[46] Today the ADF has a suite of policies designed to expand the appeal of the ADF to as broad a demographic as possible.[47]

As an example, the RAN has a target of 25 percent of those in uniform being female by 2023.[48] That number is presently 23 percent and rising and many females today serve in submarines. The USN is aware of the benefits this diversity brings and Vice Admiral Daryl Caudle of the USN recently stated that:

> Since the first women submariners joined our fleet in 2010, they have excelled in every facet of our profession. For example, 23 percent of the 2019 submarine force Junior Officers of the Year were women, despite comprising 6 percent of our wardrooms. Today, there are 100 female officers and more than 230 female sailors serving on 19 submarine crews, and 6 women lieutenant commanders have screened for submarine executive officer. We are incorporating women into the force as rapidly as we can, making sure we understand retention trends and impacts on community staffing at all levels as we integrate more crews, submarines, and homeports.[49]

This recognition of the benefits of diversity facilitates opportunities for greater numbers of high-quality recruits; however, more importantly, it is a capability enhancer.

Diversity as a Capability Enhancer

Having a broad demographic to draw upon does not just facilitate hitting recruiting targets, it can enhance the abilities of the organisation and is: "…critical to increasing capability, and to more effective problem solving."[50] As outlined throughout this paper, developing a body of uniformed nuclear propulsion expertise will be difficult; therefore, a diversity of backgrounds

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[46] "Diversity of Leadership Increases Capability" (Australian Human Rights Commission, 2014), https://humanrights.gov.au/sites/default/files/document/publication/adf-audit-2014.pdf. 53.

[47] Defence Force Recruiting, "People & Diversity," accessed April 11, 2022, https://www.defencejobs.gov.au/about-the-adf/people-and-diversity.

[48] Australian Defence Force, "Department of Defence Annual Report 2020-2021," September 28, 2021, 105.

[49] Vice Admiral Daryl Caudle, "Sustaining the Submarine Force's Competitive Edge," *Proceedings* 146, no. 10 (October 2020), 3.

[50] "Diversity of Leadership Increases Capability"…53.

will be a benefit principally through the diversity of thought and ideas that it will bring.[51] The ADF's leadership is well aware of this, and the Chief of the ADF, Air Chief Marshal Mark Binskin stated in 2017: "A diverse workforce is all about capability. The greater our diversity, the greater the range of ideas and insights to challenge the accepted norm, assess the risks, see them from a different perspective, and develop creative solutions."[52] Recent data suggests that the ADF's approach to diversity is delivering, with its most recent annual report stating: "Of the 173 candidates recruited for the 2021 Defence Graduate Program, approximately 39 per cent of graduates indicated they either spoke or wrote a second language (other than English). Collectively, the cohort has proficiency in 27 languages…"[53]

Today there are over 50 nations using nuclear power, many of which have done so for decades and have much corporate knowledge - a potential resource for the RAN.[54] The ADF has recruiting policies that facilitate immigration for suitably qualified individuals and these combined with targeted recruiting could further enhance the ADF's broad and diverse recruitment pool.[55]

Complimentary to the awareness of the value this diversity brings is a need for incentives that ensure those that join and have much invested in their subsequent training are given good reason to stay.

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[51] Sylvia Ann Hewlett, Melinda Marshall, and Laura Sherbin, "How Diversity Can Drive Innovation," *Harvard Business Review*, December 1, 2013, https://hbr.org/2013/12/how-diversity-can-drive-innovation.

[52] Andrew Greene, "Gender Diversity Crucial for Australia's Military Capability, Defence Chief Says," *ABC News*, April 5, 2017, https://www.abc.net.au/news/2017-04-05/adf-chief-says-gender-diversity-crucial-for-military-capability/8419022.

[53] Australian Defence Force, "Department of Defence Annual Report 2020-2021," September 28, 2021, 108.

[54] "Nuclear Energy - World Nuclear Association," World Nuclear Association, accessed April 25, 2022, https://world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx.

[55] Defence Force Recruiting "Overseas Applicants," Defencejobs.gov.au, accessed April 27, 2022, https://navy.defencejobs.gov.au/joining/can-I-join/citizenship/overseas-applicants.

Retention Initiatives

Recruitment and retention are both critical variables contributing to building a robust and sustainable workforce. Retention, however, is the most critical and the most difficult variable to manage as external factors often draw individuals away from service life. Retention is a challenge for militaries worldwide and Vice Admiral Daryl Caudle of the USN recently stated that as part of an initiative to retain their submariners:

> …we solicited extensive JO [Junior Officer] feedback. Learning from them, we changed the detailing process to better reward performance, offered improved career path flexibility, and implemented talent management boards to increase selection for graduate education programs and unique career-broadening experiences.[56]

As indicated in this paper, the timelines to build sufficient expertise in the RAN's technical workforce to operate nuclear-powered submarines safely will extend over years. This effort will absorb a large investment in time and money - it must be nurtured and protected. Of note, the RAN's submarine force has been a trailblazer in lateral thinking and initiatives to retain its personnel with programs that began in earnest in the late 2000s as a response to the *Submarine Workforce Sustainability Review*.[57] Key factors that led to a high separation rate of personnel at that time included: "the way Navy manages and treats its submariners; the way Navy operates its submarines; and the passion and professionalism of the submariners themselves, who have a powerfully 'mission focused' ethos that is often to the detriment of the workforce." [58] As these factors driving separation were better understood, a *Deliberately Differentiated Package* (DDP) was developed and implemented for the submarine workforce that

[56] Vice Admiral Daryl Caudle, "Sustaining the Submarine Force's Competitive Edge," *Proceedings* 146, no. 10 (October 2020), 3.

[57] Royal Australian Navy, "Navy's Response to the Submarine Workforce Sustainability Review" (Royal Australian Navy, 2009).

[58] *Ibid*, 4.

included financial incentives, better career management and block leave periods. The Director-General of Submarine Capability at the time explained it as being: "…well-constructed, offering a raft of incentives which are likely to apply and appeal, to varying degrees, to different members across the Submarine Arm." Additionally it: "…places an appropriate premium on sea-going submarine experience but also acknowledges and values the contribution of submarine experience and expertise in capability related..."[59] As a result, in part due to these initiatives, the RAN's submarine workforce numbers have stabilised and increased. A model similar to this should be replicated to complement the development of the future nuclear-powered submarines engineering workforce; which from this paper's preliminary analysis, will need to be four times larger than the current conventional submarines workforce.

Training Future Nuclear Powered Submariners

Capability Transition Hazards and Lessons

The training demands associated with the introduction of new capabilities are almost always complex and will be particularly so with the large technology differences in the transition from conventional to nuclear-powered submarines – the construction of which has: "…been described as an engineering challenge more demanding than building the space shuttle."[60] The RAN was challenged during the last capability transition as the Oberon submarines came to the end of their service lives and the Collins were entering service in the late 1990s. The Oberons were retired at a rate faster than they were being replaced by the new Collins Class, which were delayed due to technical difficulties coming out of the construction program, limiting the number

[59] Defence Force Remuneration Tribunal. "Decision - Submarine: Capability Assurance Payment." Australian Government, January 29, 2016, 5.

[60] "Nuclear Submarines for Australia – What Are the Options?" *Navy Lookout,* November 11, 2021, https://www.navylookout.com/nuclear-submarines-for-australia-what-are-the-options/.

of submarines to train personnel on.[61] As one previous Collins commanding officer stated regarding the transition: "Everything started to concertina [metaphorically collide]. You couldn't get people through the training pipeline, you couldn't get your submarines out and working, your Oberon-class boats were paying off, and you ended up with a capability gap."[62] This transition was from one conventional capability to another - conventional to nuclear presents far greater risk.[63] A robust training plan supported by the RAN's AUKUS partners will be critical to supporting the transition to nuclear-powered submarines.

Officer Training

The training of the engineering officers and technical sailors that will crew the RAN's nuclear-powered submarines will need to be carefully integrated with AUKUS partners while the necessary qualifications and sufficient expertise is established. Timelines to develop the professional knowledge required for submarine engineers to execute their roles effectively are long and challenging. It is necessary to review current practice to appreciate how much more complex the future officers' training will be with the overlay of nuclear theory and practice. Today, MEO that serve in the Collins Class submarines are highly trained and take many years to become fully employable - a fleet of eight nuclear-powered submarines will require greater numbers of this finite resource. As an example, an Astute Class submarine of the RN has five MEO's as opposed to one in a Collins Class.[64] To serve in Collins Class submarines, MEO's

[61] Thomson, Mark, and Andrew Davies. "Mind the Gap - Getting Serious About Submarines." *Australian Strategic Policy Institute*, April 2012, 11.

[62] Julian Kerr, "Applying Lessons Learned in Submarine Transition," Austrlian Defence Magazine, November 2, 2018, https://www.australiandefence.com.au/sea/applying-lessons-learned-in-submarine-transition.

[63] The UK's transition from conventional to nuclear submarines beginning in the 1960's is a relevant case study for the RAN's nuclear submarine program; however, due to the constraints of this paper and limited open-source information, it is acknowledged, but not given detailed analysis here.

[64] Peter Briggs, "Making the Shift to Nuclear-Powered Submarines: Technical Skills and Oversight," The Strategist, October 26, 2021, https://www.aspistrategist.org.au/making-the-shift-to-nuclear-powered-submarines-technical-skills-and-oversight/.

require a bachelor's engineering degree followed by approximately 12 months of naval officer and engineering specific training.[65] This is followed by submarine specific training which consists of approximately a year of classroom and simulator time, and then 12 months as part of a seagoing submarine's crew. Once qualified submariners, they then have at least another 12 months to two years to become Charge-qualified allowing them to proceed to sea as the MEO. Based on this timeline, it takes approximately eight to nine years to fully qualify a conventional submarine MEO from the time he or she commences their university studies.[66] By way of comparison, it takes approximately 16 years to develop a Charge-qualified nuclear-trained MEO within the RN training continuum.[67] Technical sailor training is likewise, significantly demanding.

Sailor Training

The senior technical sailors that will be the operators and maintainers in nuclear-powered submarines have a similar timeline to develop the critical skills they need to be proficient submariners. Whilst not requiring engineering degrees for their roles, they do require extensive classroom theory and practical training, simulator time and consolidation at sea.[68] In Collins submarines, technical sailors are employed as both system operators and maintainers – requiring a broad skill set. On average, it takes approximately 10-15 years to reach the critical Deputy MEO/senior marine technician position. These timelines demonstrate the size of the investment required to develop today's submarine workforce. Taking many years to develop and with

[65] Defence Force Recruiting, "Mechanical Engineer Submariner," accessed April 10, 2022, https://navy.defencejobs.gov.au/jobs/mechanical-engineer-submariner.

[66] *Ibid.*

[67] Peter Briggs, "Making the Shift to Nuclear-Powered Submarines: Training and Recruiting," *The Strategist*, October 27, 2021, https://www.aspistrategist.org.au/making-the-shift-to-nuclear-powered-submarines-training-and-recruiting/.

[68] Defencejobs.gov.au, "Marine Technician Submariner," accessed April 10, 2022, https://www.defencejobs.gov.au/jobs/navy/marine-technician-submariner.

significant attrition rates, both MEO and senior technical submariners are precious commodities not just for the RAN but other conventional and nuclear submarine operating navies.[69]

Training Systems

> *From the inception of the Naval Nuclear Propulsion Program, Admiral Rickover recognized that nuclear propulsion plant operators must know more than simply what to do in any given situation: they must understand why.*
>
> *— The USN Nuclear Propulsion Program Annual Report 2020*

The training framework for the RAN's nuclear submarine program is another fundamental input to capability that presents a substantial risk to program implementation. The initial and continuation training to support nuclear propulsion will need to be larger, more complex and comprehensive than anything the RAN or even the ADF has encountered before. The intention is that the Collins submarines will continue to operate into the 2040s supported by a life-of-type extension (LOTE) and many new submariners will need to be trained to man them, which results in the current submarine training facility being fully committed to that task.[70] A dedicated submarine school is located at the RAN's naval base in Western Australia supported by civilian and uniformed staff. The training package for Collins submariners consists of a mix of classroom, simulator and at-sea training; all three elements are critical.[71] The majority of the staff at the school have a background in conventional submarine service, which provides the necessary experience needed to support the training programs. As LOTE progresses, components of Collins training will become split to support legacy and updated submarines, resulting in two

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[69] Ben Packham, "AUKUS Pact: Ex-Subs Chief Peter Briggs's Warning over Workforce Fail," The Australian, September 30, 2021.

[70] "Economics References Committee – *"Australia's Sovereign Naval Shipbuilding Capability."* Commonwealth of Australia, October 15, 2021, 38. LOTE is a mid-life upgrade program that will be applied to all six Collins submarines at regular intervals.

[71] ASC "Submarine Training and Systems Centre," accessed April 12, 2022, https://www.asc.com.au/what-we-do/submarine-training-and-systems-centre/. ASC – formerly known as Australian Submarine Corporation

Collins training continuums requiring greater support. New training staff and facilities will need to be established or shared with our AUKUS allies in advance to prepare submariners for the new nuclear-powered platforms.[72] Where will the nuclear propulsion experience come from to underpin the training of the RAN's embryonic future training program? Should the RAN develop a nuclear submarine training centre of its own? Who would staff it and what would it look like? Incremental development will be possible as the RAN's experience is built; however, initial integration with the USN's or RN's training systems would be a logical pathway and, if that is the intent, it is important to understand what risks and opportunities that does present. To answer the above options and questions, it is necessary to examine how the RAN's AUKUS counterparts approach the training of their nuclear-powered submarine engineering officers and sailors.

AUKUS Partners Approach

The RN and USN both have lengthy training programs for their nuclear-trained personnel. The USN's Naval Nuclear Power Training Centre has evolved over 65 years and today supports the training of personnel in nuclear power to crew the USN's 69 submarines and 11 aircraft carriers.[73] At full capacity it consists of approximately 3,600 students and 480 staff in the training program and includes laboratories, simulators, research reactors and moored training vessels complete with operable reactors – a substantial investment.[74] The Naval Reactors annual report summarised the training commitment as:

> The Naval Nuclear Propulsion Program's unique training requirements are met by special-purpose training facilities staffed by highly qualified instructors… After

[72] To add to the complexity of the training requirements associated with nuclear propulsion is the use of high-pressure steam systems. Steam is generated by the heat from reactor operation and used to drive turbines for propulsion and electricity generation. The RAN has not had steam systems in operation for over two decades and never in submarines. This is an area of technical expertise that will need to be developed in its own right, in conjunction with nuclear reactor operation.

[73] Mark Cancian, "U.S. Military Forces in FY 2022: Navy" (Center for Strategic and International Studies, November 2, 2021), 11.

[74] Naval Sea Systems Command, "NNPTC - History," NAVSEA, accessed April 12, 2022, https://www.navsea.navy.mil/Home/NNPTC/History.aspx.

> successfully completing Nuclear Power School, hands on operator training is provided at either Moored Training Ships … or a land based prototype. In-plant training is supplemented with an extensive suite of simulation products, including various task trainers and large Engine Room Team Trainers that replicate submarine engine rooms. This hands-on training ensures that all operators have qualified on an operating naval nuclear propulsion plant before their first sea tour.[75]

While the scale of USN nuclear training requirements is considerably larger than what will be required by the RAN, it has similar key components and enablers: highly trained staff, training aids, simulators and so on. As the RAN nuclear capability evolves, integrating its sailors and officers into this continuum may be an appropriate pathway - if the USN has spare capacity. If it does not, RAN investment and co-location could be an alternate option.

The RN conducts the nuclear engineering training of its submarine officers and sailors near Portsmouth in the UK and it includes:

> …a range of training facilities including a Basic Principles Simulator used to illustrate the dynamic response of the plant and a suite of well-equipped laboratories used to provide practical training in radiation science, chemistry, materials and thermal hydraulics. The ND [Nuclear Department] also has access to high-fidelity real-time Manoeuvring Room Simulators for each class of in-service submarine, operated by the NSG [Nuclear Systems Group].[76]

Similar to the USN, the RN has a civilian nuclear industry from which to utilise particular expertise, something the RAN presently does not have access to from within Australia. Whilst it is evident that both AUKUS partners have invested heavily in initial training programs, this is only part of the picture. Maintaining operator and maintainer standards and technical proficiency building are other key components of the training framework.

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[75] Department of Energy/Department of Navy "The USN Nuclear Propulsion Program Annual Report - 2020." Naval Nuclear Security Administration, 2020, 15.

[76] Royal Navy, "Nuclear Department - Royal Navy," accessed April 23, 2022, https://www.royalnavy.mod.uk/our-organisation/bases-and-stations/training-establishments/hms-sultan/nuclear-department.

Developing Expertise

Ongoing continuation training will be an essential complementary component to the initial nuclear training that engineering officers and sailors will receive, and will be equally demanding of them. It will be a regulator mandated requirement and required to facilitate advancement.[77] This training will need to be supervised at various levels by ship's staff, sea-riding subject matter experts and independent third party authorities, both at sea and ashore. The USN summarises the criticality of continuation training in the following manner:

> Nuclear training on-board ship is every bit as demanding as it is at the schools. Newly reporting officers and enlisted personnel must completely requalify as watch-standers [referred to as watch-keepers in the RAN] and demonstrate their propulsion plant knowledge and operator ability at their new assignment. Even after qualifying, shipboard operators participate in ongoing Engineering Department training lectures, plant operational evolutions, and extensive casualty drills.[78]

A critical aspect of this training will be the requirement for training at sea; while simulation is rapidly expanding thanks to advances in technology, it is unlikely to be able to cover all training needs. Until the RAN has enough nuclear-powered submarines of its own and sufficient expertise, training opportunities on-board the RAN's AUKUS partner's submarines will be a likely component of the capability development.

There have been suggestions that leased nuclear-powered submarines, if available, might fill this need.[79] The above analysis of the training requirements identifies that this will only be

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[77] "A Guide to Nuclear Regulation in the UK" (Office of Nuclear Regulation - UK, 2016). Third-Party Oversight - The RAN's training program will require support and independent oversight from third party organizations. This will take the form of significant involvement from the Australian Radiation Protection and Nuclear Safety Authority (ARPANSA) and the Australian Nuclear Safety and Technology Organisation (ANSTO), both of whom are presently part of the Nuclear Powered Submarine Task Force. The exact nature of this involvement, however, is outside the scope of this analysis.

[78] "The USN Nuclear Propulsion Program Annual Report - 2020." Naval Nuclear Security Administration, 2020, 21.

[79] ABC News. "Could Leasing Nuclear Submarines from the US Address Australia's Capability Gap?" November 30, 2021.

feasible if leased submarines were crewed by USN or RN nuclear-training personnel and operated, in part, as training platforms for the RAN. The RAN does have a small cohort of nuclear-trained personnel that have transferred laterally from other navies. These individuals bring with them valuable expertise, but not in sufficient quantities or with the operational recency, to satisfy the scale of what will be demanding training requirements of the new submarines.[80]

Welfare of People under Training

The RAN nuclear-powered submarine training framework will need to be structured carefully and be cognisant of these pressures on members and their families to minimise training failures and avoidable separations of valuable members from the service.[81] If the training framework, at least initially, is integrated with AUKUS partners there will be a requirement for engineering officers and sailors to spend extended periods overseas conducting their training as the new submarine program becomes established. While the benefits from a capability development perspective are significant, there is also risk. Students will be subjected to lengthy and demanding training overseas, away from home. Families may or may not accompany members depending on training durations and these periods of flux will place stresses on members and families, which can drive attrition.[82] The United States Army faces similar challenges that service life can place on families and as their Chief of Staff General James McConville recently stated: "We recruit soldiers, but we retain families".[83] A holistic approach

[80] Economics References Committee – *"Australia's Sovereign Naval Shipbuilding Capability."* Commonwealth of Australia, October 15, 2021, 35.

[81] Amy Johnson, "Inside and Outside: An Investigation of Social Media Use by Australian Defence Force Partners" (Central Queensland University, July 2018), 165.

[82] Philip Siebler, "Military People Won't Ask for Help : Experiences of Deployment of Australian Defence Force Personnel, Their Families, and Implications for Social Work." (Monash University, January 12, 2017), 15.

[83] Joe Hernandez, "The U.S. Army Expands Benefits for Soldiers Who Are Parents," *NPR*, April 25, 2022.

to the management of this training framework will be critical in generating the capable workforce.

CONCLUSION

Attracting, training and retaining the 'best and brightest' to develop and sustain the RAN's future nuclear-trained submarine workforce is an extraordinary endeavour that presents significant risk. Whilst not all facets of this challenge have been explored due to the constraints of this paper, it has demonstrated that the level of effort for this undertaking to succeed will require comprehensive support from government, industry, AUKUS partners and the RAN. If not carefully mitigated, the strain will be particularly felt by the RAN, which is attempting to build an incredibly complex new nuclear submarine capability from the ground up, whilst sustaining the current conventional force, which itself is not a static entity due to the requirements of LOTE.

The RAN submarine capability was set back during the previous transition from the conventional Oberon Class to Collins Class as training plans were interrupted by technical difficulties with the new submarines. This lost ground was recovered with much time and effort and valuable lessons learned; however, these mistakes cannot be repeated with nuclear power.

The transition to nuclear-powered submarines is a huge challenge for the RAN – unlike anything it has done before. The development of the RAN's future nuclear-trained officers and sailors, key to the program's success, will require comprehensive commitment from the Australian government, the RAN and Australian industry, as well as close cooperation with Australia's AUKUS counterparts. It must succeed, as there will be no nuclear-powered submarine capability without these highly trained individuals. The future defence of Australia

will be greatly enhanced by the nuclear-powered submarine project being successful and the Australian public will expect nothing less than its success.

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