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The Australia, United Kingdom, United States (AUKUS) Nuclear Submarine Agreement: Potential Implications

Bert Chapman

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PURDUE UNIVERSITY | College of Liberal Arts

FORCES
Strategy | Security | Social Systems

The FORCES Initiative

BRNG 1240
College of Liberal Arts
Purdue University
West Lafayette, IN 47907
765 494 3666
forces@purdue.edu
http://purdue.university/forces

EDITORIAL TEAM

Professor Bert Chapman

Purdue University Libraries

chapmanb@purdue.edu

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FOREWARD

Dr. Chapman's FORCES report on the current state of the emerging southeast Pacific alliance between Australia, the UK, and the US cannot come at a timelier moment. Albeit written in the middle of a European Security Crisis, the report reminds us of the vital importance of the US Pacific Strategy. The United States has been for more than half a century by economic and political connections more of a Pacific than Atlantic power. More important, while trying to encourage the Europeans to emancipate themselves militarily, the US should renew its presence and power projection in the Pacific. Many worrisome signs indicate that this realignment is overdue, from the recent takeover of the fabled battlefields of Guadalcanal and the Solomons by Chinese interests to the increasingly aggressive stance of the Chinese Navy and strategic forces in the Western Pacific. The present report provides the necessary understanding of what is at stake and what an alliance with three major stakeholders can deliver in the long run.

As other FORCES reports, Professor Chapman's contribution highlights the work conducted at Purdue University to provide timely and practical knowledge necessary to navigate the turbulent waters of the contemporary security crisis.

Sorin Adam Matei

Associate Dean of Research and Graduate Education | College of Liberal Arts

Professor of Communication | Brian Lamb School of Communication

Director | FORCES Initiative

Purdue University

EXECUTIVE SUMMARY

- The AUKUS Nuclear Submarine Agreement seeks to enhance multinational deterrence against Chinese geopolitical assertiveness by giving Australia nuclear powered submarines.
- This agreement will pose considerable cost and technical challenges for the Australia, the United Kingdom, and the United States.
- Estimates of when Australia will be able to deploy nuclear submarines range from 2030-2040.
- The U.S. and its allies will have to make challenging decisions about where to build AUKUS in Australia.
- There is debate as to whether efforts to deter China in the Asia-Pacific should include non-Anglosphere countries in that region.
- Consideration should be given as to how China will respond to AUKUS and whether this response will include Beijing increasing security cooperation with North Korea and Russia.

OVERVIEW AND HISTORICAL INTRODUCTION

Many observers of international security developments may have been surprised when the Australia, the United Kingdom, and the United States (AUKUS) announced the September 16, 2021 signing of an agreement between these three countries which would facilitate the exchange of nuclear propulsion between the U.S. and UK with Australia. This high-profile agreement was signed by President Joe Biden, British Prime Minister Boris Johnson, and Australian Prime Minister Scott Morrison. This event was motivated by the growing power and assertiveness of China's People's Liberation Army Navy (PLAN) in the western Pacific and will result in Australia eventually receiving stealthy long-range nuclear power submarines better able to confront Beijing's increasing military assertiveness. It also reflects increasing maritime military spending in the Asia-Pacific region.[1]

Preliminary terms of this agreement were that Canberra, London, and Washington would engage in an 18-month consultation period to seek the best ways to deliver nuclear-powered submarines to the Royal Australian Navy at the earliest possible date, permitting each country to exchange Naval Nuclear Propulsion Information, and provide authorization to share restricted data. This is also the first time London and Washington have expanded the scope of this nuclear sharing agreement since these two countries signed an earlier Mutual Defense Agreement in 1958.[2]

Numerous factors motivating this tripartite agreement are derived from China's increasing geopolitical assertiveness in the Asia-Pacific region with special demonstration of this provided by PLAN's increasing military capabilities. These include its continually increasing surface, submarine, and air power capabilities, its desire to achieve greater control or dominance of its near-seas region with particular emphasis on the South China Sea; Beijing stressing that it has the right to regulate foreign military activities in a 200 mile maritime exclusive economic zone; defending commercial sea lines of communication linking China to the Persian Gulf; displacing U.S. influence in the Western Pacific, and asserting Beijing's status as the preeminent regional power and a major global power.

To achieve these goals, many believe China wants its navy to provide anti-access/area denial (A2/AD) force capability to deter U.S. intervention in a conflict in an adjacent region such as Taiwan or delaying the arrival and effectiveness of U.S. and allied forces in such a

conflict. The U.S. has responded to China's increasing assertiveness by devoting a greater percentage of its fleet to the Pacific and assigning its newest ships, aircraft, and most-skilled personnel to this region; increasing its presence and training with allied navies in this operational theater; developing new maritime warfare concepts and technologies such as unmanned and precision technologies and seeking to counter Chinese A2/AD efforts.[3]

Specific examples of China's increasing naval capability include PLAN surpassing the U.S. Navy in battle force ship numbers, their increasing technological sophistication which includes modern multi-role platforms with advanced anti-ship, anti-air, and anti-submarine weapons and sensors. This also includes weapons acquisition programs emphasizing capabilities targeting U.S. and allied surface ships, submarines, aircraft, unmanned vehicles, and command and control, computers, intelligence, surveillance, and reconnaissance systems. The Defense Department assesses that the number of Chinese ballistic missile submarines has increased from 1 in 2001 to 6 in 2021 while projecting them to reach 8 of these submarines by 2030 and 10 by 2040; China's nuclear powered attack submarines have increased from 6 in 2001 to 9 in 2021 while projecting them to reach 12 by 2030 and 16 by 2040; and the number of Chinese diesel attack submarines grew from 51 in 2001 to 56 in 2021 with this weapons platform numbers expected to decline to 55 by 2030 and 46 by 2040 as Beijing places additional emphasis on its nuclear submarine capabilities. These emerging nuclear submarines will include the Shang-class nuclear-powered attack submarine and the Jin-class ballistic missile submarine armed with wake-homing torpedoes which are difficult for surface ships to decoy and 12 JL-2 nuclear armed submarine ballistic missiles for each Jin-class submarine.[4]

U.S. NUCLEAR SUBMARINES

The U.S. Navy's Naval Nuclear Propulsion Program (also known as Naval Reactors) currently consists of 11 aircraft carriers, 50 attack submarines, and 18 strategic submarines with four of these being converted to a high-volume, precision strike platform. Its history dates back into the 1950's when it was part of the Atomic Energy Commission before becoming part of the Department of Energy (DOE) and has been part DOE's National Nuclear Security Administration (NNSA) since 2000. This program's statutory governance, codified by presidential Executive Order 12344, encompasses all aspects of naval nuclear propulsion including research, design, construction, testing, operation, maintenance, and ultimate disposition of naval nuclear propulsion plants. Program responsibilities include all related facilities, radiological controls, environmental safety and health, and selection, training, and assignment of personnel through research laboratories, nuclear-capable shipyards, equipment contractors, and suppliers, and training facilities.[5]

The USS Nautilus became the U.S. first nuclear submarine in 1955 and subsequent U.S. nuclear-powered submarines have enabled the U.S. to expand its warfighting potential to all undersea global corners with the capability to unleash deadly firepower on potential adversaries. Current U.S. nuclear submarines include Los Angeles, Seawolf, and the emerging Virginia class submarines. The Virginia class was expected to begin construction during Fiscal Year (FY) 2021 and begin supporting strategic deterrent patrols in 2031. Its nuclear reactor is designed to last for a ship's entire planned 33-year lifecycle without refueling and to support future technology upgrades and advanced payloads.

Individual Virginia class boats have an estimated annual procurement cost of approximately $3.45 billion, a planned procurement of 12 ships between FY 2020-2025, and they are jointly built by General Dynamics Electric Board Division of Groton, CT and Quonset Point, RI, and Huntington Ingalls Industries Shipbuilding of Newport News, VA. Their payload capabilities include Tomahawk cruise missiles and other payloads including large-diameter unmanned underwater vehicles, up to 24 large diameter vehicle launch tubes, acoustic and other improvements to maintain design superiority over Chinese and Russian counterparts.[6]

Historically over 142,000 sailors have been trained and qualified as nuclear propulsion plant operators. Achieving this status requires rigorous and thorough training and selection standards. Once selected for the Naval Nuclear Propulsion Program, enlisted personnel are assigned to Nuclear Field "A" School in Charleston, SC. They begin with a preparatory mathematics course and receive extensive hands-on training in equipment laboratories to teach required technical skills. After this initial training, a 24-week Nuclear Power School follows for acquiring basic academic knowledge to understand nuclear propulsion plant theory and operation. This curriculum is presented at first-year collegiate level and includes thermodynamics, reactor principles, radiological fundamentals, and additional specialized subjects. Officers, whom are all college graduates, also receive Nuclear Power School training in a 24-week graduate level course including electrical engineering, reactor dynamics, and other courses.

Following successful Nuclear Power School completion, hands-on operator training is provided for enlisted personnel and officers. 24 weeks of additional classroom training and actual instructional watchstanding experience occurs at moored training ships in Charleston or a land-based prototype in Schenectady, NY. Each student qualifies as a propulsion plant operator attaining extensive watchstanding experience and thorough knowledge of all propulsion plant systems and their operating requirements. Directed by experienced operator instructors, students learn how to operate a naval nuclear propulsion plant during normal and potential casualty stations. Prior to reporting aboard ship, they must qualify on

their watch station on an operating reactor.[7]

Maintaining and enhancing high levels of operation skill does not end with this initial training. It requires continuous augmentation as time passes. Operators and officers must continually demonstrate increasing proficiency as they qualify and serve on more demanding watch stations. Shore training facilities provide operators with advanced training in equipment repair and operation. All officers must achieve Engineering Officer qualification by passing a comprehensive examination administered by Naval Reactor Headquarters. An additional advanced training program in nuclear propulsion plant operations is conducted at this site for aspiring commanding officers of nuclear-powered warships, prototypes, and Moored Training Ships and is required more any officer taking command of a U.S. Navy nuclear powered ship.[8]

Naval nuclear program accomplishments have been applied downstream on a global scale with multiple civilian applications along with other historical, current, and emerging military education and training requirements including:

- Designing large pressurized-water reactor components and cladding for large pressure vessels.
- Containment concepts and refueling techniques for power reactors.
- A system for preventing damage to a reactor core if failures occur in the cooling system.
- The first chemical cleaning process for nuclear plant steam generators.
- Ultrasonic inspection methods for evaluating the material status of reactor vessels and major components.
- Extensive use of sold-state electronics for instrumentation, control, and power distribution.[9]

Whatever direction Australia decides on how many nuclear submarines it will purchase from either the US or UK in subsequent years it will face problems currently impacting the nuclear submarine industry in both countries. U.S. industry problems have been extensively documented in reports from the Government Accountability Office (GAO) and Congressional Budget Office (CBO). A January 2021 GAO report noted the Columbia class submarine faces challenges with lead contractor Electric Boat's computer-aided software tool which may impede construction because Electric Boat has been late in completing design products. There have also been quality problems with supplier material caused delays during early construction including missile tubes with defective welding. Shipbuilder expansion of outsourcing to suppliers has produced further delays in quality assurance oversight at supplier facilities.[10]

GAO recommendations for rectifying these deficiencies include:

- The Secretary of the Navy providing information from

the August 2020 milestone decision-making authority meeting. Such information should include updated cost and schedule information and reviewing of the independent cost assessment and assessment of the program's ability to reduce development risks.

- The Secretary of the Navy ensuring the Navy includes an update on the status of critical supplier readiness as part of its statutorily mandated 2018 Defense Authorization Act requirement to report on Columbia class program performance construction and design goals.
- The Secretary of the Navy ensuring that the Supervisor of Shipbuilding, Conversion, and Repair (SUPSHIP) work with Columbia class program management to determine whether additional materials require government source inspections and whether such inspections require taking action to ensure the shipbuilder includes inspection clauses in supplier contracts.[11]

A May 2021 GAO report indicates that Defense Department efforts to modernize the sea, land, and air components of the nuclear triad specified in the 2018 Nuclear Posture Review have experienced repeated delays and challenges leaving little or no margin for further delays without risking the nuclear deterrent. Report findings note that the Ohio class submarines have 24 missile tubes but only 20 of these can employ submarine launched ballistic missiles, and the persistence of continuing delays in Ohio submarine mid-life maintenance periods which may make the Navy unable to produce additional submarines if directed to do so by U.S. Strategic Command, while also adversely impacting Columbia and Virginia class submarine construction and costs.[12]

In January 2022, GAO released a report documenting problems with Defense Department facility sustainment funding. It revealed that aircraft, submarine, and ship acquisition initiatives are regularly prioritized over facility sustainment due to their perceived greater importance in performing Navy assigned missions. This produced a deferred Defense Department maintenance backload of $137 billion in FY 2020 with DOD officials expecting these maintenance backlogs to increase in the future.[13]

Another January 2022 GAO assessment revealed that while DOD and NNSA have begun implementing some risk management processes within their nuclear portfolios, they have failed to establish joint processes for periodically identifying, analyzing, and reporting information on these risks to stakeholders including the nuclear triad's weapons and delivery platforms. Such interdependencies may produce additional risk to individual program schedules and costs. GAO

also determined that if Columbia class submarines are not fielded by FY 2031 or if subsequent deliveries planed through FY 2040 are delayed the Navy will have insufficient submarines to meet U.S. Strategic Command requirements; assessed that DOD had not prioritized the Nuclear Enterprise Portfolio; that the Navy requested additional FY 2022 funding for the Columbia due to cost increases; and noted variations in NNSA's Office of Defense Programs program prioritizing.

GAO recommendations for DOD and NNSA in this report include:

- The DOD and the NNSA Administrator establishing a joint risk management process to periodically identify, analyze, and respond to risks affecting the nuclear enterprise and reporting to relevant stakeholders on those risks and applicable mitigation efforts.
- DOD establishing prioritization criteria for DOD Nuclear Enterprise programs, projects, and activities, including program account costs, benefits, and alternatives from recurring risk analyses and reviewing these prioritization criteria when a new component is introduced or during a strategic review.
- Following DOD Nuclear Enterprise priority criteria establishment, DOD should apply the criteria whenever portfolio changes are proposed or reviewed comparing proposed prioritization against operational requirements along with available funding and set resource capacity plans based on portfolio prioritization.[14]

Further problems in potential construction of additional submarines for AUKUS were documented in a February 2022 GAO report on Navy ship maintenance. This assessment revealed that between FY 2015-2020, that the Navy spent an annual average of $2.1 billion on high priority submarine maintenance and completed only 191 of 414 (46%) of submarine intermediate maintenance periods totaling 2,525 days of maintenance delays. This report also revealed that the Navy did not collect several data categories for submarines, surface ships, and aircraft carriers including planned and actual period maintenance costs making the Navy unable to track and improve intermediate maintenance period performance.

Comparable workforce and completion constraints in the U.S. defense industry were also identified in a February 2022 report by DOD's Office of the Undersecretary of Defense for Acquisition and Sustainment. Four challenges identified by shipyard crews and recorded by GAO in timely performance of intermediate maintenance periods include:

Crew/Workforce Shortages	Personnel shortages and not replacing personnel absent for medical/mental health reasons. Personnel lacking requisite skills.
High Operational Tempo/Scheduling	Includes long work days underway and in port. Workload and schedule demands result in sailors staying onboard in port and cancelling leave.
Limited maintenance/repair training	Poorly qualified trainers and training on obsolete equipment or equipment not used aboard ships. Limited capacity and reduced content in Navy schools and relying on on-the-job training.
Parts & Materials Shortages	Including inability to identify or locate correct parts, difficulty obtaining obsolete parts or equipment, cannibalizing items on one ship for another, lacking tools to perform maintenance, receiving refurbished parts, non-working parts, and wrong parts.[15]

GAO recommends for ameliorating these constraints include:

- The Navy ensuring shore-based maintenance providers and fleet/type commanders establish and implement procedures to collect and analyze complete and reliable data on intermediate maintenance performance for submarines, ships, and aircraft carriers. Such data should include planned and actual start and completion dates, costs, and causes of delays in completing maintenance periods.
- The Navy establishing a single entity to address challenges affecting intermediate plans for submarines, ships, and aircraft carriers.
- The Navy ensuring shore-based maintenance providers and fleet/type commanders implement a mechanism for sharing maintenance best practices and lessons learned.
- The Navy ensuring that naval maintenance-related strategic planning initiatives include problems with intermediate maintenance period performance.[16]

Meeting potential production and sustainment requirements for Australian nuclear submarines will be challenging given these long-standing problems. Such difficulties in U.S. nuclear submarine construction and capacity have been documented in 2019 and 2021 Congressional Budget Office (CBO) reports. A 2019 CBO analysis comparing submarine costs at public private shipyards found between 1993-2017 submarine maintenance costs were 31% cheaper at private shipyards. And that the average costs of Docking Selected Restricted Availability (DSRA) overhauls for Los Angeles-class submarines had risen from $20 million in the 1990s to approximately $50 million in the 2010s with 29 of these DSRA overhauls done at private shipyards and 117 at public shipyards.[17]

Maintenance and construction costs must be factored into the U.S.' potential future ability to produce nuclear submarines for Australia. The Navy owns or operates four public shipyards at the Norfolk Navy Shipyard in Portsmouth, VA; the Portsmouth Naval Shipyard in Kittery, ME; the Puget Sound Naval Shipyard in Bremerton, WA; and the Pearl Harbor Naval Shipyard in Pearl Harbor, HI. Most of the nuclear submarine work at these shipyards is performed by federal civilian employees. Private shipyards possessing the ability to build and maintain naval nuclear ships include Newport News Shipbuilding in Newport News, VA and Electric Boat in Groton, CT.[18]

Additional factors influencing shipyard maintenance costs include cost variance for overhauls in the same year and at the same shipyard due to varying material condition of individual submarines due to different operating conditions or deferred maintenance and the extent of modernization the Navy decides to incorporate into a particular DSRA. The number of labor days at public shipyards has increased from about 20,000 labor days in the 1990s to over 60,000 in the 2010s.[19]

Further concerns over the U.S.' ability to meet potential construction and delivery requirements with potential Australian nuclear submarines were documented in a March 2021 CBO report. This analysis noted that the four public shipyards have experienced delays of several years in performing submarine maintenance. These have resulted in Virginia class submarines having returned to operations nine months later than expected and Los Angeles class submarines returning four and a half months later than expected. Such delays have caused submarines to miss deployments or had sea deployments shortened reducing the number of submarines the Navy can put to sea idling expensive ships and their skilled crews. Such maintenance delays are expected to continue and exceed naval shipyard capacity in 25 of the next 30 years.[20]

Required maintenance performed in shipyards has increased and the Navy has not hired enough workers to keep pace with this enhanced workload. Over the twelve previous years attack submarine overhauls have typically taken 20-40% longer than planned in terms of the number of labor days required to complete the work and the time required for ships to spend in shipyards. Work such as this requires

security clearances which takes time and several years are required to train and apprentice workers. The Navy has also reached its goal of having nearly 37,000 new workers at public shipyards and taken steps to improve productivity including shipyard repair and redesign. CBO also projects that submarine maintenance demand will exceed labor supply over the next few decades and that the Coronavirus pandemic contributed to a 5% decrease in shipyard productivity during 2020-2021.[21]

CBO mentioned four possible options the Navy could pursue in its emerging submarine maintenance plans including improving forecasting to update class plans to more accurately reflect the actual duration of maintenance events; adding 2,500 workers to boost maintenance capacity or hire the same number of workers for private shipyards which CBO estimates would cost $275 million per year. This must recognize that hiring and training shipyard workers takes about five years from when such hiring is authorized to hiring new workers, getting them security clearances, and receiving such training to be sufficiently productive. If this can be started soon it can be accomplished before the nuclear submarine fleet grows in the 2030s and 2040s. A final option would be reducing the submarine fleet's size by approximately five attack submarines to equal shipyard maintenance capacity by acquiring older submarines early or purchasing new submarines.[22]

The U.S. will, undoubtedly, play a key role in ensuring Australia's ability to acquire and maintain nuclear submarine under AUKUS despite these problems. Concern over the U.S.' ability to meet the requirements of AUKUS and overall defense industry sustainability and supply chain security is not guaranteed and was the subject of a June 2021 interagency report directed by President Joe Biden in Executive Order 14017.[23] It is possible, however, that Canberra may decide to use British nuclear submarine parts to build its nascent nuclear submarine capability. It is now helpful to look at Britain's nuclear submarine force to learn more about its historical background and present and emerging strengths and weaknesses.

BRITISH NUCLEAR SUBMARINES

The United Kingdom has been one of the world's nuclear weapons powers since it first tested these weapons in 1952 in Australia and in 1957 at Malden Island in the South Pacific Ocean. This would facilitate multiple decades of Anglo-American cooperation on nuclear weapons subjects.[24] A 1958 treaty between London and Washington saw these two countries agree to cooperate on using nuclear energy for mutual defense matters and this agreement would be reinforced and expanded by subsequent agreements over ensuing decades. These later agreements strove incorporate changing nuclear weapon technological developments and evolving nuclear threat environments into British and U.S. military strategic planning.[25]

While the U.S. nuclear weapons arsenal

consists of land, air, and sea-based platforms (often called the Triad), the British nuclear weapons arsenal has consisted of a submarine based force since April 1969. This force, consisting of four submarines, is called the Continuous At Sea Deterrent) (CASD) and consists of at least one Royal Navy nuclear-armed ballistic missile submarine patrolling the seas undetected ready to respond to the most extreme threats facing the UK. These forces are capable of firing at several days notice and does not target its missiles at any country. British government policy is to be ambiguous about when, how, and at what scale it will use such weapons to ensure their effectiveness is not undermined while striving to complicate potential aggressor's calculations. Only the Prime Minister can authorize the use of nuclear weapons.[26]

Components of Britain's nuclear weapons program include the Atomic Weapons Establishment (AWE) in Aldermaston and Blacknest near Reading whose approximately 1,700 strong workforce is responsible for assuring, building, and replacing British nuclear warheads, the HM Naval Base at Clyde, Scotland which maintains the CASD, possesses a workforce which will increase from 6,800-8,200 and saw the 2020 opening of a £1.6 billion ($2,107,968 billion) investment program in a Submarine Center of Specialization. Submarine construction occurs at the BAE Systems Shipyard in Barrow which provides training and apprenticeships at the Submarine Academy. Nuclear propulsion systems are manufactured by Rolls Royce in Derby and Babcock supports and maintains in-service submarines at naval bases in Faslane and Plymouth support. Approximately 2,500 British companies are involved in maintaining the British nuclear deterrent's supply chain supporting thousands of jobs.[27]

Britain is initiating the process of developing the Dreadnought nuclear submarine class to replace the Vanguard nuclear submarine class beginning in 2028. This decision to retain a nuclear submarine capability was affirmed by a 2013 governmental review of nuclear deterrence options and by a July 18, 2016 House of Commons vote of 472-117 to maintain a nuclear deterrent beyond the early 2030s by building four Dreadnoughts.[28]

These four Dreadnoughts are projected to have a crew of 130, 17,200 tons displacement, be 152.9 meters long (501 feet seven inches), and have a 30-year lifespan. A December 17, 2020 British Government report to Parliament noted that the Dreadnought program had achieved 95% of its pre-Covid pandemic output; the 2020 awarding by BAE Systems of a £330 million ($432,676,200) contract to Thales UK to manufacture the sonar system for the four Dreadnoughts; that missile tube quality shortfalls which are part of the Common Missile Department have impacted the supply chain and delayed delivery; and that Dreadnought program lifetime costs have been estimated at £31 billion ($40,841,880,000) with an additional £10 billion ($13,174,800,880,000) set aside for contingency costs; and that cumulative expenditures of £8.5 billion ($11,198,580,000) had occurred as of March 31, 2020 with £1.6

billion ($2,107,968,000) being spent during financial year 2019-2020.[29]

Despite these positive developments, other British government assessments of Britain's nuclear submarine program reveal significant problems which may adversely impact its domestic programs as well as potential support of a nascent Australian nuclear submarine capability. A May 2018 National Audit Office (NAO) review of British defense nuclear capabilities noted that MOD expects to spend £5.2 billion ($6,817,928,000) on the Defense Nuclear Enterprise during 2018-2019 representing 14% of its overall budget with this including £1.8 billion ($2,360,052,000) on submarine procurement and support, £1.4 billion ($1,835,596,000 on missiles and warheads, £790 million ($1,035,800,600) on propulsion systems, and £220 ($288,450,800) million on infrastructure management. NAO also noted that the 2015 Strategic Defense and Security Review (SDSR) strove to end governance and decision-making fragmentation by creating the Defence Nuclear Organisation (DNO) and Submarine Delivery Agency (SDA) to establish a single accountability point for nuclear submarine production.[30]

This assessment went on to note that MOD has had to cut costs, identify efficiency savings, and reprogram work to keep the Enterprise affordable which has included achieving £3 billion ($3.933,420,000) of efficiency savings over the next ten years and delaying development of an Astute attack class submarine replacement by two years. NAO also noted that SDA is trying to work with contractors to address past poor performance in nuclear submarine contract costs and schedules through improved project controls, stronger collaboration and information sharing, and more rigorous oversight; asserted that MOD does not have enough qualified and experienced personnel in nuclear engineering but noted that MOD was developing skills programming and consolidated training in Scotland; and that it needs to coordinate plans to maintain submarines while also decommissioning and dismantling submarines leaving service.[31]

A 2019 NAO report documented that while MOD has pledged to dispose of nuclear submarines "as soon as reasonably practicable," it has failed to dispose of the 20 submarines retired since 1980. This has produced a situation in which MOD stores twice as many submarines as it operates with seven of these craft being in storage longer than they were in service. Government promises to dispose submarines began in 1995 with the first submarine dismantling only occurring in 2016 with the cumulative costs of maintaining and storing these submarines being £500 million ($655,570,000). Disposing these submarines requires multiple and interrelated tasks including defueling-related projects at Devonport, submarine dismantling at Rosyth and Devonport including remove radioactive submarine parts, and relying on the single contractor Babcock International Group in Babcock to carry out defueling and dismantling requirements.[32]

Additional NAO documented deficiencies in MOD nuclear submarine defueling and dismantling includes not defueling any

submarines since 2004 and not having a fully funded plan to restart defueling; an 11 year delay in a defueling facility project with a £100 million ($131,114,000) (57%) cost increase which has produced wider cost, risk and dock space ramifications with MOD paying an estimated £12 million ($15,733,680) annually to maintain and store nine fueled submarines at Devonport with these costs also including requirement to inspect, clean, and repaint stored submarines at least every 15 years; MOD needing to restart waste transportation procurement after not receiving viable bids resulting in an additional two year delay; noted that MOD was now striving to completing defueling projects in 2023; and asserted that MOD still does not have a fully developed plan to dispose of Vanguard, Astute, and Dreadnought-class submarines which have different nuclear reactor types. The projected conclusion of the submarine dismantling program is targeted to be the 2060s.[33]

A March 2021 House of Commons Library report noted that 85% of BAE's supply chain for the Dreadnought-class submarines will be in the UK potentially involving 850 British companies. However, it is unclear how much of overall program value will be spent in the UK and how much will be spent overseas with BAE contracting with a French supplier for required specialized high strength steel. In addition, MOD confirmed in December 2020 that it had spent £1 billion ($1,311,140,000) of its program contingency fund with an additional £1.3 billion ($1,704,482,000) available for the 2021-2025 time frame.[34]

The projected deployment date for these submarines is the early 2030s and they will be named HMS Dreadnought, HMS Valiant, HMS Warspite, and HMS King George VI. The Dreadnoughts are to be built into 16 units with three mega units "Aft, Mid, and Forward" to shorten the anticipated overall build timeframe. Dreadnought funding will come from MOD's core equipment budget and program costs may reach £41 billion ($53,746,740,000) making it one of the most expensive government projects with its potential costs doubling those of the London Crossrail commuter train project and triple the costs of the 2012 London Summer Olympics.[35]

A March 2021 NAO report on British defense equipment funding contended MOD had not provided sufficient funding for planned construction projects to enable them to be completed; established divergent Dreadnought funding arrangements due to program size and complexity; praised MOD for taking a more prudent funding approach on high-risk programs such as Dreadnought; and hypothesized that HM Treasury would provide additional funding for Dreadnought to offset cost increases arising from pension changes and adverse foreign exchange movements.[36]

Additional funding and staffing for the Dreadnought-class submarine must also incorporate broader funding and strategic requirements for the Royal Navy as demonstrated in a December 7, 2021 report by the House of Commons Defence Committee. This document began by noting that the 2020s will be a decade of significant

risk due to an increasingly unstainable international security environment with particular vulnerability occurring in the maritime domain due to the emergence of more assertive state adversaries, gray zone warfare, and technological risk. It noted the Royal Navy is being tasked with taking on increasing responsibilities including taking the lead in Britain's persistent engagement policy and Indo-Pacific tilt.[37]

This document proceeded to castigate the government for capping naval and defense spending while asserting that increased defense spending is required to address current and future naval capability requirements. It noted the financial costs of maintaining aging submarine and surface vessels while calling for increasing the numbers of submarines to reflect the increasing importance of undersea warfare along with increasing spending, personnel, and support shipping for this domain. Testifying before this committee U.S. Naval War College Professor Jonathan Caverley maintained:

...we need as many attack submarines as possible. Submarines are capable of doing two things. They are very good at anti-submarine warfare....Submarines are also useful for getting inside [areas that are within range of enemy weapons].[38]

First Sea Lord Admiral Tony Radakin told the committee that it is critically important that the Royal Navy be able to work with allied navies such as the U.S., India, Japan, and Australia through arrangements such as AUKUS and that such interoperability will become increasingly important. This sentiment was also echoed by other witnesses. The Committee expressed concern that Vanguard-class submarines will have to operate well beyond their planned lifespans and that Vanguard delays make it imperative that Dreadnought be delivered on time and that MOD must brief the committee annually on submarine availability to ensure program security and effective parliamentary scrutiny.[39]

The committee also expressed concern about historical and contemporary MOD shipbuilding procurement problems including the relatively slow rate at which these vessels are produced in the UK; potential labor shortages stemming from a large number of concurrent projects and an insufficiently skilled workforce in marine welding, plating and fabrication, pipe fitting, and mechanical fitting; and work concentration in particular yards leading to the risk of knock-on delays.[40]

Committee recommendations for rectifying these deficiencies include MOD emulating the U.S. Department of Defense by providing Parliament with an annual shipbuilding plan including the number of ships planned to enter and leave service each year in the next 30 years and that Dreadnought program leaders provide the committee within an annual report on program developments within six months and annually; MOD being honest with the public about the deteriorating international security situation with particular emphasis on the Indo-Pacific, the naval capabilities needed to protect Britain in this environment, and the funding required to deliver such

capabilities; and the emergence of threats such as hypersonic missiles. Additional committee recommendations include recognizing the increasing importance of the underwater domain in future naval warfare; increasing the attack submarine fleet's size; determining whether future submarine design should include horizontal or vertical missile launch systems while retaining land attack missile capability; increasing cooperation with France and interoperability with Indo-Pacific partners; and delivering existing Astute class submarines while recognizing that submarine delivery problems area prevalent with Australian and US submarine fleets.[41]

The British Government's response to the House of Commons Defence Committee report was published on February 22, 2022. It agreed with the committee's assessment of the increasingly complex and volatile Indo-Pacific international security environment; announced its ongoing public engagement efforts to promote awareness of the need to increase defense spending by referencing its 2021 Defence Command Paper and 2020 Integrated Operating Concept which include submarine capabilities as critical national security strategic components; acknowledged committee advice on future submarine attack capabilities without committing to specific class sizes, weapons system fits, or wider capabilities; stressed the importance of enhancing Indo-Pacific interoperability with the U.S. and allied partners; the First Sea Lord's desire to reduce the time ships and submarines spend being repaired and increasing the time they're available for deployment; preparing an annual report on fleet availability and shipbuilding plans; reaffirming existing MOD policy not to comment on submarine availability capabilities based on concern that this would compromise national security; and work to assess professional submarine engineering workforce skills.[42]

Britain has been involved in trilateral Joint Steering Group meetings to begin the process of implementing AUKUS. On December 9, 2021 the Joint Steering Group for Advanced Capabilities met at the Pentagon and on December 14, 2021 the Joint Steering Group for Australia's Nuclear-Powered Submarine Program met at the Pentagon. The first group saw participants identify collaboration opportunities on critical capabilities and technologies, commit to deepen and expand cooperation and interoperability; and finalize an advanced capabilities work related program by early 2022. Particular emphasis was placed on enhancing cyber capabilities, artificial intelligence, quantum technologies, and additional undersea capabilities. The second group affirmed the AUKUS commitment to enable Australian nuclear submarine capability at the earliest possible date and determined subsequent steps over an 18-month consultation period on the best way for Australia to achieve this capability and establish an enduring nuclear submarine program. Both of these groups also examined how to make sure AUKUS upholds these countries long-standing global nonproliferation activities including continuing close consultation with the International Atomic Energy Agency (IAEA)

and their ongoing support of the Nuclear Nonproliferation Treaty. This commitment to global nonproliferation was documented in a March 10, 2022 statement to IAEA.[43]

Enhanced British cooperation with Australia occurred during a January 2022 visit by Foreign Secretary Liz Truss. During her four-day visit, Truss met with leading Australian officials including Prime Minister Morrison, Foreign Minister Marise Payne, and Defence Minister Peter Dutton and discussed increasing British trade, economic, and security cooperation with Australia. She also warned about the growing dependence of Asian-Pacific countries on China and signed a Memorandum of Understanding with then South Australian Premier Steven Marshall to enhance ties with South Australian space, cyber, and green technologies industries. This agreement is also important because South Australia is the home of Australian naval shipbuilding and advanced manufacturing including Australia's submarine construction infrastructure. A February 16, 2022 virtual meeting between Morrison and British Prime Minister Johnson noted that on February 8, 2022 that an Exchange of Naval Nuclear Propulsion Agreement entered into force making it possible for the UK and US to share naval nuclear propulsion information with Australia.[44]

AUSTRALIAN CONVENTIONAL AND POTENTIAL NUCLEAR SUBMARINES

Submarines have been part of the Royal Australian Navy (RAN) for over a century. In 1914, the RAN acquired two British-built E Class submarines. The following year Australian submarines launched successful attacks against Ottoman targets in the Sea of Marmora during the Gallipoli campaign. Between 1919-1929, eight J-class submarines were given to RAN by the British Admiralty; three Royal Navy submarines at HMAS Penguin in Sydney between 1949-1969; RAN deployed six Oberon class submarines in the 1960s and 1970s, and six Collins class submarines were deployed in the 1980s and capable of quietly covering large distances quickly and quietly at depths exceeding 180 meters. Throughout their history these programs have experienced managerial and operational successes and failures.[45]

Unlike the American and British experience with nuclear submarines, Australian submarines have been conventionally powered and while Australia has nuclear science capabilities and government agencies regulating nuclear energy, there has been strong sentiment against nuclear energy within this country. This is reflected by two laws the 1998 Australian Radiation Protection and Nuclear Safety Act and the 1999 Environmental Protection and Biodiversity Conservation Act. These laws sought to prohibit construction or operation of a nuclear fuel fabrication plant, nuclear power plant, an enrichment plant, or reprocessing facility. A 2019 Australian parliamentary committee report recommended allowing nuclear energy generation through small modular nuclear reactors following results

of a technology assessment and with the consent of the local population.[46]

Enhancing Australian submarine construction capability and reliability and its domestic industrial base at the Osborne Naval Shipyard in Adelaide, South Australia were prime features of the government's 2016 Naval Shipbuilding Plan and a supplemental 2019 document both of which emphasized conventional powered submarines. An objective of this latter document was creating 12 Attack class submarines producing 1,100 direct and 1,700 indirect jobs. This emphasis on submarines increasing importance in Australia's maritime environment lead Australia to sign a contract with France in 2016 for that country to provide Australia with diesel-electric Barracuda submarines worth $A55 billion over a 25 year period. This contract would be cancelled by Australia in 2021 causing a rift between these two countries and based, in part, on U.S. concerns that this contract would weaken ties between the U.S. and Australia on Indo-Pacific security matters and that Australia needed nuclear powered submarines to more effectively respond to China's ongoing military buildup and assertiveness in this region.[47]

These factors all contributed to Australia joining AUKUS in September 2021. The Australian Government promptly established a task force to engage in a 18 month investigation to determine the best means for Australia to acquire nuclear submarines. The Australian Nuclear Science and Technology Organisation (ANSTO), which manages existing Australian nuclear facilities at Lucas Heights in Sydney, announced on September 24, 2021 that it looked forward to providing its nuclear expertise to working with other Australian stakeholders, the UK and U.S. to implement AUKUS in subsequent years by focusing on safety, training, operation, maintenance, disposal, and environmental protection.[48]

The Australian Nuclear Submarine Task Force (NSTF) is a Department of Defence entity consisting of members from the Department of Foreign Affairs and Trade, the Attorney General's Department, Department of Education, Skills, and Employment, ANSTO, and the Australian Radiation Protection and Nuclear Safety Agency. This task force, led by Vice Admiral Jonathan Mead, is charged with identifying educational and skills directions for the Australian nuclear submarine workforce to have the necessary skills to initiate and sustain a nuclear submarine program.[49] This task force notes that justifications for Australia acquiring nuclear submarines include:

- Submarines are an essential part of Australian naval capability by providing strategic advantage in terms of surveillance and protecting maritime approaches.
- Their stealth, range, endurance, and powerful weapons gives submarines the ability to operate and strike without warning. They are highly versatile and capable of striking multiple targets, collecting intelligence, conducting mine warfare, and supporting special

operations.

- As a three ocean nation relying on maritime trade and lines of communication, submarines contribute to protecting Australia and its national interests.
- They deter aggression and deny adversarial use of the sea by holding them at-risk far from Australia improving Australian access to and free use of the sea.
- Submarine defense capability is a combination of system of systems crossing multiple domains using advanced technology.
- Such deterrence capability is a combination of layering and creating systems spanning air, sea, surface, land, cyber, and systems to deliver an effect allowing Australia to shape, deter, and respond to threats.[50]

The NSTF also notes that nuclear submarines are superior to conventional powered submarines by noting that the deteriorating security environment since 2016 requires reconsideration of that year's decision to acquire conventional Attack class submarines; Australia needs the best submarine capability for subsequent decades; conventional submarines regularly needing to raise their masts above the water surface to recharge their batteries; nuclear powered submarines possessing superior stealth, speed, maneuverability, survivability, and almost limitless endurance compared to conventional submarines; nuclear submarines can deploy unmanned underwater vehicles and carry more advanced weapons and larger numbers of weapons; they can operate in contested areas with lower risk of detection and deter actions hostile to Australian interests; and nuclear submarines are the only option for meeting Australian defense requirements over subsequent decades.[51]

NSTF will use this 18 month period to determine which is the best way to purchase at least eight conventionally armed nuclear powered submarines from the UK or US including examining submarine design, construction, safety, operation, maintenance, disposal, regulation, training, environmental protection, installations and infrastructure, industrial base capacity, workforce, and force structure.[52]

Australia's potential ability to incorporate nuclear submarines into the RAN fleet by the 2030's can be assessed by examining reports on Australian submarine program management performance produced by the Australian National Audit Office (ANAO), Australian parliamentary committees, the government-funded Australian Strategic Policy Institute (ASPI), and RAN. A January 2020 ANAO report on Australia's Future Submarine Program (FSP) observed that the Defense Department (Defence) had adopted risk management methodologies to identify and assess program risk while noting that this department had identified a more than three year FSP delay would create a gap in RAN submarine capability. An ANAO conclusion was that FSP was experiencing a nine-month delay in the design phase

against pre-design contract estimates resulting in extending two major contracted milestones. Consequently, Defence cannot demonstrate that its $A 396 million ($296,823,780,000) FSP design expenditure has been effective in achieving two major program design milestones and that design expenditure on the FSP's material component represented 47% of all program spending as of September 2019.[53]

Criticism of governmental spending and the management performance of government programs is common in democratic countries. Such criticism of FSP was reflected in a November 16, 2020 letter from opposition Labour party Deputy Leader and Shadow Minister for Defence Richard Marles to Auditor-General Grant Hehir. Marles maintained that significant increases in the FSP program were withheld from the public and Parliament for several years with Marles contending that the $A 50 billion ($37,477,750,000) cost quoted by the government had risen to $A 80 billion ($59,964,400,000) by 2019 while expressing concern that the government had knowingly used incorrect figures in public statements. In his December 11, 2020 response to Marles, Hehir noted that he had written to the Departments of Defence and Finance to seek additional information about FSB cost estimation practices. Hehir's March 19, 2021 letter to Marles said these departments 2020 advice to Parliament was based on Defence maintained financial information and that ANAO would include FSP as a proposed performance audit in its future work program.[54]

A December 13, 2021 ANAO report noted the arrival of AUKUS as a key component of its oversight scrutiny of FSP financial and management performance. ANAO noted that cancellation of purchase of 12 conventional Attack class submarines stemmed from deterioration in Australia's strategic environment and was not related to Attack class submarine program performance. This assessment also noted that the 2020-21 FSB budget was $A 488.7 million ($366,307,529,000) and that the long-term total approved budget for this project was $A 5,655.4 billion ($4,239,033,347).[55]

Concern over management of the FSP program and domestic Australian political contentiousness between the governing center-right Liberal/National Party and the leftist opposition Labour Party were reflected in two interim reports issued in May 2021 and February 2022 by the Australian Parliament's Senate Economic References Committee. This report questioned why Australia initially contracted with France to produce new submarines in 2016 when other possible contractors were Germany's Thyssen-Krupp Marine Systems and Japan's Soryu class boats.[56]

The committee report also expressed displeasure at what it considers to be Defence opaqueness, obfuscation, and lack of accountability concerning naval shipbuilding expenditure. Examples of committee concerns included a $A 38.5 billion ($28,857,867,500) discrepancy between naval shipbuilding figures reported in 2015 and projected in 2020; the committee failing to receive documents on naval industrial shipbuilding capacity

or redacted documents on this from the Defence and this department providing misleading answers to committee questions.[57]

Recommendations made by committee opposition members in this report included Defence and government reporting to Parliament on discussions undertaken with alternative submarine builders on successor boats to Collins-class submarines; providing unredacted versions of renegotiated contracts to the Senate Economics References Committee; and Defence examining how it trains its staff to be aware of its obligations to enable Parliament to be answerable to the Australian public through providing information assisting parliamentary oversight activities. Coalition Senators on this committee dissented from report findings by recommending that it is not in the national interest of the of participating countries or companies for detailed contractual information to be publicly released; they disagreed that Defence officials had been deficient in disclosing information to the committee due to its national security relevance; and that the government must pursue continuing and active engagement with Australia's shipbuilding industry to achieve and robust and efficient procurement process to produce a vibrant domestic naval shipbuilding industry to meet national security requirements which they maintain were neglected by Labour governments.[58]

A supplemental February 2022 interim report by this committee noted the initiation of the AUKUS program reinforced conclusions and concerns expressed in the May 2021 report about Defence candor and governmental and shipbuilding industry financial management. It noted former coalition Prime Minister Malcolm Turnbull calling the decision to cancel the submarine contract with France "a diplomatic debacle of the first order and the consequences being that it has undermined Australia's honour, security, and sovereignty.," questioned Australia's ability to handle the infrastructure required of a nuclear submarine industry including long-term storage of spent reactor fuel of high-level waste; the possibility that the costs of a nuclear submarine program could be $A116-171 billion ($86,948,380,000-$128,173,905,000); that it might not be until 2038-2040 that Australia could begin receiving nuclear submarines; and that Australia may want the ships to be built in Australia for domestic political reasons instead of the UK or US.[59]

Recommendations made by committee opposition members included stressing bipartisan support for AUKUS to ensure delivery of this critical material capability while also urging the government establish an bipartisan process to ensure AUKUS partnership implementation and timely delivery of AUKUS objectives and military capability; that Defence provide in publication a suitable format explaining discrepancies between 2016 and 2020 FSP funding totals; and Defense reporting back to Parliament on its progress in training staff on the importance of providing timely and transparent information to Parliament and the public.[60]

In their dissenting report, Coalition

committee members said the majority report did not give fair or reasonable recognition to the positive steps they believe the Coalition Government has taken concerning Australian sovereign shipbuilding capability. They described AUKUS as a change in Australian strategy, but not capability, while noting that the Association of Southeast Asian Nations (ASEAN) would remain critical to Australian regional engagement. These Senators also noted that AUKUS is also a framework facilitating deeper practical cooperation to develop leading-edge military capabilities and technologies ensuring Australia remains a major Indo-Pacific security partner. Additionally, Coalition committee members noted the government intends for the future fleet of nuclear submarines to be built at South Australia's Osborne Naval Shipyard, that ongoing naval shipbuilding, including submarines, will occur at the Australian Maritime Complex in Henderson, Western Australia, and that the Coalition Government is spending far more on defense than the previous Labour Government. Coalition committee member recommendations included contending that the Coalition Government regularly provides defence briefings to relevant opposition members including the Shadow Minister of Defence; that the government and Defence are subject to proper parliamentary oversight through the budget process, parliamentary committees, and Question Time; and that Defence has been consistent in answering questions about the FSP.[61]

An exhaustive assessment of the infrastructure and technical requirements needed for Australia to build and maintain a nuclear submarine infrastructure is provided in a December 2021 study by the government-funded Australian Strategic Policy Institute (ASPI). This organization noted that this would probably be the largest and most complex construction project in Australian history facing enormous challenges, costs, and risks; require at least two decades; and tens of billions of dollars in sunk costs before Australia has a useful nuclear-powered military capability. It will require NSTF deciding to choose the UK Astute class submarine or the US Virginia class submarine and whether the UK and US have the capability assist Australia in delivering military effects, industrial base capacity, and workforce training.[62]

ASPI also noted that submarine design modification would have to occur due to national regulatory and safety regimes; the need to build submarines continuously in a 30 year cycle, since existing Collins class submarines are due to be obsolete by the government's aspirations of delivering the first nuclear powered submarine by the early 2030s; the possibility of Australian nuclear submarines adopting a production model similar to the Joint Strike Fighter where Australian companies would be directly involved in submarine production with either American or British companies; properly training the Australian submarine workforce; and ASPI's cost estimate that an eight boat nuclear submarine program will cost between $A70-$116 billion ($ 52,468,850,000- $86,948,380,000) depending on inflation.[63]

This report proceeded to provide analysis of possible outcomes including determining possible national supplier partners who must assist Australia in designing, building, operating, and sustaining the submarines and their operational assets; the best ways to build the submarine while maximizing Australian industry participation in the program and the best way to build nuclear submarines; the need for the Australian Submarine Task Force to consider all factors involved in building an effective military force; andthe program's delivery schedule with the government indicating that the late 2030s would be the time frame for an operational nuclear submarine capability to occur.[64]

Additional factors stressed by this ASPI report include the need for Australia to develop a nuclear industrial capacity to maintain and sustain nuclear submarines operating out of Australian facilities; recognizing that a conventionally powered Collins submarine traveling from the HMAS Stirling Base in Western Australia would take nearly 20 days traveling 3,500 nautical miles at a speed of 18 knots to reach the South China Sea, could only patrol there 11 days and need 30 days to return while requiring it to surface several times to recharge its batteries and make it vulnerable to detection from ships, submarines, and satellites due to its increased heat, noise, and radar signatures. By contrast, a nuclear submarine could make this journey to the South China Sea in seven days at speeds of 20-25 knots, stay on patrol 75 days, and require a another seven days to return enabling it to spend 600% additional time on patrol without surfacing and rapidly relocating to other operational areas if security conditions required.[See Figure 11].[65]

The following table from this study demonstrates the difference in submarine power capacity between Collins, Astute, and Virginia class submarines:

	Peak power (Megawatts thermal heat)(MWTH)	Peak Power Megawatts electric (MWe)	Average Power (MWe)
Virginia Class	210.0	42.0	17.0
Astute Class	145.0	29.0	11.6
Collins Class	5.2	4.2	0.6[66]

ASPI went on to assert that while the UK and US face capacity constraints in their nuclear submarine programs, the U.S. has better size, depth, and capacity with its naval and private sector submarine building industry in areas including nuclear propulsion technology, safety and reliability, and training sailors on reactors; that Australia should not be responsible for storage of high-level nuclear waste since it has no experience or expertise in this area; the number of RAN submariner

personnel will have to grow from 900-3,000; the desire to maximize Australian industry participation could produce increased subsystems and components which would potentially increase program cost, schedule, and risk; questioned whether submarine maintenance could be done by an existing dock in Sydney or whether building new dry docks in Adelaide would be required; determining whether these submarines should be based on Australia's west, south, or heavily populated east coasts will politically challenging; the need to alter the current legal prohibitions on licensing, building, and operating a nuclear fabrication plant in the 1998 Nuclear Safety Act and 1999 Environment Protection and Biodiversity Conservation Act and state and territorial legislation regulating nuclear and radiation activities; determining which agency(ies) will regulate nuclear submarines; determining whether the workforce should be all Australian or a mixture of imported American and British workers and Australians; and determining whether to use highly enriched uranium (HEU) or low enriched uranium (LEU) naval reactors. The U.S., UK, Russia, and India use HEU nuclear reactors in their submarines while China and France use LEU nuclear reactors in their submarines. [67]

RAN reports have also scrutinized multiple factors required for developing and deploying a nuclear submarine fleet. A 2021 assessment noted that providing solutions to workforce, sustainment, and nuclear technical capability are key challenges this force will face in the coming decade. It also observed that significant efforts will be required to enhance submariner recruitment and retention to counter a diminishing submarine workforce. Examples of such methods Defence should be engaging in to incentivize submariner careers include conducting tours of Navy ships; science, technology, engineering, and mathematics partnership programs; fitness preparation programs; and a national competition rewarding applicants with a tour of a submarine. This document also suggested Australia should look at ways the UK has been able to raise submariner's profiles without compromising national security.[68]

This work also expressed concern that RAN recruitment has failed to distinguish submarine service from the rest of the fleet and that future naval recruitment should highlight the secretive and exciting nature of submarine service by linking it to an individual's need for national recognition. This can be done by highlighting past submarine force achievements including creating specialized submarine exhibitions and documentaries and using the Australian War Memorial to tell stories of historical service on Australian submarines. Additional steps the government should take to enhance submarine workforce development is integrating a civilian nuclear energy workforce capacity into RAN requirements so nuclear submariners can serve in this industry following their naval careers; including nuclear specialists as a priority migration skilled occupational list; developing partnerships with universities and the defense industry; and stressing the nuclear submarine force as being Australia's foremost strategic deterrent.[69]

Additional debate considers where Australia should deploy its nuclear submarines upon completion. Adelaide and Stirling have already been considered as possible options. In March 2022, Prime Minister Morrison announced possible Australian east coast basing options include Brisbane, Port Kembla in Wollongong, and Newcastle though a problem with this last site is that this port is 50% Chinese owned. The ultimate decision on purchasing nuclear submarines will be made after the May 21, 2022 national election in which Morrison's center-right Coalition Government could be defeated by the center-left Labour Party opposition lead by Anthony Albanese which has said it conditionally supports AUKUS with these conditions including not supporting a domestic civil nuclear industry, not acquiring nuclear weapons, and continued compliance with the Nuclear Nonproliferation Treaty.[70]

Another potential RAN nuclear submarine base option is Lombrun Naval Base on Manus Island in Papua, New Guinea. This facility has experienced naval activity since World War II and been the subject of European historical interest since Spanish exploration in the 16th century and during World War I. More recently it served as a detention and processing center for individuals seeking asylum in Australia. During July 2018, Australian Prime Minister Malcolm Turnbull and Papua New Guinean (PNG) leader Peter O'Neill discussed possible base redevelopment with Vice-President Mike Pence announcing U.S. support for this initiative in November 2018. In May 2021, Acting U.S. Ambassador to Papua New Guinea Mike Goldman emphasized that the U.S. had strong expectations for the potential scale and capability of this naval base without offering U.S. financial support or direct negotiations with PNG.[71]

A 2021 RAN study stressed Manus Island's strategic value to Australia as follows:

> There are three reasons why Australia continues to be interested in Manus. First, the islands are proximate territory through which a conventional military attack would most likely originate.... If a hostile great power possessed a forward operating military base, they would be more capable of undertaking a conventional attack upon the Australian mainland with lower risks, fewer capabilities and sustain the operations longer than if they were forced to launch the assault from more distant areas. Since Europeans first settled Australia it has been an enduring security anxiety that a hostile great power may acquire a foothold within the Melanesian Arc-which stretches from East Timor to Papua New Guinea, Solomon Islands, Vanuatu, New Caledonia, and Fiji-flanking most of the north and north-east of the continent.[72]

This RAN analysis went on to stress that Australian sea lines of communication (SLOC) to Asia and North America pass through this area and that Japan's 1942 occupation of New Caledonia, Fiji, and Samoa established air and submarine bases which sought to disrupt supply routes between the U.S. and Australia. If

tensions escalate in the South China Sea and the Straits of Malacca, it would increase the desirability of alternative routes through Indonesia including Sunda Strait and Lombok Strait that would enhance Lombrun and Manus' attractiveness. China has expressed interest in developing PNG ports at Wewak, Kikori, Vanaimo, and Manus Island and media reports in March 2022 announced that China had signed a draft security cooperation agreement with the Solomon Islands which are 1,133 miles from PNG which would enable the Solomon Islands to request China sending police and military personnel and potentially establish a military base. Australian Defence Force Joint Operations Commander Lieutenant General Greg Bilton said the possibility of a Chinese base in the Solomon's would require Australia to change its patrolling patterns, maritime awareness activities, and the strategic calculus if Chinese navy vessels operate in this area since it puts them much closer to the Australian mainland. In partial response, Australia's High Commissioner (Ambassador) to the Solomon Islands Lachlan Strahan announced an extra $A 20 million ($14,870,480) in assistance to that country including extending the Solomon Islands International Assistance Force until December 2023 and building a radio network and second border patrol boat outpost.[73]

This RAN assessment made various capabilities and cost estimates for Manus Island including

Option 1 Maintenance Hub for Pacific Patrol Boats	Use for 21 Guardian Class patrol boats built by Australia for various Pacific Island countries.	$A 26.55 million $19,900,685,000
Option 2 Mothballed Launch Pad	Build sufficient infrastructure to be used on short notice for full spectrum operations.	$A 414 million 310,315,770,000
Option 3 Strategic Observation Post	Expand Australian forward surveillance capability into South East and East Asia using piloted and unpiloted aircraft	$A 281 million-$1.011 billion $210,624,955,000-$757,800,105,000
Option 4 Forward Operating Base	Assist and simplify RAN and Royal Australian Air Force forward operations by enhancing warfighting capabilities, strategic presence, implant strategic uncertainty in opponents minds, and be more attractive for submarines	$A 807.1 million $604,965,841,000

Option 5 Geostrategic Strongpoint	Develop Lombrun Base as the point of Australian geopolitical spear; use to project Indo-Pacific influence and launch sea control operations; serve as a hardpoint in Australian maritime layered defense to complicate or prevent opponent seapower projection into the Melanesian Arc; and integrate into emerging U.S. Indo-Pacific strategy.	$A 3.737 billion ($2,801,087,035,000).[74]

An updated demonstration of Australian submarine budget priorities for the upcoming fiscal year and presented ahead of a projected May 2022 parliamentary election was made in a defense portfolio budget document submitted to the Australian Parliament by that country's Minister of Defense Peter Dutton in the annual budget speech made March 29, 2022 by Australian Treasurer Josh Frydenberg. This document called for spending $A 425 million ($318,560,875,000) on AUKUS nuclear submarine capacity for fiscal year 2022-2023 and the upcoming election results and subsequent security environment and program planning and building developments will determine how accurate this initial spending proposal is.[75]

Australia, the United Kingdom, and United States being able to sustain AUKUS program development and sustainment will require considerable political will and strategic persistence over the next two decades. There is ample literature documenting increasing Chinese geopolitical assertiveness in the maritime buildup as reflected in their conventional and nuclear force structures and behavior in numerous global oceanic venues. The 2021 U.S. Defense Department report on Chinese military power documents that China has the world's largest navy consisting of approximately 355 surface ships and submarines; that it has enhanced its antisubmarine warfare inventory and training to protect its aircraft carriers and ballistic missile submarines; and that it currently operates six nuclear-powered ballistic missile submarines, six nuclear-powered attack submarines; and 46 diesel-powered attack submarines. It is expected that by the mid-2020s China's nuclear powered attack submarine capabilities will include the Type 093B Shang guided-missile attack submarine capable of providing a clandestine land-attack option if equipped with land-attack cruise missiles. Although China does not have a robust deep water antisubmarine warfare capability it is enhancing its antisubmarine warfare assets and training to better protect high value targets such as aircraft carriers and submarines while striving to increase the importance of ASW in achieving broader

maritime goals including open seas protection and preserving access to the Indian Ocean and Western Pacific.[76]

China also seeks to exert coercive leverage over its Indo-Pacific neighbors, including Australia, by using its growing ballistic missile arsenal as documented in the current report on this subject produced by the U.S. Air Force's National Air and Space Intelligence Center with the following two tables demonstrating the numbers and ranges of Chinese intercontinental ballistic missiles (ICBM's) and submarine and ship-launched ballistic missiles:

Intercontinental Ballistic Missiles

Systems	Number of Stages	Warheads Per Missile	Propellant	Deployment Mode	Maximum Range (km)	Number of Launchers
CSS-3 ICBM	2	1	Liquid	Transportable	5,500+	10-15
CSS-4 Mod 2 ICBM	2	1	Liquid	Silo	12,000+	About 20
CSS-4 Mod 3 ICBM	2 +PBV	Multiple	Liquid	Silo	12,000+	About 20
CSS-10 Mod 1 ICBM	3	1	Solid	Road-Mobile	7,000+	15+
CSS-10 Mod 2 ICBM	3	1	Solid	Road-Mobile	11,000+	15+
DF-31AG ICBM	3	Unknown	Solid	Road-Mobile	Unknown	16+
CSS-20 ICBM	3+PBV	Multiple	Solid	Road-Mobile	Unknown	16+[77]

Submarine and Ship-Launched Ballistic Missiles

Systems	Number of Stages	Warheads Per Missile	Propellant	Deployment Mode	Maximum Range (km)	Number of Launchers
CSS-N-14 (JL-2) SLBM	3	1	Solid	JIN Sub	7,000+	48
JL-3	3	Multiple	Solid	Type 096 Sub	10,000+	Not available[78]

The AUKUS agreement has produced mixed reactions among Australia's neighbors. Indonesian and Malaysian leaders expressed concern to Morrison that AUKUS could instigate a regional arms race in Southeast Asia and cause countries to act more aggressively in the South China Sea while Cambodia expressed alarm about AUKUS and how it might impact international nonproliferation commitments. Indonesian Defense Minister Prabowo Subianto later said he understood and respected AUKUS following direct communications with Australian Government leaders. Philippine President Rodrigo Duterte castigated AUKUS as an "arms race", but Manila's Secretary of Defense Delfin Lorenzana and Foreign Minister Teddy Locsin said Australia had every right to strengthen its defense. Thailand, Singapore, and Vietnam presented more measured responses saying each country is responsible for its own security and should strive not to contribute to a regional arms race. There has also been sentiment for expanding AUKUS to other Asian countries including Japan, India, South Korea, and Association of Southeast Asian Nations (ASEAN) countries although opposition to South Korea acquiring a nuclear submarine capability has been expressed on practical operational grounds.[79]

As AUKUS countries prepare to embark on this program and its possible use in military operations against China, they should heed the advice expressed in an Australian Defence and Security Studies Journal analysis on ten questionable assumptions about a future Indo-Pacific war. These include:

- Not assuming the Chinese way of war is similar to the West's. Chinese strategic culture and operational mindsets stem from their continental power status and fending off foreign invasions by extensively using political, psychological, and kinetic operations.
- Viewing the West as being in competition with China such as an athletic competition or business rivalry. China actually sees itself as being in a continuous struggle or Long March against the West consisting of united front political warfare, new generation warfare, and non-war warfare.
- China is not a serious rival since its defense spending is only ¼ of the U.S. defense budget. When using Purchasing Power Parity methodology as a measure Chinese defense spending rises to nearly 70% of U.S. defense spending, but when lower costs of Chinese personnel spending are included, Chinese defense spending reaches 90-120% of U.S. defense spending.
- Beijing initiating a major war against Western allies is too risky to happen. China could engage in such a war if confronted by a failing

economy; rapidly aging workers; a resurgent U.S.; rising dissent in the Communist Party or a direct challenge to its survival might cause Beijing to conclude that drastic action such as reunifying Taiwan may be needed to deliver the "China dream" and unite the country.

- The West has superior strategies, operational concepts, and forces. Chinese military transformation has rapidly narrowed its technological and operational proficiency gaps with the U.S. Beijing will make extensive use of disinformation and breaking the political will of its adversaries in future conflict scenarios based on U.S. experiences in Korea, Vietnam, and potentially Afghanistan and political will play a decisive role in a Sino-Western military confrontation.
- A major war will be geographically limited. China's military development and capability acquisition programs make clear that it will engage in heavy cyber and space attacks, sabotage operations by insiders and special forces, long-range missile and air attacks, mining, and other attacks against allied military assets and civilian infrastructures.
- A future Indo-Pacific war would be short. China is preparing for an extended, multidimensional, and very complex war, has many strategically important military assets underground, hardened strategic communication systems; developed large fuel, spare parts, and food reserves, and promoted a national narrative with formidable information control, and taken steps to prepare China psychologically for a lengthy struggle.
- It is enough for the west to plan for a single phase kinetic conflict instead of a conflict continuum. China sees war as a multi-layered continuum based on Mao Zedong's belief that if communist forces fight powerful advanced technology opponents they must ensure the conflict is protracted by undermining and dividing enemy communities and disrupting opposition campaigns.
- Non-military capabilities will be peripheral in a future major war. Emerging U.S. and allied Western Pacific military capabilities are just geared toward conducting conventional advanced military operations. The West should place increased attention on preparing for extended conflict going beyond military activities and incorporating non-military

elements.

- The West has the best structures for planning, preparing, and commanding next-generation warfare. The U.S. and its allies have not fought a major power opponent since the Korean War and have not hardened, dispersed, or protected key personnel and systems. Difficult to manage and clumsy acquisition systems ensure that it takes 20-40 years for new aircraft, ships, and tanks to be delivered into service. This poses an acute disadvantage to fast-moving defense acquisition systems of China and other dictatorial militaries which is exacerbated by western deficiencies in the second and third kinetic layers of major military conflict.[80]

RECOMMENDATIONS AND SOLUTIONS

Building and successfully deploying AUKUS nuclear submarines will prove to be formidable challenges for Australia, the United Kingdom, and United States. It will require ongoing patience and persistence by all three countries despite political governance changes in subsequent years, the need for consistent funding streams, transcending news about inevitable cost overruns, management problems and program delays, pressures to divert funding from AUKUS to existing domestic political and social objectives, being attentive to a continually changing Indo-Pacific maritime threat environment, and coping with other national security challenges such as the 2022 Russian military aggression against Ukraine, potential military action by rogue nations such as Iran and North Korea, and other potential transnational military scenarios which may emergent in subsequent years.

POLITICAL/MILITARY/TECHNICAL

- Proceed with program with acute awareness of cost overruns, potential management problems, delays, and evolving international security threat environment.
- Recommendations for the U.S. broken down by governmental entity for implementing and effectively overseeing AUKUS should include:
- The Chief of Naval Operations shifting the submarine tender's homeport to Australia to incentivize Australian sailors and maintainers learning the requirements of supporting nuclear-powered submarines.
- Opening U.S. Navy nuclear training facilities to the Royal Australian Navy creating fresh cadres of nuclear submariners ready to go to sea while also training future Australian nuclear-power instructors to

facilitate eventual development of an indigenous Australian nuclear-power training pipeline.

- Increasing submarine port visits and expanding nuclear maintenance at Australian ports where nuclear facilities are located while also considering potential long-term Australian basing.
- The Secretaries of Energy and the Navy should direct the Naval Reactors program to establish field offices in Australia which are critical to Australia's nuclear submarine program to assist with future submarine manufacture, maintenance, and training while inviting Canberra to create a parallel institution.
- The Director of National Intelligence should establish a consultation forum for sharing naval nuclear information with Australia based on the existing Five Eyes Intelligence sharing agreement providing a trustworthy basis for securely handling sensitive information.
- The Secretary of State should expand the existing 1958 U.S.-UK nuclear agreement to include Australia.
- House and Senate congressional leaders should establish a joint congressional coordinating working group on AUKUS. This will require the Navy to receive sustained congressional support on a decades long project to assist in building Australia's nuclear submarine program, forward-basing U.S. Navy personnel and platforms, and enhancing the U.S.-Australian alliance for forthcoming generations.
- Explore possibility of expanding AUKUS to other Indo-Pacific countries.
- Continual and candid public information campaigns from participating national governments on why AUKUS is essential for the economic and national security of these countries and their allies in view of emerging Chinese maritime and geopolitical challenges.
- The need for Australia to achieve rapprochement with France and include Paris as a valued partner in consulting about future Indo-Pacific strategic policies given France's historical and contemporary influence in this region.
- The need for rigorous and effective congressional and parliamentary oversight of AUKUS to ensure that it remains on time, meets operational objectives, and does not have inordinate cost overruns and production delays.
- AUKUS countries remaining continually aware of submarine warfare technological and

strategic developments by China and other hostile international actors and incorporating countermeasures into submarine construction and military doctrine.

- Being agile in responding to Chinese attempts to thwart or deflect AUKUS development and deployment through diplomatic, economic, information, and covert or overt operations.[81]

GEOSPACIAL AND PICTORIAL INDEX

FIGURE 1: U.S. NAVY VIRGINIA-CLASS NUCLEAR SUBMARINE

Source: U.S. Naval Institute[82]

FIGURE 5: BRITISH DREADNOUGHT CLASS NUCLEAR SUBMARINE

Source: UK Ministry of Defence[83]

FIGURE 3: ROYAL AUSTRALIAN NAVY COLLINS CLASS SUBMARINE

Source: Royal Australian Navy[84]

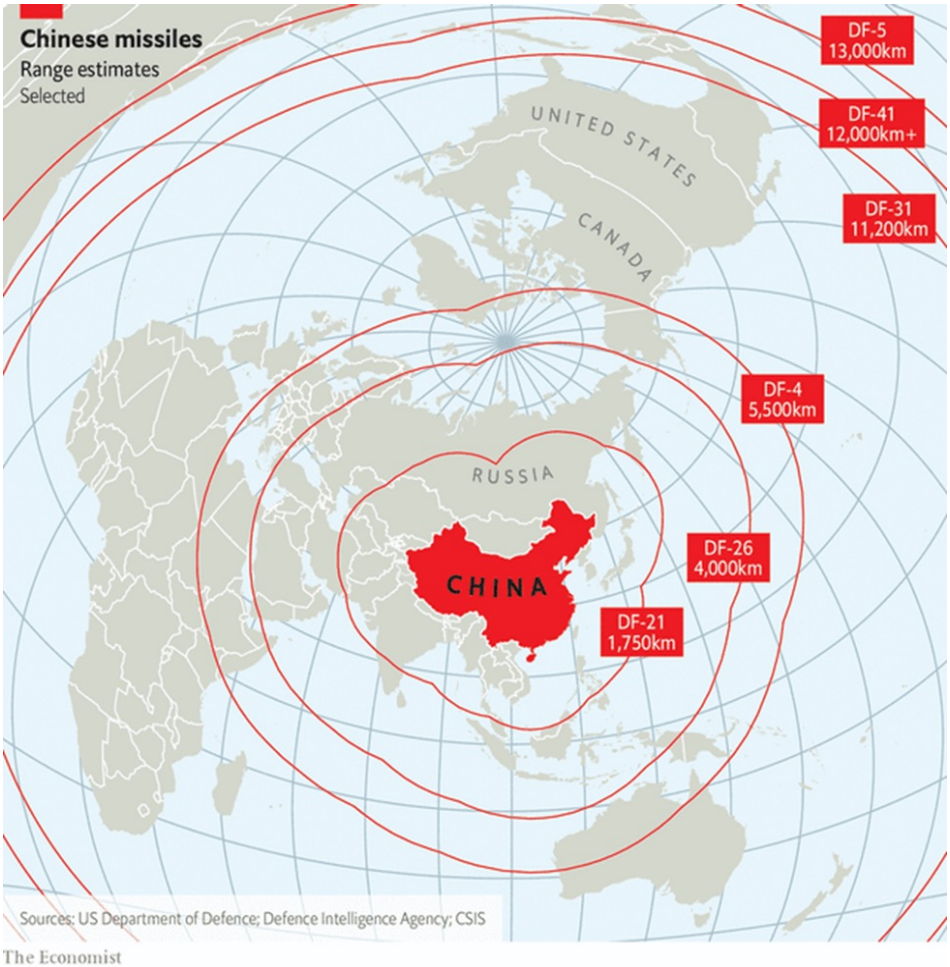
FIGURE 4: ROYAL AUSTRALIAN NAVY SHIPYARD-OSBORNE NEAR ADELAIDE, SOUTH AUSTRALIA

Source: Australian Department of Defence[85]

FIGURE 5: ROYAL NAVY SUBMARINE AT HM NAVAL BASE CLYDE, SCOTLAND

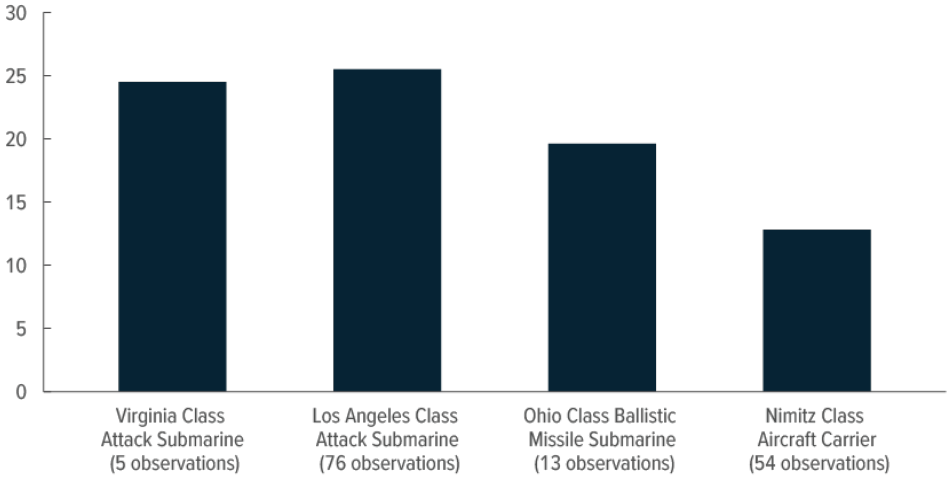
Source: UK Government, Delivering for Scotland[86]

FIGURE 6: CHINA ICBM MISSILE RANGES



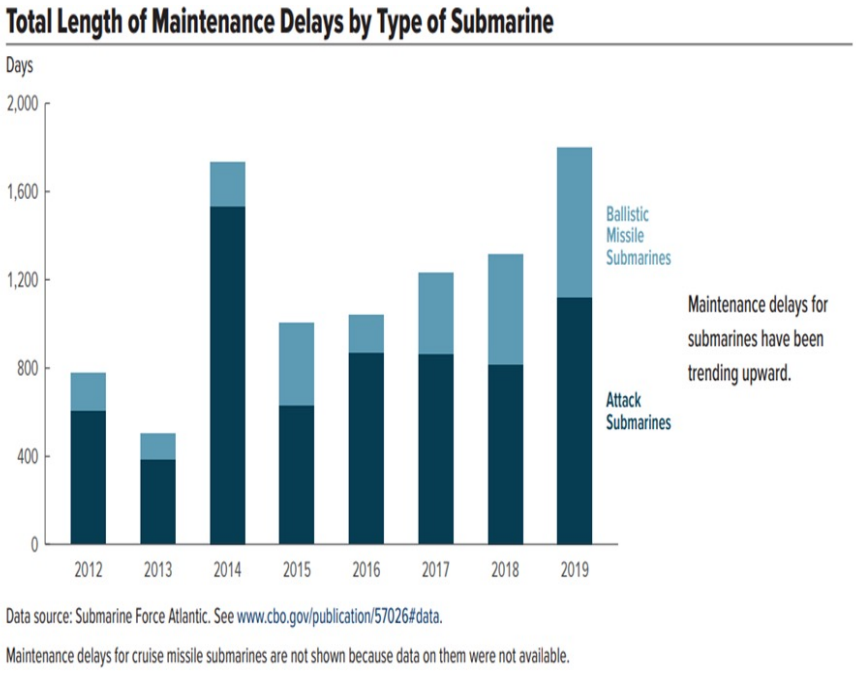
Source: Economist and Defense Intelligence Agency[87]

FIGURE 7: AVERAGE DAYS OF LABOR EXCEEDING THE SCHEDULED NUMBER FOR NUCLEAR SHIPS 2008-2019



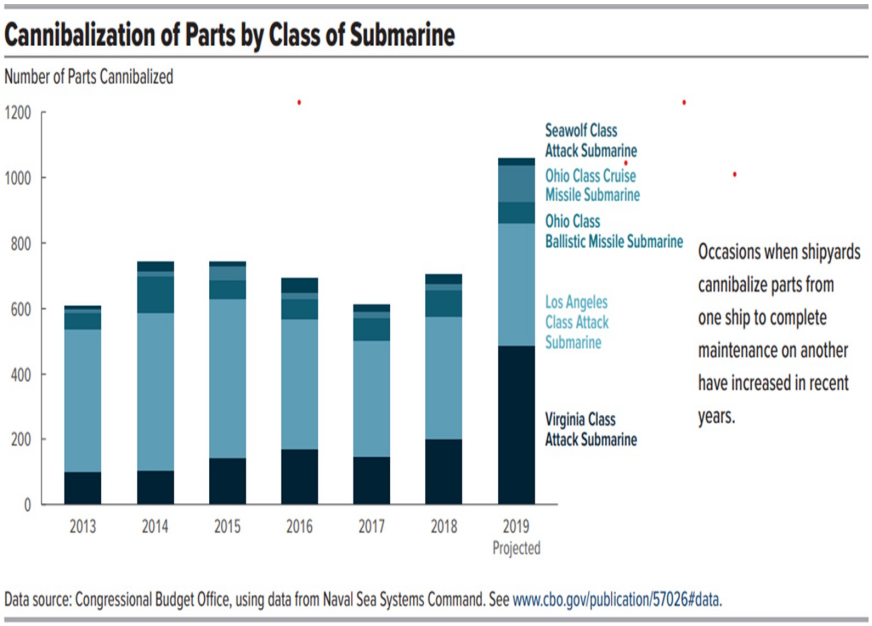
Source: Congressional Budget Office[88]

FIGURE 8: TOTAL LENGTH OF MAINTENANCE DELAYS BY TYPE OF SUBMARINE



Source: Congressional Budget Office[89]

FIGURE 9: CANNIBALIZATION OF PARTS BY CLASS OF SUBMARINE



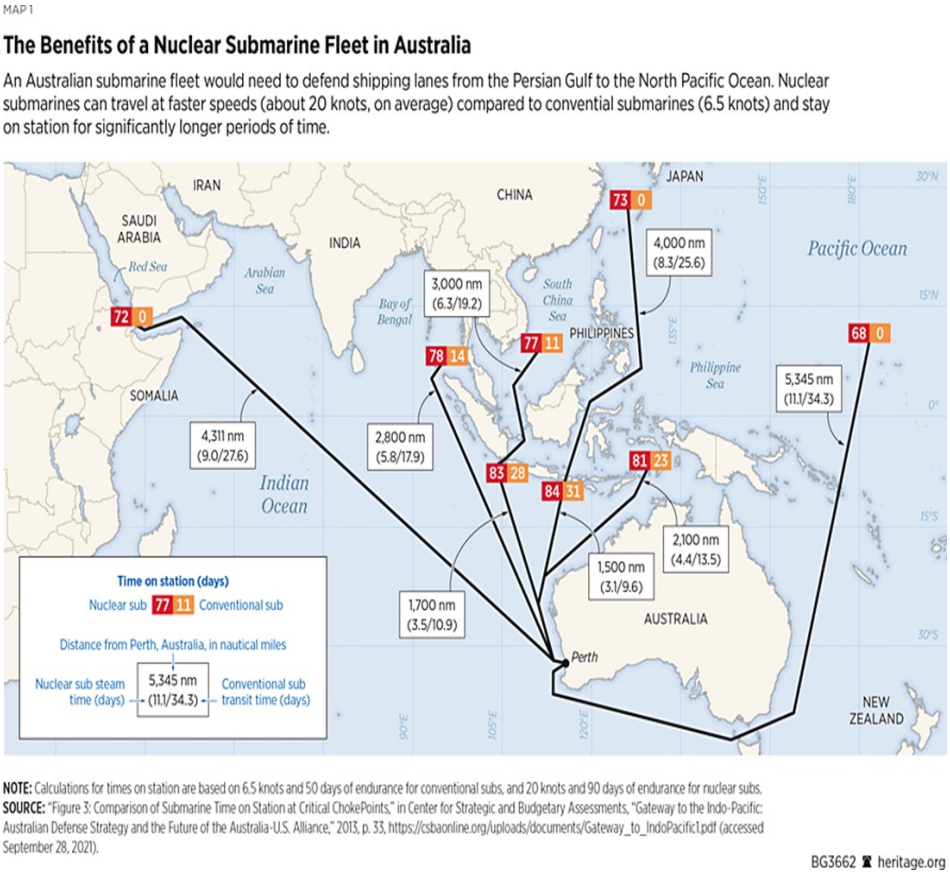
Source: Congressional Budget Office[90]

FIGURE 10: LOCATION OF U.S. NUCLEAR SUBMARINE ASSEMBLY FACILITIES AND OWNERSHIP STATUS

Shipyard	Sector	Location
Electric Boat	Private	Groton, CT
Norfolk Naval Shipyard	Public	Portsmouth, VA
Newport News Shipbuilding	Private	Newport News, VA
Pearl Harbor Shipyard and Intermediate Naval Facility	Public	Pearl Harbor, HI
Portsmouth Naval Shipyard	Public	Kittery, ME
Puget Sound Shipyard and Intermediate Naval Facility	Public	Bremerton, WA91

Source: U.S. Department of Energy, National Nuclear Security Administration[91]

FIGURE 11: THE BENEFITS OF A NUCLEAR SUBMARINE FLEET IN AUSTRALIA



Source: The Heritage Foundation[92]

FIGURE 12: CHINESE SHANG CLASS ATTACK SUBMARINE

Source: TCongressional Research Service[93]

FIGURE 13: CHINESE JIN CLASS BALLISTIC MISSILE SUBMARINE

Source: Congressional Research Service[94]

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