Nuclear Attack Submarines
The Elixir for a True Blue-Water Navy

Roby Thomas*

India's tryst with its destiny for the twenty-first century will greatly depend upon how it prioritises its strategic necessities in the face of current Covid-19-induced economic crisis. While still on course to be the third largest world economy by 2050, India will need to ensure it has the essential tools—economic, military and diplomatic—by then to provide the necessary leverage as a great world power. Great thinkers have stressed and history has shown that maritime power is one such leverage. This will provide the nation with the ability to influence affairs at a distance, which is the epitome of a blue-water navy. Considering its overwhelming utility, nuclear attack submarines today are the 'Brahmastra' in the fleet of a true blue-water navy and India needs to prioritise this.

Introduction

Naval submarines have been the epitome of stealth and covertness since their induction into naval warfare in the late nineteenth century. Their primary mission was to go where no ship could, strike from the deep without warning and melt back into the largely opaque medium of the oceans, hopefully without being noticed. This is in complete contrast to what has been expected from another formidable naval military machine, the aircraft carrier. The aircraft carrier gains much from projecting strength by showing the flag during peacetime, displaying force and presence in disputed waters, thereby giving confidence to allies while

* The author is currently a Senior Fellow at the Manohar Parrikar Institute for Defence Studies and Analyses (MP-IDSA), New Delhi. The views expressed here are his own.

ISSN 0976-1004 print

Journal of Defence Studies, Vol. 14, No. 4, October–December 2020, pp. 59–76

sowing dread in enemies. Submarines, on the other hand, are discreet war machines. They can apply similar pressure without being overt. Their presence needs only to be hinted, whether there or not, and their invisibility will have a disproportionate effect on opposing naval forces.

Today, a few ballistic missile nuclear submarines carry more firepower within their hulls than was unleashed during World War II by all the armed forces of the world combined. This makes them the singular most destructive piece of military hardware ever created. They are considered to have helped 'keep the peace' during the long Cold War period. Now, as we transition through a world marred by geopolitical flux and great power contestations in the twenty-first century, the use of submarines, as machines of coercion and war, will continue to evolve with emerging technologies and remain relevant to 'maintain the peace'.

Navies across the globe continue to invest in submarines for their stealth, but this expansion has mostly been limited to conventionally powered submarines. Nuclear power-driven submarines, which came into existence with the sailing of the *USS Nautilus* in 1955, had remained the exclusive club of only five nations, namely, the United States (US), Russia, the United Kingdom (UK), France and China, till the early twenty-first century. However, in August 2016, India announced its inclusion with the induction of the Indian-made ballistic missile nuclear submarine, *INS Arihant*.[1] Now, other nations such as Brazil are known to be pursuing nuclear submarine programmes, which is likely to expand the numbers in this presently exclusive club in the near future.[2]

Submarines in the World Wars

The versatility of submarines as an efficient machine of war was well established during World Wars I and II when they largely indulged in commerce raiding in packs in order to starve enemies of food and raw materials. Subsequently, these duties expanded to include attacking fleet escorts, that is, enemy warships, and mine laying. As they continued to excel, naval commanders used them to run blockades, carry out reconnaissance and insert spies and Special Forces. Size-wise, mini-submarines were used to enter shallow harbours and sink ships, while bigger submarines carried guns and even launched aircraft, in some cases, for observation and attack missions.

The impact of the submarine on the naval war psyche of World War II was so strong that it completely changed the way naval strategy and tactics was practised till then. In the 1940s, there was a parallel war going

on in the Atlantic. The Battle of the Atlantic saw the establishment of anti-submarine forces, which involved a large number of Allied destroyers and patrol aircraft hunting German U-boat wolf packs that preyed on shipping. Anti-submarine warfare (ASW) operations soon became the most important part of any operation, without which the rest of the navy would not dare leave port.

However, the 'submarines' that were responsible for causing havoc during World War II cannot be classified as true submarines. They were vessels that mostly ran on diesel engines on surface and operated on batteries underwater, and only submerged while carrying out an attack or while being attacked. In comparison, a true submarine is a vessel that mostly operates underwater and surfaces occasionally, if at all, to enter and leave harbour. This change came about with the introduction of the first practical application of nuclear power, the commissioning of the nuclear-powered submarine *USS Nautilus* in 1954.[3] This ensured that submarines could now remain underwater almost indefinitely, with the only restriction being the rations and human endurance.

Broad Classifications

This brings us to the broad classification of the modern submarine forces as we recognise it today. The submarines can be classified based on their primary missions. The first of these is the ballistic missile submarines, classified as SSBNs, which in almost all cases have been nuclear propelled. They carry multiple sets of submarine-launched ballistic missiles (SLBMs), tipped with single or multiple nuclear warheads. Their primary mission is to fulfil the vital third leg of the nuclear triad.[4] This is because an enemy can possibly locate another country's land-based missiles and airfields using various methods, which makes nuclear first strike a possibility. However, in reply, an undetected ballistic missile submarine would assure a devastating retaliation or an assured second-strike capability. This is the reason almost all nuclear-capable countries keep their vital third leg of the nuclear triad on submarines.

Another variation of this class is the guided-missile nuclear submarine, classified as SSGN. Such submarines, though nuclear powered, carry both conventional and nuclear-tipped cruise missiles. These submarines, unlike their ballistic missile counterparts, are regarded as tactical rather than strategic weapons. Though operated mostly by the Soviets during the Cold War, the US has currently four such submarines that were originally built to carry Trident nuclear missiles, but later

had their missiles removed and their tubes altered to carry almost 150 conventionally armed Tomahawk cruise missiles as well as a deck pod for commando operations.[5]

The next class is the nuclear attack submarines, classified as SSNs. These are designed for speed and agility and are considered the most versatile of all submarine classes. Due to their innate advantages of almost unlimited underwater endurance and high sustained speeds, they are capable of multitasking on numerous critical missions while out of base port on a single prolonged duration patrol. These include: escorting own ballistic missile submarines to patrol areas; providing forward underwater cover to own fleet units or carrier battle groups; precision strike using submarine-launched cruise missiles against inland strategic targets of the enemy; insertion or extrication of special forces teams from the enemy's coast; enforcing 'Sea Denial' by preventing the enemy's assets from using portions of the ocean; real-time surveillance and intelligence collection off the enemy's coast where it would be difficult for other assets to penetrate; and of course, as the name suggests, an attack submarine is designed to seek and destroy the enemy's submarines and surface ships, while very often forcing the enemy to commit precious naval resources to hunting down a nuclear attack submarine that might only rumoured to be there.[6] The submarine fleets of major navies operating nuclear-powered submarines are given in Table 1.

Finally, we have the original diesel-electric submarine, classified as SSK, which has undergone numerous iterations since World War II and is as relevant now as it was then. Though designed and constructed by only a handful of countries, today the conventional submarine is operated by over 35 navies and these numbers are expanding.[7] These submarines are operationally limited by the need to charge their batteries, using their diesel engines for a certain period of time every day at sea, which is termed as their 'indiscretion rate'. This brings their masts partially above water to a depth classified as periscope depth, or a position defined as snorkelling, to clear the exhaust from running their diesel generators to charge their batteries. During this period, they need to raise multiple masts. At the same time, their diesel generators are a source of high self-noise, which degrades their own underwater sensor performance. All this increases their exposure to possible detection by enemy ships, aircraft and even other submerged submarines. Another more severe drawback is its speed and endurance underwater. This remains seriously constrained

Table 1 Submarine Fleets of Nuclear-Submarine Operating Navies

Country	*SSBN*	*SSGN*	*SSN*	*SSK*
United States	14	4	37	–
Russia	13	7	17	23
China	5	–	5	56
France	4	–	6	–
United Kingdom	4	–	7	–
India	1	–	1 (Lease)	14

Source: Szondy, 'Rising Tide', n. 5.
Note: SSK: conventional diesel-electric submarine.

due to the limitation of running on batteries. While high speeds might be undertaken for short durations, it rapidly depletes batteries. Thus, though retaining most of the advantages of stealthy operations, these disadvantages reduce the operational radii of conventional diesel-electric submarines, largely limiting them to littoral operations.

The function of 'indiscretion rate' has now been partially turned around by the advent of the air-independent propulsion (AIP) capsule for conventional submarines. Few solutions that came about in the early years included: the closed-cycle diesel engine developed by the Dutch; the turbine-driven Module d'Energie Sous-Marin Autonome (MESMA) plant developed by the French; the Stirling engine developed by the Swedes; and the hydrogen fuel-cell technology developed by the Germans. In the last case, in 2013, a German Type 212A submarine, displacing 1,800 tons, transited totally submerged for 18 days without coming up to snorkel.[8] However, the AIP does not impart any speed and range advantage.

Japan, meanwhile, has taken the lead to replace the traditional lead-acid batteries used on conventional submarines with lithium nickel cobalt aluminium oxide (lithium ion) batteries. This has been done by replacing the Stirling cycle engine AIP system on the last two of the Soryu-class submarines and the newly launched Taigei-class boats.[9] Compared to the traditional lead-acid batteries, these batteries have greater energy density, can charge a lot faster and discharge their energy with 80–90 per cent efficiency, as compared to 60–70 per cent for lead batteries, which substantially decreases their need to snorkel to charge batteries and thus their indiscretion rate.[10]

India's Experience with Submarines

The need for submarines as a potent force multiplier was realised by the Indian Navy right at its inception. This was reflected in the first plans paper drawn out right after independence on 25 August 1947, when force requirements of the navy for free India comprised of four submarines, including other platforms.[11] However, notwithstanding Indian Navy's continued commitment to acquire submarines, it somehow did not materialise till the Russians agreed to provide India with the Type 641 (North Atlantic Treaty Organization [NATO] code 'Foxtrot') diesel-electric submarines in 1965. This led to the commissioning of India's first submarine, *INS Kalveri*, in Vladivostok in December 1967. This was followed by seven more Foxtrot-class submarines, making it a total of eight submarines by the mid-1970s.[12]

The 1980s and 1990s saw a large modernisation push for the Indian submarine arm. This period witnessed the commissioning of four HDW 1500-class diesel-electric submarines from Germany, as also the acquisition of eight Kilo-class diesel-electric submarines from erstwhile Soviet Union. By the mid-1990s, the Indian Navy had developed a mature and robust submarine arm of 20 diesel-electric submarines.

The Indian Navy's tryst with nuclear propulsion came with the lease of its nuclear attack submarine, *INS Chakra I*, on 5 January 1988. The submarine, taken on a three-year lease from the Russian Federation, benefited the Indian Navy for all the experience that the crew gained by sailing it at sea and maintaining it ashore, before returning it in January 1991. Meanwhile, the Indian Navy's Advanced Technology Vessel project was taking shape in the 1990s. Though the initial intent was to construct a nuclear-powered attack submarine, this was later aligned towards a nuclear-powered ballistic missile submarine to complete India's nuclear triad, post the nuclear tests conducted by India in 1998.[13] This fructified with the induction of the first Indian-made nuclear-propelled ballistic missile submarine, *INS Arihant*, in August 2016 and it completing its first deterrent patrol in November 2018. The second in the class, *INS Arighat*, was launched in November 2017 and is expected to join the submarine fleet after its trials.[14]

Meanwhile, in an effort to maintain its critical littoral underwater capabilities which were fast depleting due to decommissioning of older conventional submarines, the Indian Navy began inducting Project 75 submarines in 2017. This was based on a procurement contract between India and France for the construction of six Scorpene-class submarines.

Three of these submarines, named the Kalvari class, have already been delivered by Mazagaon Dock Limited, with three more to follow. The last two in the class are expected to be fitted with the indigenous AIP system being developed by the Defence Research and Development Organisation (DRDO). This is to be followed by six advanced conventional submarines of Project 75I, which are to be built in India in collaboration with a foreign manufacturer.[15]

With the intent of maintaining its edge in the underwater domain in the larger Indian Ocean space, while providing support to fleet operations and its SSBN fleet, the Indian Navy leased the second nuclear-powered attack submarine from Russia, *INS Chakra II*, in 2012 for a period of 10 years. This is to be followed by the lease of another nuclear attack submarine from Russia in 2025, to be christened *Chakra III*, also for a period of 10 years.[16] These on-lease nuclear attack submarines are critical towards providing vital operational experience and training to the submarine crew. However, to exploit the complete operational envelope of nuclear attack submarines, India would need have its own Indian-made nuclear attack submarines. The construction of six of these was sanctioned by the Cabinet Committee on Security (CCS) in 2015.[17]

Accordingly, Indian Navy's planned expansion, with a focus on 'capabilities' instead of 'numbers', was detailed in the Indian Navy's Maritime Capability Perspective Plan (MCPP). This was further deliberated during the Naval Commanders Conference held in April 2019, where the need to boost operational capability was highlighted with a view to expand the Indian Navy's overall influence in the strategic maritime zones. This required the Indian Navy to have a force level of 200 ships, 500 aircraft and 24 attack submarines. This was further reiterated by the Chief of Naval Staff, Admiral Karambir Singh, in the Commanders Conference in October 2019, when he stressed the need to bridge the capability gaps, especially in light of the increasing mandate of the Indian Navy in the Indian Ocean Region (IOR).[18]

Utility of SSNs in the Current Geopolitical Situation

The ongoing China-initiated crisis in Ladakh has forced India to initiate a strategic rebalancing of its land and air forces, that is, reorienting certain Indian Army and Air Force formations from the western theatre against Pakistan to now face the borders with China.[19] This is also a recognition that the Chinese threat on India's land borders is not going away any time soon. However, as would have been analysed and understood in the

last few months, beyond the existing gridlock situation, the possibility of escalation along the land borders cannot be afforded by two normative thinking nuclear-armed neighbours. De-escalation, even if delayed, is the only solution. Still, that does not mean that bilateral relations can go back to normal with the existing regime in China. The great power game to gain leverage over each other has only just begun and this is going to span all fronts, mainly economic, diplomatic and military.

Here, it is imperative to stress the importance of the maritime domain as the playground for this great power game, which happens to be central to the evolving geostrategic calculus. The oceans happen to be the only medium where the three main geopolitical fronts, namely, economic, diplomatic and military, criss-cross and either feed into each other or drain each other out. It is for this very reason that the oceans are called the economic highways of the world, transporting 80 per cent of the world's trade by volume and 70 per cent by value,[20] which also remains the outlook going forward. Similarly, diplomacy has been travelling along these maritime highways to the world's littorals either on merchant ships or men-of-war through the ages. Therefore, the common catalyst to both these fronts has been the navies, a fact well recognised by emerging powers of the past few centuries who had vital interests to extend beyond their shores. This hard truth has not been lost on China as it started expanding on all frontiers. Indeed, it has been an important factor for the explosive growth of its navy in the last few decades, pitchforking it to become the largest navy in the world today by way of number of naval platforms, even ahead of the US.

The Chinese Challenge in the IOR

The People's Liberation Army (PLA) Navy has also been extending its reach since 2008. During this time, it began deploying naval assets continuously for anti-piracy patrols in Gulf of Aden. This included its latest warships and even nuclear attack submarines (SSNs) in some cases. Such prolonged deployments, particularly of submarines, underscore its growing familiarity and confidence in operating in the IOR, which is also a demonstration of its intent in protecting its economic interests that traverse the sea lines of communication beyond South China Sea. Further, the fact that Chinese oceanographic vessels have been collecting hydrological data over more than the past decade in the IOR, including in the Bay of Bengal and the Arabian Sea, is a strong pointer that the PLA Navy has firm ambitions of attaining capability for offensive deployment

of its SSNs and conventional submarines in the IOR. This intent has been further confirmed with the establishment of the first Chinese overseas base at Djibouti, where facilities like suitable piers to replenish a major war vessel, such as an SSN, have been developed. Such facilities can also be extended from the Chinese-developed naval base at Gwadar and possibly many more in India's areas of interest in the near future.

As the Chinese Navy continues to expand in numbers and exert its influence outside the Second Island Chain, the one naval asset that would increasingly cause consternation among rival naval forces are its attack submarines, particularly the SSNs. This is because, among the naval assets, fleet ships, however strong in numbers, cannot go undetected on the seas surface, while ballistic missile nuclear submarines have the singular responsibility of ensuring a water-tight nuclear triad. It is only the attack submarines that have the advantage of concealment, stealth and surprise as their primary operational package. Out of these, the SSNs are particularly potent due to their inherent advantages of almost unlimited range, very high underwater speeds, and powerful and sometimes flexible weapons package as compared to conventional submarines.

Lesson from Falklands War

The utility of SSNs was more than aptly demonstrated during the operations phase of the Falklands War of 1982. Out of the six submarines used in the war, five were nuclear-powered attack submarines. In fact, the first British naval units to reach off Falklands, a distance of 8,500 nautical miles (NM) from Britain, were the SSNs. The maritime exclusion zone of 200 NM from Falklands Islands, declared by the British on 12 April 1982, was initially to be enforced by SSNs as they were the only initial naval assets available. Furthermore, the biggest casualty of the war was the large Argentine cruiser, *ARA General Belgrano*, that was sunk by torpedoes fired from the British SSN, *HMS Conqueror*. The Argentinean Navy immediately removed its entire surface fleet from the high seas, never to be seen again in the conflict. It was evident that SSNs had a devastating effect on the outcome of this war.[21]

The Lesson of 1971

A contrasting example of what might happen when a nation does not have SSNs was evident in our own waters in the 1971 Indo-Pak War. On 14 December 1971, when East Pakistan was on the verge of collapse to marauding Indian forces, the US Seventh Fleet—comprising of the *USS*

Enterprise, the 75,000 ton aircraft carrier, *USS Tripoli*, the 17,000 ton amphibious assault ship, with guided missile frigates and destroyers as escorts—crossed the Malacca Straits into the Bay of Bengal.[22] Though the Indian Navy had the aircraft carrier, *INS Vikrant*, other naval assets and even conventional submarines on the same seaboard, these were not units that would deter the US Seventh Fleet. In his book, *We Dared*, Admiral S.N. Kohli, the Chief of Naval Staff during the 1971 War, quoted Russian Admiral Gorshkov as stating that it was the Soviet SSNs in the Indian Ocean that deterred the US Fleet from taking any action.[23] This was a lesson that went down very hard with the Indian Navy and was, in all probability, the genesis for the Indian Advanced Tactical Vessel programme that gave India its first nuclear submarine.

The Bullet India Needs to Bite

The Indian Navy, accordingly, has been well onto the path of developing a viable nuclear-powered submarine fleet for the past few decades. As brought out earlier, this has included SSBNs, which are already operational with more to follow, and SSNs, which have been approved by the government. However, due to current economic slowdown and the accompanying shrinking of budgets, there is a possibility that so-called 'expensive options' for strategic security might be shelved or delayed indefinitely. This possibility is accompanied by the much-touted argument that conventional submarines, especially AIP-enabled submarines, being the much cheaper options should be able to do the job of an SSN as a strategic enabler. This argument is patently flawed and dangerous for national security and there are many reasons for this, which are enumerated next.

SSBN Escort

It has been well understood that nuclear-powered ballistic missile submarines or SSBNs have the well-demarcated responsibility of being the vital third arm of the nuclear triad. For this to be effective, SSBNs need to be positioned in areas which were colloquially called 'bastions' by the Soviet Navy during the Cold War. These positions are based on the range of the SLBMs carried by the SSBN, the intended targets and the relative safety the area offers from enemy anti-submarine forces.[24] Accordingly, depending on these factors, these 'bastions' could be closer to own coast or clearly in international waters accessible by all naval forces. The SSBNs are important strategic assets and in most cases, carry

firepower more than all the conventional forces put together. For it to be the survivable second-strike nuclear option, it needs to be protected from enemy ASW forces at various stages of its deployment and this can only be done by another submarine. This 'protector' submarine needs to keep up in speed and endurance with the SSBN and be capable of defending and decoying where required. All these requirements can only be met by another nuclear-powered submarine, an SSN. An AIP-enabled conventional submarine will not be able to keep up with a nuclear-powered SSBN to undertake these tasks, however capable it might be.

Fleet ASW Protector

In a true blue-water navy, the carrier battle group or amphibious landing force group would be a large body of ships specifically tasked to go into harm's way to accomplish a national task. Such fleets, though capable of maintaining a defensive bubble over the surface, will be constrained in the underwater domain, which is fundamentally opaque. This is where a fast-moving SSN with phenomenal endurance would act as a lifeguard against enemy submarines waiting to sabotage the operations. This has been typically referred to as 'battle group' operations by the US Navy and would mean shifting of SSN tactical control to the battle group commander.[25] Such operations require speed, endurance and firepower that can only be delivered by an SSN and is not in the operational ambit of an AIP-enabled conventional submarine.

Inland Precision Strike

Precision strike by submarine-launched land attack cruise missiles is fast becoming the most effective way of attacking strategic enemy targets inland, while maintaining a cloak of surprise and secrecy in operations. This has been repeatedly demonstrated by the US Navy, for example, when its SSNs launched Tomahawk cruise missiles to take out targets during Operation Desert Storm (Iraq in 1991), Operation Desert Strike (Iraq in 1996), Operation Infinite Reach (Afghanistan in 1998), Operation Allied Force (Yugoslavia in 1999), and many more since.[26] This, in turn, requires a submarine to operate as part of an integrated strike force and be positioned and repositioned when required and as the operational situation demands. This requires speed, agility, endurance and sufficient firepower on part of the submarine; and more importantly, the ability to vacate the firing area with speed before enemy ASW forces start saturating the area. In such situations, though an AIP-enabled

conventional submarine may have the firepower, it may not have the speed, agility and reach to meet operational commitments and the speed required to vacate the area before being pursued.

Sea Denial

Sea denial is a typical submarine operation. This involves stopping enemy surface ships and submarines from using a portion of the sea for a certain amount of time. Such attacks can be directed against enemy surface ships and submarines, as a war of attrition, or merchant shipping. A typical example of this, as already discussed, is the sinking of the Argentinian cruiser *General Belgrano* during the Falkland War. These operations can be very successfully carried out by conventional submarines; however, the drawback remains of reach and endurance. A conventional submarine's distance to the operational area will remain limited to its endurance and the size of area it can cover would be limited to the speed available to bring a target within its weapon range. Both of these will be typically much lesser than that of an SSN. If we transpose this onto the Indian maritime scenario, it is evident that a conventional submarine's reach is limited to the near regions of the Arabian Sea, the Bay of Bengal and the Northern Indian Ocean, within India's 'primary areas of maritime interest' as defined by India's Maritime Security Strategy, while it will require one or more SSNs to attempt this in the large expanse of Southern Indian Ocean, in other words, India's 'secondary areas of interest', which encompasses the west coast of Africa and the entire Indo-Pacific,[27] as defined today. Only an SSN is capable of putting a massive amount of uncertainty into the mind of an adversary, even in maritime areas seemingly under his control, forcing him to change his strategies or his thinking. Therefore, this capability is critical considering China's continued intransigence into India's areas of interest.

Miscellaneous Operations

Similarly, there are many typical submarine operations which can be executed by both conventional submarines and SSNs alike. These include enemy surveillance and intelligence gathering, insertion and extrication of marine commandoes and intelligence operatives off the enemy's coast, mine laying, launching of unmanned underwater vehicles, etc. The only difference, as already discussed, is that an SSN has the advantage of speed and endurance over a conventional submarine, even AIP-enabled, and hence the flexibility of a much wider canvas of operations. This provides

operational commanders of a blue-water navy with many more options and in contrast, causes severe headache for the enemy side.

Challenges of Ownership

All having been said, building and maintaining a nuclear-propelled fleet has its own challenges, which an emerging power like India would need to consciously take on. When compared one-to-one, SSNs are known to be more expensive to build and maintain than SSKs. However, studies carried out by the United States navy to assess the utility and viability of SSKs compared to SSNs on the metrics of life-cycle cost and equivalent effectiveness have proven otherwise. Instead of comparing the life-cycle cost of a single SSK to that of one SSN, the study considered it more prudent to compare the total life-cycle cost of the number of SSKs that would provide equivalent on-station capability to one SSN. The results indicated that it would require anywhere between 2.2 to 6 SSKs to have the equivalent effectiveness of one SSN. Therefore, by this metric, even with a lower single platform cost, an SSK fleet would cost 1.3 to 3.5 times more than a SSN fleet, to maintain the same on-station capability.[28]

At a higher level though, what needs to be understood is that nuclear submarines are national strategic assets and even the best of friends do not part with this technology. For example, notwithstanding the closest of relations between the US and the UK post-World War II, the US only gave Britain the reactor to operationalise its first SSN, *HMS Dreadnought*, and subsequently the Trident SLBM, but never the entire submarine.[29] Similarly, Russia provided India with SSNs on lease to gain experience and training, never to own. Conversely, if you pay the right price, you may buy or make in collaboration a conventional submarine, but never an SSN. As this technology takes decades to develop, nurture and maintain, it needs to be a very carefully thought through strategy by any country which seeks to make and maintain a presence on the world stage.

An important operational drawback of a nuclear submarine is the high self-noise generated by the submarine, which is an anathema to own forces and music for enemy ASW forces. This is because nuclear submarines need to run pumps which circulate cooling water around the reactor core at all times, while conventional submarines, if well designed and while on batteries, are almost silent with the only noise coming from the shaft bearings, propeller and flow noise around the hull. A crude comparison to this situation would be an analogy of a bicycle and a

motorcycle tasked to reach customers covertly in an area. A bicycle would be far cheaper to buy, own and also reach customers in congested areas, but would be limited to covering an area the size of a village. Thus, its reach cannot be compared to that of a motorcycle, which for same task and at the same time could cover an area equivalent to a city, albeit with an added self-noise component. Therefore, both types of propulsions have their advantages and utilities. A conventional submarine is irreplaceable for littoral operations, like that which surround the Indian subcontinent. However, SSNs are a necessity for an emerging world power like India with global interests and ambitions and are necessary to transform the Indian Navy into a true blue-water force.

Conclusion

Submarines are one of the most complex pieces of military machinery ever developed by mankind, even more so when the submarine is nuclear propelled. A country which has proven this capability has transitioned to a different league. This becomes apparent when we realise that only a handful of nations have achieved this and India should be supremely proud of being among these. This is similar to aircraft carrier construction, which is an equally complex engineering process, again attempted by very few nations, out of which India is one. Both of these are important milestones a country and its navy must cross to be acknowledged as a truly self-made blue-water force. Construction of such complex pieces of military machinery also spawns a host of other associated major and minor industries that simulates the local economy, which would be a booster dose for 'Atmarnirbhar' Bharat. Therefore, India requires to continue investing in such critical technologies.

In all probability, the era of large-scale land interventions by major powers could be a thing of the past, considering the chastening experience the US coalition received in Iraq and Afghanistan. While land-based forces are also important, they are not as responsive to developing situations from a distance as sea power. Major powers with global interests are now going to use the oceans as a vital attribute to exert control. This would mean that navies would increasingly be used by leading powers to shape geopolitics from a distance. In China's case, this has been very evident by the way it has developed and expanded its navy over the past few decades. It is instructive to observe that China has been able to precisely time the fruition of its major naval platforms

by adequately funding the PLA Navy to synergise it with its rise to great power status.

As we progress further into the twenty-first century, India is still projected to become the third largest economy in the world, after China and US, by 2050. With the base year taken as 2017 when India was the seventh largest economy, India is currently the fifth largest economy and would move to become the fourth largest economy by 2030 and the third largest by 2050.[30] Therefore, taking a leaf out of the path treaded by other great rising powers, including China, and notwithstanding the current Covid-19-related economic contractions, India needs to 'keep its eye on the horizon' and astutely plan its rise by facilitating the strengthening of its maritime capacities, like its SSN fleet, to meet its great power expectations in the Indo-Pacific and beyond, in the decades to come.

Notes

1. 'INS Arihant is Now Operational: All About India's Nuclear Deterrent in the Sea', *The India Express*, 6 November 2018, available at https://indianexpress.com/article/india/ins-arihant-all-you-need-to-know-india-first-indigenous-nuclear-submarine-5435116/, accessed on 31 October 2020.
2. Admiral Bento Costa Lima Leite De Alburquerque, Jr., 'The Brazilian Navy Nuclear and Submarine Program: Origins, Current Focus, and Perspectives', talk delivered at to the Wilson Center in April 2018, available at https://www.wilsoncenter.org/sites/default/files/media/documents/article/adm_bento_remarks_at_the_wilson_center.pdf, last accessed on 26 November 2020.
3. John F. Schank, Frank W. Lacroix, Robert E. Murphy, Cesse IP, Mark V. Arena and Gordon T. Lee, 'The History of British Submarine Programs', in *Learning from Experience*, RAND Corporation, available at https://www.jstor.org/stable/pdf/10.7249/j.ctt3fgzx8.9.pdf, accessed on 31 October 2020.
4. A nuclear triad is a three-pronged military force structure that consists of land-launched nuclear missiles, nuclear-missile-armed submarines, and strategic aircraft with nuclear bombs and missiles. Specifically, these components are land-based intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and strategic bombers. The purpose of having this three-branched nuclear capability is to significantly reduce the possibility that an enemy could destroy all of a nation's nuclear forces in a first-strike attack. This, in turn, ensures a credible threat of a second strike, and thus increases a nation's nuclear deterrence.

5. David Szondy, 'Rising Tide: Submarines and the Future of Undersea Warfare', *New Atlas*, 5 July 2017, available at https://newatlas.com/future-submarines-modern-warfare/49896/, accessed on 31 October 2020.
6. Robert Sherman, 'Submarine Warfare', FAS Military Analysis Network, available at https://fas.org/man/dod-101/sys/ship/submarine.htm, accessed on 2 November 2020.
7. 'Submarine Fleet Strength by Country (2020)', *Global Firepower*, available at https://www.globalfirepower.com/navy-submarines.asp, accessed on 2 November 2020.
8. Sebastian Roblin, 'Why Germany's New Super Stealth Submarines COULD Take on Any Navy', *The National Interest*, 6 June 2017, available at https://nationalinterest.org/blog/the-buzz/whygermanys-new-super-stealth-submarines-could-take-any-21021, accessed on 31 October 2020.
9. Mike Yeo, 'Japan Launches First of its New Class of Submarines', *Defense News*, 14 October 2020, available at https://www.defensenews.com/naval/2020/10/14/japan-launches-first-of-its-new-class-of-submarines/, accessed on 31 October 2020.
10. Sebastian Roblin, 'Japan's Lithium-Ion Battery Submarines are a Leap Forward for Navies Everywhere', *The National Interest*, 14 May 2020, available at https://nationalinterest.org/blog/reboot/japans-lithium-ion-battery-submarines-are-leap-forward-navies-everywhere-153801, accessed on 31 October 2020.
11. Satyindra Singh, *Under Two Ensigns: Indian Navy 1945–50*, New Delhi: Oxford University Press, 1986, p. 69.
12. Anup Singh, *Blue Waters Ahoy! The Indian Navy 2001–2010*, Noida: HarperCollins Publishers, 2018, pp. 241–44.
13. Ibid., pp. 245–48.
14. Franz-Stefan Gady, 'Indian Navy Boomer Completes First Deterrent Patrol', *The Diplomat*, 6 November 2018, available at https://thediplomat.com/2018/11/indian-navy-boomer-completes-first-deterrent-patrol/, accessed on 31 October 2020.
15. Rajeshwari Pillai Rajagopalan, 'The Trouble with India's Slow Naval Build-up', Commentary, Observer Research Foundation, 5 October 2019, available at https://www.orfonline.org/research/trouble-india-slow-naval-buildup-56188/, accessed on 31 October 2020.
16. 'Russia to Lease Nuclear Submarine to Indian Navy in $3 Billion Deal', *The Week*, 8 March 2019, available at https://www.theweek.in/news/india/2019/03/08/russia-lease-nuclear-submarine-indian-navy.html, accessed on 31 October 2020.

17. Rajat Pandit, 'Govt Approves Construction of 7 Stealth Frigates, 6 Nuclear-powered Submarines', *The Times of India*, 18 February 2015, available at https://timesofindia.indiatimes.com/india/Govt-approves-construction-of-7-stealth-frigates-6-nuclear-powered-submarines/articleshow/46281364.cms, accessed on 31 October 2020.
18. Naresh Chand, 'Navy's Quest for Modernisation', *SP's Naval Forces*, No. 1, 2020, available at http://www.spsnavalforces.com/story/?id=652&h=Navyandrsquo;s-Quest-for-Modernisation, accessed on 31 October 2020.
19. 'India to Rebalance Forces, Firepower to Line of Actual Control and Indian Ocean Region', *Indian Defence News*, 2 November 2020, available at http://www.indiandefensenews.in/2020/11/india-to-rebalance-forces-firepower-to.html, accessed on 3 November 2020.
20. CONCAWE, *Marine Fuel Facts*, January 2017, available at https://www.concawe.eu/wp-content/uploads/2017/01/marine_factsheet_web.pdf, accessed on 18 November 2020.
21. J.M. Branley, 'Post Cold War Submarine Force Changes', Thesis presented at US Army Command and General Staff College, Fort Leavenworth, Kansas, 14 June 2019, available at https://apps.dtic.mil/sti/citations/AD1084859, accessed on 2 November 2020.
22. G.M. Hiranandani, *Transition to Triumph: History of the Indian Navy 1965–75*, New Delhi: Lancer Publishers, 2000, pp. 212–56.
23. Quoted in ibid., p. 264.
24. Michael Kofman, 'The Role of Nuclear Forces in Russian Maritime Strategy', *Russian Military Analysis*, 12 March 2020, available at https://russianmilitaryanalysis.wordpress.com/2020/03/12/the-role-of-nuclear-forces-in-russian-maritime-strategy/, accessed on 2 November 2020.
25. Sherman, 'Submarine Warfare', n. 6.
26. 'Tomahawk Missiles brought Power to the Punch during Operation Enduring Freedom', *The Sextant*, Naval History and Heritage Command, Communication and Outreach Division, 7 October 2020, available at https://usnhistory.navylive.dodlive.mil/2014/10/07/tomahawk-missiles-brought-power-to-the-punch-during-operation-enduring-freedom/, accessed on 2 November 2020.
27. Indian Navy, *Ensuring Secure Seas: Indian Maritime Security Strategy*, Naval Strategic Publication (NSP) 1.2, New Delhi: Integrated Headquarters, Ministry of Defence (Navy), October 2015, pp. 31–32.
28. John B. Padgett III, 'Projecting Power: The Case for Maintaining an All Nuclear Submarine Fleet', *Armed Forces Journal*, 1 September 2011, available at http://armedforcesjournal.com/projecting-power-2/, accessed on 19 November 2020.

29. Shank et al., 'The History of British Submarine Programs', n. 3.
30. 'India to Become Third-largest Economy by 2050: Lancet', *Business Today*, 10 October 2020, available at https://www.businesstoday.in/current/economy-politics/india-to-become-third-largest-economy-by-2050-lancet/story/418496.html, accessed on 2 November 2020.