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POLICY BRIEF

“The Significance of INS Arighaat”

Author

Lalit Kapur

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Delhi Policy Group
Core 5A, 1st Floor, India Habitat Centre, Lodhi Road, New Delhi- 110003
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Author

Commodore Lalit Kapur (Retd.), Senior Fellow for Maritime Strategy, Delhi Policy Group

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Cover Photographs:

The Indian Navy's conventionally powered submarines exercising in the Arabian Sea on March 25, 2024.
Source: Western Naval Command

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The induction of INS Arighaat into the Indian Navy on August 29, 2024 has been welcomed with great expectations. Speaking at the commissioning ceremony, Defence Minister Rajnath Singh exuded confidence that the submarine would further strengthen India's nuclear triad, enhance nuclear deterrence, help in establishing strategic balance and peace in the region, and play a decisive role in the security of the country[1]. But does the induction of the second Ship, Submersible, Ballistic, Nuclear (SSBN) platform, eight years after the first, INS Arihant, was commissioned in August 2016, mark the maturing of India's nuclear triad? How does India's capability compare with that of other SSBN operators? What are the critical technologies that have been developed indigenously to give India its 'boomer'? This brief examines the issues involved and the implications for India's strategic power.

SSBN Operators

When the US launched its first nuclear submarine (USS Nautilus) in 1954, it was the world's leading industrialised nation, backed by a well-developed research base, a rich cadre of scientific and technological manpower, and a well-developed submarine design capability. The first US designed and built submarine, USS Holland, had been commissioned in April 1900, so there was over five decades of designing and building experience to count on. Having successfully proved the concept with USS Nautilus, the US went on to build the George Washington class of SSBNs, commissioned from 1959 onwards, and carrying the Polaris ballistic missile with a range of 2600 Km. Six and half decades have gone by since then. The US is now building its seventh generation of SSBNs.

Russia's first submarine was the Delfin, commissioned in 1903. It commissioned its first nuclear boat, the November Class, in March 1959, as the result of a coordinated effort by 20 design bureaus and 35 research institutes for just the design work. The first Russian SSBN was the Hotel-class, commissioned in November 1960, with a 600 Km range SLBM (R-13, SS-N-4 Sark). Russia is now building its fifth generation of SSBNs.

[1] Second Arihant-Class submarine 'INS Arighaat' commissioned into Indian Navy in the presence of Raksha Mantri in Visakhapatnam, August 29, 2024, https://pib.gov.in/PressReleasePage.aspx?PRID=2049870

The Royal Navy built and commissioned its first submarine, HMS Holland 1, in 1901. The UK started researching designs for a nuclear propulsion plant in 1946, but did not make progress. It needed Lord Mountbatten, the then British Chief of Defence Staff, to persuade the US to transfer reactor technology following the 1958 US-UK Mutual Defence Agreement. Even then, the first British nuclear submarine, HMS Dreadnought, was commissioned only in April 1963. The Resolution-class, the first British SSBN, was commissioned in 1967. The UK is now building its third generation of SSBNS.

Country	Class	No. Built	In Service	SLBM & Range (Km)
USA	George Washington	5	1959-1985	Polaris A1 (2600)
	Ethan Allen	5	1961-1992	Polaris A2/A3 (4600)
	Lafayette	9	1963-1994	Poseidon (5900), MIRV
	James Madison	10	1964-1995	Trident D-1 (7400), MIRV
	Benjamin Franklin	12	1965-2002	Trident D-1 (7400), MIRV
	Ohio	18	1981-present	Trident D-5 (12000), MIRV
	Columbia	On order	To be inducted	
UK	Resolution	4	1967-1996	Polaris (4600)
	Vanguard	4	1993-present	Trident D-5 (12000), MIRV
	Dreadnought	4 on order	To be inducted	
France	Redoubtable	6	1971-2008	M-51 (approx. 10,000)
	Triomphant	4	1997-present	M-51 (approx. 10,000)
Russia / USSR	Hotel	8	1960-1991	R-13 (600) or R-21 (1650)
	Yankee	35	1967-1995	
	Delta	43	1976-present	
	Typhoon	6	1981-2023	RSM52 (8300), MIRV
	Borei	8 of 11	2013-present	Bulava (15000), MIRV
China	Type 092	1	1983-present	JL-1 (1770) or JL-1A (2500)
	Type 094	6 of 8	2007-present	JL-2 (7200) or JL-3 (10,000), MIRV
	Type 096		To be inducted	JL-3 (10,000), MIRV
India	Arihant	2	2016	K-15 (750-1500) K-4 (3500-4000)

Table 1: List of SSBN Operators

France, the fourth SSBN operator, built its first submarine Plongeur in 1863. It built the first electric submarine, Gymnote, in 1877. The name was also given to the platform for its nuclear submarine programme which began in the 1950s, but a reactor small enough to fit in its hull could not be designed. France had to start again with the Redoubtable class, ordered in 1963 and commissioned on December 01, 1971. Like India, France commissioned SSBNs before they commissioned the Rubis-class, its first nuclear propelled attack submarines. It is now operating its second generation of SSBNs.

The fifth nation in this club was China, which commissioned its first nuclear propelled boat, pennant number 401 (of what is known as the Han Class) in 1974. The class was known for its high noise levels, poor radiation shielding and inability to launch missiles when submerged. Asia's first boomer, the Xia class, was commissioned in 1987, nine years after construction started at Huludao in 1978. The second generation is now in operation, while a third is reported to be building.

India's nuclear submarine project began in the 1990s, as the Advanced Technology Vessel programme. The keel of the first submarine of the class, INS Arihant, was laid in 2004, and the boat was commissioned in August 2016. INS Arighaat is the second boat of the class, commissioned eight years after Arihant. The submarines are reported to be 111 metres long, have a beam of 11 metres and draw 15 metres. They are propelled by one indigenously designed pressurised water reactor, providing 83 MW and enabling a speed of 12-15 knots on the surface and 24 knots submerged. They carry 12 K-15 Submarine Launched Ballistic Missiles (SLBM) with a range of 750-1500 Km, enabling the missile to reach virtually any target in Pakistan from the Arabian Sea. Alternatively, they carry four K-4 SLBMs with a reported range of 3500-4000 Km, enabling coverage of practically all of China and Pakistan from the Bay of Bengal.

For India, to put an indigenous SSBN to sea despite its poorly developed industrial base, limited research capacity in cutting edge technology, and rudimentary submarine design capability (the only submarines built in India so far, the HDW and Scorpene class, are based on German and French designs respectively; an indigenous submarine design still lies in the future) is an achievement of considerable magnitude.

SSN Vs SSBN

There has been a visible tendency in the media to conflate the Ship, Submersible, Nuclear (SSN) with an SSBN. Both are certainly nuclear propelled submarines. However, their operating philosophies are completely different. Nuclear propulsion and the temperature, pressure and salinity of sea water provides the SSN the edge in speed as well as detectability over surface ships, as well as the speed edge over conventional submarines. They thus become the preferred attack instrument for naval tasks; in fact, they are called attack submarines. SSNs are thus very capable instruments of naval power, operating under the command and control of naval command authorities.

SSBNs, on the other hand, carry the nation's nuclear retaliatory capability and are employed only for 'strategic' tasks. This capability cannot be risked in conflict; the basic objective is to keep it hidden till it is required to be brought into use. Speed is thus not such a vital attribute. SSBNs operate under the command of the nation's Nuclear Command Authority (NCA), under the control of the Strategic Forces Command (SFC).

Three critical technologies differentiating a conventional submarine (SS) from an SSBN have had to be developed to enable operation of the Arihant-Class: nuclear propulsion, SLBMs and communications. An elaboration on these technologies is necessary to understand their employment.

Nuclear Propulsion

Nuclear propulsion first. This technology has been in use for nearly seven decades, since USS Nautilus made her historic message "Underway on nuclear power" on January 17, 1955. The primary users of nuclear propulsion still remain submarines (SSNs or SSBNs), built by the US, Russia, France, UK, China, and now India. Other users include aircraft carriers (ten of America's Nimitz Class and the lead ship of the Gerald Ford class have nuclear propulsion; John F Kennedy and Enterprise are building; the French Charles de Gaulle, in service, is also nuclear powered) and two classes of Russian icebreakers. Most use pressurised water reactors (PWR) and that technology is not new to India: it was first seen in the CANDU Pressurised Heavy Water Reactor put into service at the Rajasthan Atomic Power Project in 1973.

There are, however, major differences between reactors used for power generation on land and those used at sea. Land based power plants can be spread over a space housing many football fields, but those on a submarine must necessarily be compressed into a much smaller volume, enabling their fitment within the space earmarked for the propulsion package. The marine reactor must, therefore, generate substantially higher power per unit of space than a land based one, calling for more efficient conversion of thermal into electrical energy. This necessitates a completely different design.

There are other factors to be considered on a submarine. In land based systems, the reactor always remains upright. Gravity can be used to drop control rods into their sockets. Seaborne platforms, however, cannot guarantee they will remain upright in rough seas: ships and submarines have to cope with rolling, pitching and yawing, all of which could interfere with gravity operated control rods at critical moments. Moreover, land based systems are designed for a steady power output and can power down slowly. Those on warships, however, have to be designed to cater for instant and rapid changes in output necessitated by manoeuvring for combat. The saline environment poses additional challenges by way of corrosion, necessitating design to cater for the sharply increased maintenance load. The sound generated by pumps and other machinery that must run continuously to cool the reactor is not a major consideration on land. On a submarine, however, it could spell the difference between life and death – each source of sound adds to the detectability of the submarine by opponents and must be ruthlessly suppressed. Accessibility for maintenance in the much smaller space available at sea becomes a nightmare, so the system must be designed for minimal maintenance, and for repair that may become necessary far from home port. Radiation, nuclear safety, shock and numerous other challenges add to design complications. Marine reactors are not available for sale off the shelf, particularly to nations who were nuclear have-nots after signing of the Non-Proliferation Treaty; they have to be designed and manufactured indigenously. After the UK, Australia will become only the second country ever to be provided nuclear reactors designed elsewhere, under the AUKUS agreement.

The IN began its search for marine nuclear propulsion in 1967, with the preparation of a joint feasibility report by BARC and the IN. A more detailed report was prepared in 1971. 30 years after the USN deputed a core team of naval engineers and civilians led by the iconic Hyman Rickover to Oak Ridge, Tennessee (the production site for the Manhattan Project), the IN replicated the step by deputing a core team of technical officers to BARC, under the Department of Atomic Energy, to undertake design and feasibility studies for the production of a marine nuclear reactor. Turf battles, however, led to this effort proving unsuccessful.

The nuclear submarine project was re-launched as the ATV Project in 1985, this time under a joint IN-DRDO team headed by a retired Vice Admiral. The DAE's confidence in being able to provide a nuclear reactor quickly led to India accepting the Soviet offer to lease a Project 670 (Charlie I class) submarine, so that naval personnel could gain experience in operation of nuclear reactors in a marine environment. The submarine, named INS Chakra, arrived in India in January 1988 – and went back in 1991, with the indigenous reactor design nowhere near completion. India acquired a second 'Chakra' on lease from the USSR and commissioned her at Visakhapatnam on April 04, 2012; she was returned in June 2021. Meanwhile, the design that powers the Arihant was developed with assistance from Russia's Rubin Design Bureau. A prototype was built at Kalpakkam.

An oft-voiced criticism of the reactor used on board the Arihant class is that it is 'underpowered', limiting the speeds that can be achieved by the submarine. However, speed is not a vital factor for an SSBN, whose employment is in hiding in the depths till needed. Not for it the needs of catching up with or protecting high value surface forces, or escaping from them. Moreover, India's SSBN will be employed in a defended 'bastion', with surface ships and aircraft providing it protection from adversary air, surface and submarine forces. Nevertheless, a reactor with a higher rating is said to be under development. This will equip heavier SSBNs like the third and fourth boats of the Arihant Class, as well as SSNs to be built in the future.

Reports indicate that the current reactor design is based on first- or second-generation Soviet technology, with a refuelling cycle of a few years. Refuelling a nuclear reactor is a complex process that will take the submarine out of commission for anything from 18-24 months, so there is need to graduate to a more modern design which does not require refuelling during the submarine's in-service life. Suffice to say that this technology, new to India, will take time before it can be brought into use.

The SLBM

Underwater missile launch next. The first launch of a ballistic missile from a submarine took place on September 16, 1955, when the Soviet diesel electric submarine B-67 successfully launched an R-11FM Scud missile, with a range of 350 miles. However, this launch required the submarine to surface. The first underwater launched ballistic missile was the American Polaris A-1, launched by USS George Washington on July 20, 1960. 40 days later, USSR made its first underwater launch, again from B-67.

Conceptually, the process of underwater SLBM launch is well-defined. Because of their size, missiles are stored in a vertical tube, somewhat like a silo, fitted into the submarine hull. They cannot be open to the corrosive influence of sea water, so the tube has to be capped, with the cap being able to resist the high-pressure environment experienced at the operating depth. To fire the missile, the cap is remotely opened. The missile is then ejected either by high pressure gas, or using a gas and steam generator. It is propelled towards the surface with sufficient velocity to enable it to break into the air. Once it clears the water, the first stage of the missile is ignited, powering its flight to a ballistic trajectory. Additional stages may be used, depending on its range.

The concept may be simple, but converting it to reality involves many technological challenges generated by the much higher pressures of the underwater environment, difficulties of accessibility, gravity, the need to keep the missile upright from the time of firing till it is on its ballistic trajectory and the potentially, catastrophic consequences of any malfunction.

Arihant reportedly fields either 12 K-15 SLBMs, or 4 larger K-4s. Development of the K-15, initially named Sagarika, started in 1998. The project was highly classified, so much so that the name was changed to B-05 when the then Defence Minister inadvertently admitted to the existence of a project named Sagarika when talking to journalists at an exhibition in Bengaluru. It was changed again to K-15. The first fully integrated version of the missile was tested from an underwater pontoon-based silo at a depth of 20 metres in January 2010. Numerous underwater test firings have been conducted since then.

The 1500 Km maximum range of the K-15 constrains the submarine's deployment. India's NFU policy predicates its use only against 'value' targets, such as big cities. Pakistan's ten biggest cities can be covered from potential deployment areas in only the Northern Arabian Sea. To target say Beijing, however, the submarine would have to be deployed in the East or South China Seas. The former is known for its relatively shallow waters. Submarines operating close to the surface can often be sighted from the air, especially if the water is clear. It is only in the South China Sea that sufficient depths for the submarine to hide become available, but even then, the deployment would have to be well inside the first island chain, a heavily trafficked area China keeps under near continuous surveillance because it is the operating area for its own nuclear submarines.

The inescapable conclusion is that the K-15 SLBM can be deployed only against Pakistan.

The K-4, with a reported range of 3500-4000 Km, overcomes this problem to some extent. Its maximum range enables the missile to cover most of China (including Beijing), and all of Pakistan, from the Bay of Bengal. Developmental trials for the K-4 were completed in 2020 and the missile can be considered fully operational. The number carried by the Arihant-Class (just 4) are, however, not adequate to comply with India's doctrine of massive retaliation.

Reports indicate that design work on the K-5 SLBM, with a range of 5000-6000 Km, is in progress. The K-6 SLBM, with a range of 8000-12000 Km, is also reported to be under development. Both these missiles are expected to have Multiple Independently Targetable Re-entry Vehicle (MIRV) capability. Proving these missiles to their maximum range will give substantial freedom in choice of deployment area to Arihant's successors. It is only then that India's underwater deterrent capability can be considered to have fully developed.

Doctrinal Requirements and Communications

India's nuclear doctrine necessitates four levels of political approval and communication of action messages for nuclear warhead use: to integrate the warhead, to move it from DRDO/DAE storage to a military facility, to mate it to the missile, and to launch. For an SSBN, the first and second levels of approval can be complied with before the missile is loaded on the boat. However, the missile and warhead must be mated before the boat sails; it is physically not possible to mate a warhead weighing a ton or more at sea. The workaround has been that the missile is provided to the boat in physically mated form. However, electronic mating is possible only on receipt and inputting of the requisite codes. Similarly, to comply with doctrinal requirements, launch is possible only when the necessary codes are input into the system. These codes must, therefore, be received from the Nuclear Command Authority (NCA) once the boat is in its deployment area and before a retaliatory launch is executed.

This necessitates secure and dependable communications between the Strategic Forces Command, which will receive the codes from the NCA, and the SSBN, which will input them into the launch system. An elaborate communications system has been developed for communicating these codes to all nuclear vectors. Unlike other vectors, which can receive these signals through normal radio or satellite frequencies, SSBNs must hide underwater. Normal radio frequencies will not penetrate the water surface. The only known way to communicate with a submerged submarine is through Very Low Frequency (VLF) or Extremely Low Frequency (ELF) transmission. VLF penetrates the ocean to a depth of a few metres, necessitating the submarine coming relatively close to the surface to receive messages. ELF signals, however, can penetrate the water to the submarine's operating depth.

India commissioned its VLF station at INS Kattaboman in Tamil Nadu in 1990. Reports indicate that this has been upgraded, with the new equipment becoming operational in 2015. However, a known VLF station would inevitably be a target for a pre-emptive strike by any adversary who makes the choice to use nuclear weapons against India. There is thus need for redundant capacity for safeguarding the security of VLF/ELF communications.

Number of Boats Needed

Finally, how many SSBNs does India need? This is a function of weapon range and acceptable time lapse between the directive to launch a retaliatory strike and its actual launch. India's doctrine presently requires that retaliation be carried out within six hours of the directive. This means that the boat must be deployed within six hours reach of the desired launch position.

If the primary weapon is the K-15 SLBM, launch positions will have to be in the Northern Arabian Sea for Pakistan, and the East or South China Seas for China. The requirement then is for at least two boats deployed on deterrent patrol round the clock. Going by the thumb rule of three boats being required to maintain one on task, the requirement becomes of at least six boats. More would be needed if redundancies are to be provided. With the K-4 SLBM, however, one boat in the Northern Bay of Bengal/Andaman Sea can cover both adversaries. That translates into a requirement of at least three boats, and four to provide a reasonable level of strategic comfort.

Conclusion

Independent underwater deterrent capability is not something that can be acquired off the shelf. It is a matter of considerable significance that this has been developed indigenously, traversing a long road. INS Arighaat and INS Arihant are operational. The progress achieved in developing the requisite technology to operationalise them has been commendable. To the extent that the nuclear triad is operational, India's expectations have been fulfilled.

INS Arighaat, however, is part of India's first generation of SSBNs. There is much to be done by way of developing higher power reactors, better quieting systems for the machinery, better stealth capability for the boat, longer range missiles, secure communications, and better survivability. Continuous technological improvement will be the name of the game. This is a strategic imperative on which there can be no compromise.

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