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AI and Sea-Based Nuclear Command and Control in India: Implications for Crisis and Deterrence Stability in South Asia

Maryyum Masood¹

Abstract

This paper examines how India's expanding use of AI-enabled capabilities in naval sensing, undersea surveillance analytics, communications support, and cyber defence is reshaping the information environment that conditions nuclear command and control (NC2) for its sea-based deterrent, and assesses the implications for crisis and deterrence stability in South Asia, with particular focus on Pakistan. India's Arihant-class SSBN force is designed to provide survivable retaliation under conditions of concealment, isolation, and constrained connectivity. Open sources do not substantiate any role for AI in nuclear launch authorisation or automated nuclear decision-making. The paper therefore treats AI as an enabling variable within sea-based NC2, arguing that AI's strategic significance lies in how it compresses and prioritises information, reduces decision latency for command-relevant judgments, and shapes force-protection behaviour around SSBN survivability in a verification-poor maritime environment. The study identifies crisis stability risks arising from AI-assisted classification under ambiguity, including compressed decision windows, automation bias in interpreting machine-generated alerts, and escalatory action–reaction dynamics when precautionary NC2 measures are misread as intent. It also highlights NC2-adjacent vulnerabilities associated with cyber intrusion, spoofing, and adversarial data manipulation across sensor-to-decision pipelines, as well as the heightened risk of third-party interference in the maritime domain where attribution is difficult. The paper further argues that improvements in AI-enabled undersea awareness may narrow uncertainty around submarine activity and intensify perceived pressures on the concealment and ambiguity that underpin Pakistan's sea-based second-strike posture, which relies on nuclear-capable SLCMs deployed from conventional submarines rather than SSBNs. The paper concludes by recommending stronger human oversight and layered verification for AI-assisted NC2 functions, maritime crisis communication

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and incident-management mechanisms, and restraint-oriented norms discouraging destabilising AI applications in NC2.

Keywords: Artificial Intelligence, Sea-based Nuclear Command and Control, India, Pakistan, Crisis Stability, Deterrence Stability, South Asia.

Introduction

The integration of Artificial Intelligence (AI) into military information systems is reshaping how nuclear-armed states collect, filter, and interpret operational data that can be relevant to nuclear command and control (NC2).² This effect is most pronounced in the maritime domain. Sea-based nuclear platforms are designed to operate under concealment, physical separation from national leadership, and constrained connectivity. These conditions create persistent uncertainty about what is occurring at sea and about how quickly that information can be verified and translated into command-relevant judgments.³ In South Asia, where crises can evolve quickly and political signaling is often imperfect, AI does not need to automate nuclear use to carry strategic consequence. Its significance lies in how it changes the informational environment in which human decision-makers seek to preserve control, prevent miscalculation, and manage escalation.⁴

India's sea-based nuclear deterrent, centered on the Arihant-class SSBNs⁵ and supported by K-series submarine-launched ballistic missiles,⁶ represents a major evolution in the region's nuclear force posture. Sea-based deterrence is intended to strengthen assured retaliation by placing nuclear forces on platforms that are difficult to locate and neutralise. Yet survivability at sea produces a distinctive NC2 problem. Submerged submarines cannot maintain continuous, high-bandwidth communication with national leadership without compromising operational security. Communication links are constrained by physics, bandwidth, and the need to avoid exposure. Sea-based NC2 therefore relies on intermittent connectivity, strict authentication, and procedures designed to sustain positive control under degradation while preventing unauthorised use. These structural constraints increase the premium

² Zaigham Abbas, Fouzia Amin, and Muhammad Mashhood Khan, "Integration of Artificial Intelligence in Nuclear Command and Control Systems (NC2): Assessing Cold- War Paradigm," *Journal of Social Sciences Review* 5, no. 1 (2025): 180–88, <https://doi.org/10.62843/jssr.v5i1.476>

³ Muhammad Azam Khan, "Sea-Based Nuclear Weapons," *The News*, January 8, 2018, <https://www.thenews.com.pk/print/265829-sea-based-nuclear-weapons>.

⁴ Shahbaz Ahmed Shahzad and Aamir Khan, "AI and Modern Warfare: Opportunities and Risks in South Asia," *International "Journal of Academic Research for Humanities"* 4, no. 3 (2024): 1–10, published May 22, 2024, <https://jar.bwo-researches.com/index.php/jarh/article/view/433>.

⁵ "Arihant Class Submarine," *Naval Technology*, August 19, 2009, <https://www.naval-technology.com/projects/arihant-class/>

⁶ "K Missile Family," *Shankar IAS Parliament*, October 5, 2020, <https://www.shankariasparliament.com/current-affairs/k-missile-family>

placed on accurate threat interpretation, disciplined signaling, and resilient communications in crisis conditions.⁷

Open sources do not substantiate any role for AI in India's nuclear launch authorisation or automated nuclear decision-making. This paper therefore treats AI as an enabling variable within sea-based NC2 rather than as a substitute for political control. The analytical focus is on NC2-relevant enabling functions that India is expanding in the maritime domain, including AI-assisted acoustic processing and undersea surveillance analytics, information filtering and prioritisation, communications support under bandwidth constraints, and cyber defence for naval networks. In practice, these applications operate as "information compression" tools. They reduce large volumes of noisy maritime data into prioritised assessments and alerts that can shape how operators and commanders perceive threat, manage force protection, and adjust posture around SSBN survivability in a verification-poor environment.

The paper evaluates how these enabling functions can influence stability through three linked mechanisms i.e., detection, decision time, and ambiguity. First, improved AI-enabled undersea awareness can reduce uncertainty about submarine activity, potentially narrowing the concealment and ambiguity that sea-based postures depend upon.⁸ Second, AI-driven compression and prioritisation can reduce decision latency for command-relevant judgments, especially during episodes of heightened anti-submarine warfare activity or ambiguous undersea encounters. Faster assessment can support survivability, but it can also increase the likelihood that precautionary NC2 measures are taken quickly and interpreted by an adversary as escalatory intent.⁹ Third, over time, persistent improvements in classification and pattern recognition may erode strategic ambiguity in a domain where

⁷ Ghazala Yasmin Jalil, "India's Development of Sea-Based Nuclear Capabilities: Implications for Pakistan," *Strategic Studies* 38, no. 1 (2018): 45–66, https://issi.org.pk/wp-content/uploads/2018/04/3-SS_Ghazala_Yasmeen_Jalil_No-1_2018.pdf

⁸ Dr Shamim Quadir, "AI, Drone Ships and New Sensors Could Leave Submarines with Few Places to Hide in the Ocean," *City St George's*, University of London, October 9, 2025, <https://www.citystgeorges.ac.uk/news-and-events/news/2025/september/ai-drone-ships-new-sensors-could-leave-submarines-few-places-hide-ocean>

⁹ Clarisse Joy Absalon, "Integrate AI on Submarines to Predict, Detect, and Decide," *Proceedings* 151, no. 7 (1,469) (July 2025), U.S. Naval Institute, <https://www.usni.org/magazines/proceedings/2025/july/integrate-ai-submarines-predict-detect-and-decide>

dual-capable platforms and overlapping conventional operations already complicate interpretation.¹⁰

For Pakistan, the principal concern is the possibility that India's AI-shaped maritime information environment could intensify crisis instability and gradually reshape deterrence stability. During crises, AI-assisted classification under uncertainty can compress decision windows and amplify automation bias, increasing the risk that ambiguous indicators are treated as more definitive than they are. As SSBN-related force protection measures may be observable indirectly through changes in naval activity, communications posture, or inferred operational behaviour, action-reaction dynamics can accelerate even when neither side intends escalation.¹¹ Over the longer term, India's improving undersea awareness may generate perceived pressures on the survivability and ambiguity that underpin Pakistan's sea-based second-strike posture, which relies on nuclear-capable Submarine-Launched Cruise Missiles (SLCMs) deployed from conventional submarines rather than an SSBN-based posture. Even when doctrinal positions remain unchanged, shifting perceptions of concealment and control can alter incentives and risk tolerance.¹²

A further source of instability arises from cyber vulnerabilities inherent in AI-enabled, data-dependent systems. AI-assisted NC2-relevant functions rely on the integrity of sensor inputs, software, training data, and communications networks. In the maritime domain, verification is difficult and attribution is contested. This expands exposure to cyber intrusion, spoofing, and adversarial data manipulation across sensor-to-decision pipelines. Compromised data can generate spurious alerts, suppress genuine indicators, or distort confidence levels in assessments relevant to SSBN survivability and command connectivity. These risks are not limited to bilateral dynamics. The maritime theatre involves multiple actors and overlapping operations, increasing pathways for third-party interference that could shape perceptions

¹⁰ Mayukh Dey, "Dual-Use AI Technologies in Defense: Strategic Implications and Security Risks," *WorldAndNewWorld*, first published January 19, 2026, <https://worldnewworld.com/page/content.php?no=6259>

¹¹ Sreekanth Narayan, "Strategic Decision-Making Under AI-Related Uncertainty: Navigating Risks, Biases, and Opportunities in the Age of Intelligent Systems," *Social Sciences* (December 2025), https://www.researchgate.net/publication/398357858_Strategic_Decision-Making_Under_AI-Related_Uncertainty_Navigating_Risks_Biases_and_Opportunities_in_the_Age_of_Intelligent_Systems.

¹² Rauf Khalid, "Analyzing Pakistan's Second Strike Capability and Nuclear Deterrence: Pakistan's Babur 3 vs India's INS Arihant," *Paradigm Shift*, January 24, 2022, <https://www.paradigmshift.com.pk/second-strike-capability/>.

without clear attribution. The danger is not automated nuclear authorisation, but human decisions taken under uncertainty on the basis of manipulated or degraded information.¹³

Against this backdrop, this paper examines how India's AI-enabled maritime capabilities interact with the specific constraints of sea-based NC2 and assesses the implications for crisis stability, deterrence stability, and command robustness in South Asia. The argument is not that AI integration is inherently destabilising or that it implies a shift toward automated nuclear employment. Rather, the argument is that AI-enabled improvements in sensing, filtering, and cyber defence can narrow margins for restraint by accelerating operational tempo, heightening sensitivity to misperception, and altering perceived survivability conditions at sea. The paper concludes by identifying practical risk-reduction priorities centered on human oversight and layered verification for AI-assisted NC2 functions, maritime crisis communication and incident-management mechanisms, and restraint-oriented norms discouraging destabilising AI applications in NC2.

NC2 of Sea-Based Nuclear Deterrent

NC2 refers to the institutional, technical, and procedural mechanisms through which a state exercises authority over its nuclear forces, ensures positive control, prevents unauthorised use, and manages escalation during crises. At its core, NC2 is designed to balance two competing imperatives; maintaining tight political control over nuclear use and ensuring the survivability and responsiveness of nuclear forces under conditions of uncertainty and attack. This balance becomes especially difficult to manage in the maritime domain, where sea-based nuclear forces operate in physically isolated, communication-constrained, and high-risk environments.¹⁴

Sea-based nuclear deterrent differs fundamentally from land-and air-based forces in how they are commanded and controlled. Submerged

¹³ Lt. Gen. John "Jack" N. T. Shanahan, "Artificial Intelligence and Nuclear Command and Control: It's Even More Complicated Than You Think," *Arms Control Today*, September 2025, <https://www.armscontrol.org/act/2025-09/features/artificial-intelligence-and-nuclear-command-and-control-its-even-more>.

¹⁴ Giles David Arceneaux, *Nuclear Command and Control and Strategic Stability* (The Hague: The Hague Centre for Strategic Studies, February 2023), <https://hcss.nl/wp-content/uploads/2023/02/02-Arceneaux-Nuclear-Command-and-Control-and-Strategic-Stability.pdf>

nuclear-capable submarines rely on stealth and endurance to guarantee survivability, but these same attributes restrict continuous communication with national leadership.¹⁵ Very Low Frequency (VLF) and Extremely Low Frequency (ELF) systems allow limited one-way communication, often transmitting brief, preformatted messages rather than real-time situational updates. As a result, sea-based NC2 systems necessarily involve higher degrees of autonomy, redundancy, and procedural pre-planning than other legs of the nuclear triad.¹⁶

This distinction is central to Pakistan's security calculations. The credibility of a sea-based deterrent does not rest on rapid reaction or launch-on-warning postures, but on assured retaliation under conditions of degraded command connectivity. This creates structural pressures toward pre-delegation arrangements, rigid authentication protocols, and simplified decision trees. While such arrangements enhance survivability, they also increase sensitivity to misinterpretation, especially during crises at sea where conventional and nuclear operations may overlap.

AI as an Enabling Variable in NC2

This study treats AI not as an autonomous decision-maker but as an enabling variable within NC2 systems. AI is increasingly integrated into supporting functions that shape how information is collected, processed, prioritised, and presented to human decision-makers. In the maritime nuclear context, these functions include undersea surveillance and acoustic analysis, maritime domain awareness, communications management, cybersecurity, and decision-support modelling.¹⁷

Conceptually, AI alters NC2 by accelerating information flows and influencing perception rather than by transferring launch authority to machines. AI-assisted data fusion allows large volumes of sensor data to be filtered and interpreted more quickly than traditional methods. Decision-support tools can

¹⁵ Commander Vijay Sakhuja, "Sea Based Deterrence and Indian Security," *Strategic Analysis* 25, no. 1 (April 2001), https://ciaotest.cc.columbia.edu/olj/sa/sa_apr01sav01.html

¹⁶ "Underwater Communication," *Aviation and Defense Market Reports*, March 9, 2022, <https://aviationanddefensemarketreports.com/underwater-communication/>

¹⁷ Miltiadis Alamaniotis and Konstantinos Ipiotis, "Artificial Intelligence as Enabler for Adoption of Sustainable Nuclear-Powered Maritime Ships: Challenges and Opportunities," *Sustainability* 17, no. 8 (2025): 3654, April 18, 2025, <https://doi.org/10.3390/su17083654>.

model escalation pathways, assess threat indicators, and recommend response options. In communication-constrained environments, AI can prioritise critical messages and assist in authentication under bandwidth limitations.¹⁸

For Pakistan, the key concern is that AI is restructuring the human-machine relationship in ways that can compress decision time and amplify uncertainty. When operators or commanders are presented with AI-generated assessments under stress, the risk of automation bias increases, particularly if alternative sources of verification are unavailable.

The conceptual framework of this paper links AI-enabled NC2 to crisis stability through three mechanisms - detection, decision time, and ambiguity. First, improvements in AI-assisted detection and tracking may undermine the survivability of sea-based deterrent by reducing uncertainty about submarine presence, movement, or mission type.¹⁹ Second, faster processing and alert generation can shorten decision windows, increasing the likelihood of precautionary or risk-acceptant behaviour during crises.²⁰ Third, AI-driven transparency can erode strategic ambiguity, a key stabilising factor in Pakistan-India deterrence, particularly at sea where dual-capable platforms operate.²¹

These mechanisms are especially destabilising when combined with asymmetries in technological capability. If one side believes its maritime deterrent is increasingly vulnerable, it may adopt compensatory measures that lower thresholds, increase readiness, or rely more heavily on pre-delegated

¹⁸ Mark Fitzpatrick, "Artificial Intelligence and Nuclear Command and Control," Survival Online (International Institute for Strategic Studies), April 26, 2019, <https://www.iiss.org/online-analysis/survival-online/2019/04/artificial-intelligence-nuclear-strategic-stability/>.

¹⁹ Dr Shamim Quadir, "AI, Drone Ships and New Sensors Could Leave Submarines with Few Places to Hide in the Ocean," *City St George's*, University of London, published October 9, 2025, <https://www.citystgeorges.ac.uk/news-and-events/news/2025/september/ai-drone-ships-new-sensors-could-leave-submarines-few-places-hide-ocean>.

²⁰ Sarah Al-Hussaini, Yuxiang Guan, Jason M. Gregory, Kimberly Pollard, Peter Khooshabeh, and Satyandra K. Gupta, "Assessing the Impact of Alerts on the Human Supervisor's Decision-Making Performance in Multi-Robot Missions," *ACM Transactions on Human-Robot Interaction* 14, no. 1, art. no. 7 (November 28, 2024): 1–40, <https://doi.org/10.1145/3689828>

²¹ Dr Shamim Quadir, "AI, Drone Ships and New Sensors Could Leave Submarines with Few Places to Hide in the Ocean."

authority. Such adaptations may be rational individually but destabilising collectively.²²

India's Sea-Based Nuclear Posture

India is transitioning from a fledgling sea-based deterrent toward a more established force. Its SSBN program under the Advanced Technology Vessel (ATV) project, initiated in the 1980s, has begun to mature over the past decade.²³ The Arihant-class²⁴ forms the backbone of India's nascent sea-based nuclear forces and signals a gradual improvement in second-strike potential at sea.

INS Arihant (SSBN-80), the lead boat (about 6,000 tons), was quietly commissioned in August 2016. Its 83 MW pressurised-water reactor went critical in 2013 and the submarine entered sea trials in 2014. By late 2018, Arihant reportedly completed India's first deterrent patrol, effectively operationalising the naval leg of the triad. With four vertical launch tubes, Arihant can carry up to 12 K-15 "Sagarika" SLBMs (three per tube) or up to 4 K-4 SLBMs (one per tube).²⁵

INS Arighat (SSBN-81), the second Arihant-class boat (originally codenamed "Aridhaman"), was launched in 2017 and commissioned on 29 August 2024. It is described as an improved Arihant-class submarine but retains broadly similar dimensions and has the same four-tube missile capacity. At the time of commissioning, it was reported that Arighat would initially be armed with K-15 SLBMs (about 750 km range) under the Strategic Forces Command. With Arighat's induction, India operates two SSBNs, with Indian leadership portraying this as strengthening "strategic balance." Two boats also move India closer to a rudimentary form of continuous at-sea deterrence, with at least one SSBN on patrol while the other refits or prepares.²⁶

India has at least two more Arihant-class SSBNs in advanced stages, S4 and S4* ("S4 Star"). These are reported to be slightly larger variants (around 7,000 tons) with extended hulls to accommodate 8 missile tubes, doubling the

²² *ibid*

²³ Nuclear Threat Initiative, "India Submarine Capabilities," fact sheet, March 25, 2025, <https://www.nti.org/analysis/articles/india-submarine-capabilities/>

²⁴ "Arihant Class Submarine," *Naval Technology*.

²⁵ Nuclear Threat Initiative, "India Submarine Capabilities."

²⁶ *ibid*

capacity of Arihant/Arighat. S4 was launched in 2021 and is undergoing sea trials, with commissioning expected by 2026. S4* was launched in October 2024 and was also in trials as of early 2026. Beyond these, India is designing a new S5-class SSBN expected to displace around 13,500 tons and carry 12 long-range SLBMs. The S5, intended for the 2030s, would be a major step toward a larger SSBN comparable in size to other established nuclear powers' ballistic missile submarines. All Arihant-class submarines and their successors are being built under the ₹900 billion ATV program, involving a consortium of Indian agencies (DRDO, BARC, Indian Navy) and industry, including Larsen & Toubro Limited (L&T).²⁷

In parallel, India has developed a family of K-series SLBMs through DRDO, varying in range and sophistication. The force spans an operational short-range missile, a medium-range missile in late induction, and longer-range systems in development.

K-15 "Sagarika" (B-05) is a short-range SLBM with an approximate range of ~750 km (some accounts cite 1,000–1,500 km for an extended version). It is nuclear-capable, generally assessed to carry a single warhead (potentially low kiloton to tens of kilotons yield). It is a two-stage, solid-fuelled missile about ~10 meters long. K-15 was successfully test-fired multiple times between 2005 and 2013, and entered service aboard INS Arihant between 2016 and 2018. Each Arihant-class submarine can carry up to 12 K-15s (three per tube). Its current status is operational. Both Arihant and Arighat are currently equipped with K-15 as their primary armament. With a 700–750 km range, K-15 can threaten major Pakistani cities from Indian coastal waters, but it cannot hold deep inland targets in China at risk. India's early sea-based nuclear reach was therefore constrained; an SSBN would need to patrol closer to adversary coastlines (for example, deeper into the Arabian Sea) to target key sites, increasing exposure in wartime. This constraint drove India's emphasis on longer-range SLBMs.²⁸

K-4 is a medium-range SLBM with an estimated range of ~3,500 km. It is a two-stage, solid-fuelled missile capable of carrying a nuclear warhead of over a ton. Owing to its size, only one K-4 fits per launch tube (replacing three K-15s). K-4 is pivotal as its 3,500 km range enables Indian SSBNs to strike targets across all of Pakistan and much of China from safer patrol areas in the

²⁷ *ibid*

²⁸ *ibid*

Indian Ocean. It was first test-fired from a submerged pontoon in 2010, with subsequent tests in 2016 and January 2020. In December 2023, India reportedly conducted two successful underwater launches within six days, with officials highlighting the missile's emergence from underwater and stable ballistic flight, supporting reliability claims. After these tests, sources described K-4 as ready for serial production. The Navy planned deployment beginning 2025, and by mid-2025 a former DRDO scientist indicated that K-4 had been inducted into service aboard Arihant-class submarines. Its current status is near-operational, in late-stage induction. Each of the first two SSBNs can carry up to 4 K-4s at maximum load, while S4/S4* with 8 tubes could carry up to 8 K-4s each. For Pakistan, K-4 is particularly consequential because it covers the entirety of Pakistani territory even if launched from India's own waters or Bay of Bengal bastions, complicating deterrence planning and raising the survivability of India's retaliatory option.²⁹

K-5 is a new-generation SLBM intended to provide true long-range sea-based reach. It is envisioned as a three-stage, solid-fuelled missile with an estimated range of 5,000–6,000 km, broadly comparable to India's land-based Agni-V. It is designed for a 2-ton payload, configurable as a large single warhead or Multiple Independently Targetable Re-entry Vehicles (MIRVs). Indian sources report K-5 may be MIRV-capable, potentially delivering 2–3 warheads to separate targets, which would mark India's first MIRV-capable SLBM (with India also having tested Agni-5 with multiple-warhead/MIRV). K-5's development is largely complete. Initiated around 2015, DRDO reportedly shifted focus to K-5 after finishing K-4 development by 2020. By mid-2025, Indian officials stated that development was completed and preparatory tests (such as rocket motor work) had occurred. Reports suggested an initial submerged pontoon launch was expected earlier. K-5 is planned for integration on later Arihant-class boats (S4/S4*) and eventually S5-class SSBNs, which could carry more missiles with 8 or 12 tubes. It is still under development, not yet deployed.³⁰

K-6 is a more ambitious proposed SLBM reportedly under design at DRDO's Advanced Naval Systems lab. It is described as a three-stage, solid-fuel missile with a range exceeding 6,000–8,000 km, expected to carry a 2–3 tonne MIRV payload (possibly 4+ warheads), and sometimes associated with higher-speed or "hypersonic" claims (Mach 7+). It is envisioned for the

²⁹ *ibid*

³⁰ *ibid*

future S5-class SSBNs, which would carry 12 long-range SLBMs.³¹ It will pose a grave threat to international peace, security and strategic stability.

• ***India's Integration of AI in NC2 of its Sea-Based Deterrent***

India has not integrated artificial intelligence into nuclear launch authority or decision-making. However, AI-enabled systems increasingly shape the conditions under which command and control of sea-based nuclear forces is exercised. By influencing threat detection, information filtering, communication reliability, and cyber resilience, AI affects the timeliness, confidence, and stability of human command and control, even though formal authority remains centralised and human-controlled.³²

A core challenge in sea-based NC2 is information overload under uncertainty. SSBN survivability depends on accurately distinguishing benign signals from hostile activity while operating in a cluttered acoustic environment.³³ Indian developers, including DRDO and defence startups, have applied AI and machine-learning techniques to acoustic signal classification and passive sonar processing, enabling faster discrimination between ambient noise, marine life, and genuine threats such as adversary submarines or Anti-Submarine Warfare (ASW) platforms.³⁴ Indo-French collaboration on AI-driven acoustic intelligence, supported by a New Delhi research facility and French Naval Group expertise, reinforces this trajectory.³⁵

For NC2, these systems act as information compression mechanisms. They reduce raw sensor data into prioritised threat assessments before information reaches operators or higher command. This improves situational

³¹ *ibid*

³² Sonia Naz, *India's Military Application of AI: Implications for Pakistan* (Lahore: Center for Security, Strategy and Policy Research, July 2021), <https://csspr.uol.edu.pk/wp-content/uploads/2021/07/Indias-Application-of-AI-Tech.pdf>.

³³ Nicholas C. Makris, "Acoustic Clutter in Continental Shelf Environments," final report, Award No. N00010-99-1-1059 (Cambridge, MA: Massachusetts Institute of Technology, Department of Ocean Engineering, n.d.), Defense Technical Information Center (DTIC), ADA533225, <https://apps.dtic.mil/sti/pdfs/ADA533225.pdf>.

³⁴ Team LoS, "DRDO Delivers Four 'Made in India' SONAR Systems to the Indian Navy Which Will Provide Ears in Operational Waters," *Life of Soldiers*, November 18, 2016, <https://www.lifeofsoldiers.com/2016/11/18/drdo-delivers-four-made-in-india-sonar-systems-to-the-indian-navy-which-will-provide-ears-in-operational-waters/>.

³⁵ "Paris and Delhi Join Underwater Acoustic Intelligence Forces," *Intelligence Online*, March 19, 2024, <https://www.intelligenceonline.com/europe-russia/2024/03/19/paris-and-delhi-join-under-water-acoustic-intelligence-forces,110193088-art>.

awareness but also shapes threat interpretation, potentially influencing how rapidly alerts propagate through the command chain.³⁶

India's deployment of AI-enabled autonomous underwater systems further affects escalation dynamics.³⁷ In late 2025, DRDO unveiled man-portable AUVs equipped with deep-learning algorithms for mine detection and classification. These platforms autonomously identify mine-like objects using sonar and optical sensors and can operate cooperatively as swarms. Successful trials and movement toward production mark a confirmed enhancement in underwater mine countermeasures.³⁸ In NC2 terms, such systems contribute to escalation control by reducing the likelihood that routine environmental hazards or legacy mines are misinterpreted as hostile action against SSBNs. By stabilising the operating environment of sea-based nuclear platforms, AI-enabled autonomy lowers the risk of inadvertent escalation triggered by ambiguous undersea events. However, they come with their own set of risks as AI-enabled AUVs can lead to misclassification or automation bias which can generate false "hostile" undersea cues, prompting precautionary SSBN force-protection moves that an adversary may misread as escalation.

Planned initiatives such as the National Underwater Domain Awareness (NUDA) framework³⁹ extend this logic. Although still developmental, NUDA aims to integrate AI-assisted sonar analytics and unmanned platforms into a networked maritime sensor grid.⁴⁰ If realised, this would further compress and standardise undersea information flows, allowing SSBNs to operate within a shared threat picture. However, AI-driven route optimisation and real-time manoeuvre guidance remain conceptual, with no confirmed operational deployment.

³⁶ Sarah Al-Hussaini et. al., "Assessing the Impact of Alerts on the Human Supervisor's Decision-Making Performance in Multi-Robot Missions."

³⁷ "India's Deployment of AI-Enabled Autonomous Underwater Systems," *Defense Mirror*, https://defensemirror.com/news/40537/India___s_DRDO_Develops_Intelligent_Underwater_Vehicles_for_Mine_Detection.

³⁸ Government of India, Ministry of Defence, "DRDO Develops New Generation Man-Portable Autonomous Underwater Vehicles for Mine Countermeasure Missions," Press Information Bureau (PIB), November 14, 2025, <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2190096®=3&lang=1>.

³⁹ "The Underwater Domain Awareness Framework: Infinite Possibilities in the New Global Era," *India Foundation*, accessed January 2026, <https://indiafoundation.in/articles-and-commentaries/the-underwater-domain-awareness-framework-infinite-possibilities-in-the-new-global-era/>.

⁴⁰ SEAANDJOB, "India to Launch Advanced Underwater Sensor Network in Indian Ocean to Counter China," *Sea and Job*, April 22, 2025, <https://www.seaandjob.com/india-to-launch-advanced-underwater-sensor-network-in-indian-ocean-to-counter-china/>.

Sea-based NC2 is uniquely constrained by low-bandwidth, one-way communications with submerged submarines. India relies on Very Low Frequency (VLF) broadcasts for SSBN connectivity and is constructing a second VLF station at Vikarabad to ensure continuous encrypted coverage.⁴¹ While this improves reach and redundancy, it does not resolve bandwidth limitations. Within this constraint, AI's relevance lies in reducing decision latency. Indian innovators, such as startup Airbotix, are developing advanced submarine communication systems.⁴² Although technical details are undisclosed, such systems likely employ AI-assisted data compression, prioritisation, and signal optimisation to ensure that critical commands and alerts are transmitted first. In NC2 terms, this does not accelerate launch authority but shortens the time between information generation and human comprehension, particularly under crisis conditions.

Authentication and message integrity further intersect with NC2 stability. AI-based anomaly detection and pattern recognition can support authentication under severe bandwidth limits, reducing the risk of spoofed or corrupted orders.⁴³ While India has not publicly described its naval Nuclear Command, Control and Communications (NC3) procedures, the parallel integration of AI in naval cyber defence suggests functional overlap in protecting communication integrity.

India's Strategic Forces Command⁴⁴ remains firmly human-controlled. There is no evidence of AI exercising autonomous nuclear decision-making. However, India's demonstrated use of AI-supported simulations, intelligence fusion, and scenario modelling in conventional operations illustrates how AI can compress analytical timelines and assist planners in evaluating escalation

⁴¹ Government of India, Ministry of Defence, "Raksha Mantri Lays Foundation Stone of Very Low Frequency Station in Vikarabad, Telangana to Bolster Navy's Operational Readiness," Press Information Bureau (PIB), October 15, 2024, <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2064991®=3&lang=2>.

⁴² Team India Sentinels, "Underwater Communication Technologies for Safer Indo-Pacific Ocean," *India Sentinels*, March 25, 2025, <https://www.indiasentinels.com/defence-industry/private/underwater-communication-technologies-for-safer-indo-pacific-ocean-6693>.

⁴³ *ibid*

⁴⁴ Usman Haider, "The Evolution of India's Strategic Forces Command," *The Diplomat*, August 2, 2025, <https://thediplomat.com/2025/08/the-evolution-of-indias-strategic-forces-command/>.

pathways.⁴⁵ Applied to the sea-based leg, similar tools would influence how quickly and confidently human authorities assess deterrence stability, without altering formal command authority.

Taken together, India's integration of AI does not automate sea-based nuclear command. Instead, it restructures the informational environment of NC2 by compressing sensor data, stabilising undersea operations, reducing communication latency, and hardening cyber defences. These developments affect how escalation is perceived and managed, not who authorises nuclear use.

Crisis Stability Implications of AI-Shaped Sea-Based NC2

Crisis stability in the nuclear domain depends on the ability of adversaries to manage confrontation without being driven toward rapid escalation or premature nuclear use.⁴⁶ In the context of India's sea-based deterrent, crisis stability is shaped not by automated nuclear decision-making, which India does not employ, but by how AI alters the information environment in which human command and control decisions are exercised over SSBN operations.⁴⁷

A central challenge for sea-based NC2 is managing ambiguity under time pressure. SSBNs operate in acoustically cluttered environments where benign contacts, environmental noise, and hostile activity can be difficult to distinguish.⁴⁸ India's adoption of AI-assisted acoustic classification and passive sonar processing is intended to compress raw undersea sensor data into prioritised threat assessments. This improves SSBN survivability by enabling faster recognition of potential threats and more timely evasive or protective actions.⁴⁹ However, this same compression can accelerate the pace at which

⁴⁵ Aliza Saeed, "Artificial Intelligence and Modern Warfare: Comparative Analysis of India and Pakistan," *Modern Diplomacy*, April 7, 2023, <https://modern diplomacy.eu/2023/04/07/artificial-intelligence-and-modern-warfare-comparative-analysis-of-india-and-pakistan/>.

⁴⁶ Sumit Ganguly and Kent L. Biringir, "Nuclear Crisis Stability in South Asia," *Asian Survey* 41, no. 6 (November–December 2001): 962–981, <https://library.fes.de/libalt/journals/swetsfulltext/14218813.PDF>.

⁴⁷ Shiza Khan, *Impact of Technological Changes on Strategic Stability in South Asia* (Lahore: Center for Security, Strategy and Policy Research, August 2021), <https://csspr.uol.edu.pk/wp-content/uploads/2021/08/IMPACT-OF-TECHNOLOGICAL-CHANGES-ON-STRATEGIC-STABILITY-IN-SOUTH-ASIA.pdf>.

⁴⁸ Nicholas C. Makris, "Acoustic Clutter in Continental Shelf Environments."

⁴⁹ Team LoS, "DRDO Delivers Four 'Made in India' SONAR Systems to the Indian Navy Which Will Provide Ears in Operational Waters."

command-relevant judgments are formed and transmitted.

For Indian commanders, AI-driven information compression not only reduces uncertainty but also shortens the interval between detection and response. In a maritime crisis involving heightened ASW activity or ambiguous undersea encounters, faster classification of contacts as potentially hostile could prompt rapid adjustments in SSBN alert levels, communications posture, or patrol behaviour. These adjustments are not nuclear launch decisions, but they are NC2 actions that signal perceived threat levels. Because such changes may be detected indirectly through adversary intelligence or inferred from shifts in naval activity, they can provoke reciprocal countermeasures. The risk lies in a feedback loop in which AI-compressed threat assessments drive faster command responses, narrowing the space for political de-escalation or clarification.⁵⁰

False alarms and misclassification represent a second crisis stability concern. AI systems, while improving pattern recognition, remain probabilistic and context-dependent. Errors in acoustic classification or network anomaly detection can elevate benign activity into perceived hostile intent. In a crisis environment, automation bias, the tendency of operators to place excessive confidence in machine-generated assessments, can amplify the impact of such errors.⁵¹ If Indian command authorities interpret an AI-generated threat assessment as evidence that an SSBN is being trailed or targeted, they may increase readiness or alter command protocols. Pakistan, observing heightened Indian naval alertness without insight into the underlying cause, could interpret these moves as preparatory escalation rather than precaution, leading to mirrored responses. The risk to crisis stability arises from the speed at which AI shapes command perceptions and responses surrounding the survivability and control of sea-based nuclear forces.

⁵⁰ Lukas Albrecht, Hagen Braun, Tim Robin Kosack, and Thomas Krüger, “The Limits of Meaningful Human Control of AI in the Maritime Domain,” *Transactions on Maritime Science* 14, no. 3 (October 2025), <https://doi.org/10.7225/toms.v14.n03.w02>.

⁵¹ Anna Nadibaidze and Nicolò Miotto, “The Impact of AI on Strategic Stability Is What States Make of It: Comparing US and Russian Discourses,” *Journal of Global Security Studies* 8, no. 2 (2023): 47–67, published online April 26, 2023, <https://doi.org/10.1080/25751654.2023.2205552>.

Deterrence Stability and the Asymmetry Introduced by Sea-Based NC2 Evolution

Deterrence stability rests on the mutual confidence that each side can retaliate following a nuclear attack and that neither side has incentives to seek advantage through preemption.⁵² India's SSBN program fundamentally strengthens its second-strike capability by placing nuclear weapons on platforms that are difficult to locate and neutralise.⁵³ However, the interaction between India's sea-based deterrent and AI-shaped NC2 introduces asymmetric effects. As India's confidence in the survivability and controllability of its SSBN force increases, regional deterrence and strategic stability could come under pressure. The induction of longer-range SLBMs, particularly the K-4 and prospective K-5, enables Indian SSBNs to hold Pakistani targets at risk from distant patrol areas. This reduces India's dependence on vulnerable land-based systems and enhances its confidence that retaliation is assured even under severe stress.⁵⁴

AI-enabled NC2 reinforces this confidence by stabilising command over SSBNs through improved threat discrimination, information filtering, communication prioritisation, and cyber resilience. For India, these capabilities strengthen negative control (preventing unauthorised use) while preserving positive control (ensuring responsiveness when ordered).⁵⁵ For Pakistan, however, the same developments may be interpreted as India gaining greater flexibility and assurance in managing escalation from a position of safety.

The asymmetry can affect deterrence stability by altering perceptions of risk. If Pakistan perceives India's sea-based forces as survivable and tightly controlled under AI-enhanced NC2, it may infer that India could absorb

⁵² Dr. Beyza Unal and Yasmin Afina, *Perspectives on Nuclear Deterrence in the 21st Century* (London: Chatham House, April 20, 2020; updated December 11, 2020), ISBN 978-1-78413-391-7, <https://www.chathamhouse.org/2020/04/perspectives-nuclear-deterrence-21st-century-0/nuclear-deterrence-destabilized>.

⁵³ *The Hindu*, "INS Arighaat, India's Second Nuclear Ballistic Missile Submarine, Commissioned into Service," updated August 29, 2024, <https://www.thehindu.com/news/national/andhra-pradesh/indias-second-nuclear-powered-submarine-ins-arighaat-commissioned/article68581283.ece>.

⁵⁴ Syed Kazim Ali Shah, "Issue Brief on *Deterrence in Deep Waters: India's Naval Nuclear Build-Up and Options for Pakistan*," Institute of Strategic Studies Islamabad (ISSI), September 1, 2025, <https://issi.org.pk/issue-brief-on-deterrence-in-deep-waters-indias-naval-nuclear-build-up-and-options-for-pakistan/>.

⁵⁵ *ibid*

escalation while retaining credible retaliatory options. Even without evidence of doctrinal change, such perceptions could compel Pakistan to take countermeasures by dispersing forces, increasing readiness, or relying more heavily on non-sea-based deterrent elements.⁵⁶ These responses are defensive in intent but can cumulatively strain deterrence stability by increasing the number of actors, systems, and decision points involved in NC2.

AI does not change the formal authority structure of India's nuclear deterrent, but it influences confidence asymmetry. This could lead to security dilemma in the nuclearised South Asia.

In addition, robust command and control is essential to nuclear stability. It requires preventing unauthorised or accidental use while ensuring the ability to execute authorised orders under extreme conditions. Sea-based deterrence complicates this task because SSBNs operate at great distance from national leadership, under communication constraints, and in environments where situational ambiguity is high.⁵⁷

India's naval NC2 architecture remains firmly human-controlled, with no evidence of delegated or automated nuclear launch authority, and current AI integration does not alter this foundational command structure. Instead, AI is applied at the level of supporting and enabling functions that shape how command decisions are informed, transmitted, and protected. AI-assisted threat assessment, information filtering, communication prioritisation, and cyber monitoring can enhance NC2 robustness by reducing cognitive burden on operators and improving system resilience under stress.⁵⁸ In this sense, AI strengthens both positive control, by supporting the reliable execution of authorised decisions, and negative control, by helping prevent unauthorised or accidental actions.

At the same time, the growing reliance on AI introduces new control and stability challenges rooted in system complexity and data dependence. AI-enabled NC2 functions rely on the integrity of software, training data,

⁵⁶ Jenna Rosenthal, "The Diminishing Reassurance of Mutually Assured Destruction," Organization for World Peace, September 25, 2017, <https://theowp.org/reports/the-diminishing-reassurance-of-mutually-assured-destruction/>.

⁵⁷ Shishir Rao, "Sea-Based Platforms in South Asia's Nuclear Equation," *The Defence Horizon Journal*, July 8, 2021, <https://tdhj.org/blog/post/nuclear-weapons-sea-based-platforms-south-asia/>.

⁵⁸ Shahbaz Ahmed Shahzad and Aamir Khan, "AI and Modern Warfare: Opportunities and Risks in South Asia."

sensor inputs, and secure digital networks. While India has invested in AI-based naval cyber defence platforms to monitor anomalies and protect maritime networks, the introduction of sophisticated algorithms creates additional layers that must be continuously validated, audited, and secured. Vulnerabilities in any part of the data pipeline, whether through corrupted sensor inputs, compromised training datasets, software flaws, or network intrusions, can distort threat assessments or command-relevant information without immediately obvious indicators of failure.⁵⁹

Cyber risks are particularly salient in the maritime domain, where independent verification is limited and attribution is difficult. AI systems can be susceptible to spoofing, data poisoning, and adversarial manipulation, in which false or misleading inputs are deliberately introduced to shape system outputs. In a naval NC2 context, such interference could generate spurious alerts, suppress genuine warnings, or alter confidence levels in assessments related to SSBN survivability or command connectivity. Even if human authority remains intact, decisions taken on the basis of compromised AI-mediated information can inadvertently escalate a crisis or degrade control over strategic forces.⁶⁰

These risks are compounded by the possibility of third-party interference. In a complex maritime environment involving multiple actors and overlapping naval operations, a third party could seek to exploit cyber or data vulnerabilities to influence perceptions and behaviour between India and Pakistan without clear attribution. The danger is that manipulated or ambiguous information could prompt precautionary actions, changes in readiness, or shifts in communications posture that are misinterpreted by the other side. Any uncertainty about the reliability or intent behind such actions raises the risk of inadvertent escalation or loss of confidence in centralised control.⁶¹

Delegation is another sensitive issue. SSBN operations inherently require a degree of operational autonomy for submarine commanders, even if political authority remains centralised. AI does not increase delegation of

⁵⁹ James S. Johnson, "Artificial Intelligence: A Threat to Strategic Stability," *Strategic Studies Quarterly* 14, no. 1 (Spring 2020): 18–41, https://www.airuniversity.af.edu/Portals/10/SSQ/documents/Volume-14_Issue-1/Johnson.pdf.

⁶⁰ Tymoteusz Miller et al., "Artificial Intelligence in Maritime Cybersecurity: A Systematic Review of AI-Driven Threat Detection and Risk Mitigation Strategies," *Electronics* 14, no. 9 (2025): 1844, <https://www.mdpi.com/2079-9292/14/9/1844>.

⁶¹ *ibid*

launch authority, but it can influence how much discretion commanders exercise in managing readiness, communications, and evasive actions. Clear procedural boundaries and robust authentication mechanisms are therefore critical. The risk arises not from India strengthening control, but from misalignment of perceptions.⁶² If Pakistan doubts the reliability or intent of India's sea-based NC2, it may assume worst-case scenarios in a crisis, regardless of India's actual procedures.

For Pakistan, the principal risks lie in speed, perception and asymmetry. Faster information processing could compress decision timelines, improved Indian confidence could erode reciprocal reassurance and increased complexity could introduce new failure modes, even as it strengthens control.

The challenge for crisis and deterrence stability is therefore not technological per se, but relational. As India's sea-based NC2 becomes more resilient and AI-assisted, stability will depend on whether both sides can maintain confidence that escalation will remain deliberate, controlled, and reversible. Without that confidence, even stabilising technologies can contribute to destabilising perceptions.

The Way Forward

India's integration of AI into the NC2 systems supporting its sea-based deterrent is a structural trend that Pakistan must treat as enduring, not episodic, and take appropriate countermeasures in line with its policy of maintaining Credible Minimum Deterrence in order to preserve deterrence credibility and crisis stability. India's growing use of AI for undersea surveillance, data fusion, communications management, and decision-support increases the risk that machine-generated assessments could compress decision time and shape crisis behaviour. Layered verification is therefore important for Pakistan. Strengthening NC2 resilience under degraded conditions, including redundancy in communications with submerged platforms and robust cyber defences against data manipulation, reduces the likelihood that warning information or operational cues are treated as decisive when they may be uncertain, noisy, or compromised.

⁶² Center for International Strategic Studies (CISS), *Report of the CISS International Conference on Nuclear Deterrence in the Age of Emerging Technologies* (Islamabad: CISS, 2025), <https://ciiss.org.pk/wp-content/uploads/2025/12/FinalForWeb2.pdf>.

Because the destabilising effects of India's AI-enabled maritime NC2 are most acute during crises, Pakistan should emphasise practical crisis-management tools in the naval domain. The Indian Ocean environment is already characterised by limited transparency and weak incident-management arrangements, and AI-enabled monitoring can intensify action-reaction cycles when alerts are generated quickly and interpreted conservatively. Pakistan's interest lies in slowing escalation and improving signalling clarity during naval encounters, not in disclosing sensitive operational details. This can be pursued through narrowly scoped risk-reduction measures such as agreed procedures for handling close encounters at sea, communication channels between naval commands during incidents, and predictable practices around major naval exercises. Even modest mechanisms that allow rapid clarification of intent can reduce the probability that AI-influenced warnings or threat classifications translate into escalatory postures before political leaders have time to assess and intervene.

Pakistan also has to maintain balance between a survivable sea-based deterrent and avoiding steps that lower thresholds in an AI-mediated environment. As India's AI-enabled maritime domain awareness improves, Pakistan may perceive greater pressure on the survivability and opacity of its sea-based second-strike option, particularly because it relies on nuclear-capable SLCMs deployed from conventional submarines rather than SSBNs. The stabilising response is not to move toward hair-trigger readiness or expansive pre-delegation, both of which increase escalation risks under uncertainty, but to preserve deterrence through survivability practices, selective deployment, and ambiguity that complicates adversary targeting and interpretation. In practical terms, this means keeping political control central, maintaining disciplined release procedures, and investing in reliability and concealment measures that support assured retaliation without incentivising rapid use decisions.

A further concern for Pakistan is that AI-enabled NC2 systems, especially those dependent on complex data pipelines and software ecosystems, expand exposure to cyber intrusion, data poisoning, and spoofing. These risks are not limited to India-Pakistan interaction. Third-party manipulation of sensor inputs, training data, or communications pathways could generate false indicators that shape India's threat perception and crisis posture, creating escalation without clear attribution. Pakistan should therefore

strengthen its own cyber resilience for NC2-adjacent systems while also supporting restraint norms against interference with nuclear command infrastructure and against AI-enabled spoofing of early warning or maritime surveillance data. This is a stability interest, not a competitive one, because the most dangerous scenario is one in which either side acts on corrupted information in a compressed decision environment.

Finally, Pakistan should support the development of regional and global norms for responsible AI use in NC2, with particular emphasis on retaining human control over nuclear decision-making and discouraging destabilising applications that erode survivability at sea. India's increasing reliance on AI-enabled tools in maritime operations makes norm-building more relevant for South Asia, even if formal agreements remain difficult. Engagement through multilateral forums and technical Track-II exchanges can help promote principles such as human-in-the-loop decision-making, rigorous verification before escalation-relevant judgments, and restraint in targeting NC2-related digital infrastructure. Over time, crisis stability in the maritime nuclear domain will depend less on who integrates AI faster and more on whether both sides can prevent AI-enabled systems from narrowing political control, distorting threat perception, and accelerating escalation beyond deliberate intent.

Conclusion

This paper assesses how India's expanding use of AI-enabled capabilities in naval sensing, undersea surveillance analytics, and communications support is reshaping the information environment that conditions NC2 for its sea-based deterrent, and how this may affect crisis and deterrence stability in South Asia, with particular focus on Pakistan. Open sources do not substantiate any AI role in nuclear launch authorisation or automated nuclear decision-making; accordingly, the paper treats AI as an enabling variable whose strategic significance lies in compressing and prioritising maritime information, reducing latency for command-relevant judgments, and shaping force-protection behaviour around SSBN survivability under constrained connectivity and limited verification. The analysis finds that crisis stability risks can emerge even without doctrinal change, because AI-assisted classification under ambiguity may shorten decision windows, amplify automation bias in interpreting machine outputs, and intensify action-reaction dynamics when precautionary NC2 measures (readiness,

communications posture, patrol behaviour) are misread as intent in a cluttered undersea environment. Over time, improvements in AI-enabled undersea awareness may narrow uncertainty around submarine activity, reinforcing India's confidence in the survivability and controllability of its SSBN force while increasing Pakistan's perceptions of pressure on the concealment and ambiguity that underpin its sea-based second-strike posture, which relies on nuclear-capable SLCMs deployed from conventional submarines rather than SSBNs. The paper also highlights NC2-adjacent vulnerabilities that expand with data-dependent AI; cyber intrusion, spoofing, adversarial data manipulation and poisoning across sensor-to-decision pipelines, and the heightened risk of third-party interference in a maritime domain where attribution is difficult and independent verification is limited. These pathways can generate spurious alerts or distorted assessments that shape human decisions under stress even when political control remains centralised. The conclusion is that unmanaged AI integration around sea-based NC2 can narrow margins for restraint in South Asia by accelerating tempo and degrading confidence under uncertainty, and that stability is best supported through strong human oversight and layered verification for AI-assisted functions, hardened cyber and authentication practices for communications, and practical maritime crisis communication and incident-management mechanisms that slow escalation when ambiguity is high.