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BRAHMOS: THE MAKING OF INDIA'S STRATEGIC EDGE

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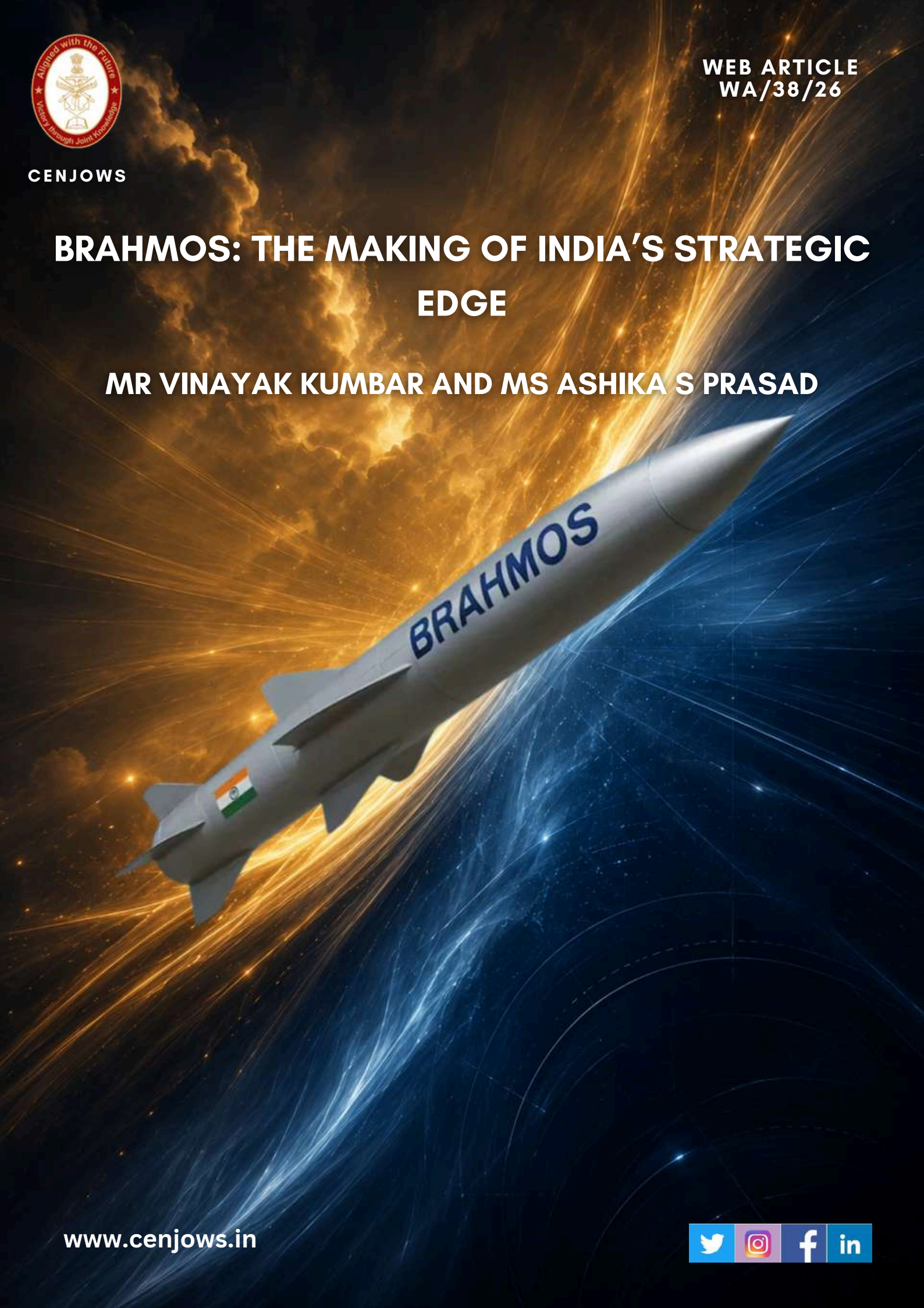

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BRAHMOS: The Making of India's Strategic Edge

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Introduction

What began as an ambitious joint venture aimed at developing a world-class supersonic cruise missile, a quarter century later, has evolved into something far more significant. 'BrahMos' today represents one of the finest examples of India's ability to generate, absorb, institutionalise, and network globally (GAIN) such advanced and strategic technologies. Its success story is something that extends beyond military capability and offers valuable lessons in **V**isionary institution building, **I**ndigenisation capability, **K**nowledge and technology absorption, **A**utonomous strategic capacity, and **S**ustainable development (VIKAS). Hence, BrahMos is not merely a missile programme. It is rather a blueprint for India's journey towards technological sovereignty.

It is a well-known fact that, for decades, India has remained heavily dependent on foreign suppliers for critical military technologies. Although acquisitions provided immediate operational capabilities, they rarely translated into domestic technological competence. The BrahMos experience demonstrates a shift from this. Instead of viewing self-reliance as simply domestic production, the programme clearly illustrates that genuine strategic autonomy emerges when a nation possesses the ability to develop **N**ext-generation design, **I**ndigenous manufacturing, **R**eliable maintenance, **M**odernisation and upgrades, **A**utonomous innovation, and **N**ational capability

(NIRMAN). This distinction is critical. Strategic power in the twenty-first century will be determined not by ownership of technology alone, but by the ability to continuously improve and adapt it.

The Evolution of BrahMos

The BrahMos program emerged from the Indo-Russian Inter-governmental Agreement (IGA) signed in Moscow on 12 February 1998.[1] It led to the formation of BrahMos Aerospace as a joint venture between DRDO and NPO Mashinostroyenia (NPOM).[2] It was named after the Indian Brahmaputra and Russian Moskva rivers.[3] The venture was established with an authorised capital of US$300 million, with India and Russia holding 50.5% and 49.5%, respectively.[4] BrahMos Aerospace was tasked with the design, development, production, and marketing of the BrahMos supersonic cruise missile. The programme combined DRDO's expertise in navigation systems, mission software, and mobile launchers with NPOM's strengths in ramjet propulsion and cruise missile technologies,[5] resulting in the rapid development of one of the world's most successful supersonic cruise missile systems.

What makes BrahMos Special?

BrahMos is a two-stage, supersonic cruise missile capable of sustaining speeds of approximately Mach 2.8-3.0.[6] This makes it the fastest operational cruise missile in the world.[7] The missile employs a solid-fuel booster in its initial stage, followed by a liquid-fuel ramjet propulsion system that enables sustained high-speed cruise throughout its flight profile.[8] The missile has a range of 290 km.[9] The ship- and land-launched variants are 8.2 m long, 0.67 m in diameter, can carry a 300 kg payload, and weigh anywhere near 3,000 kg at launch, while the air-launched version is 8.0 m long, has the same 0.67 m diameter, carries a 200 kg payload, and weighs about 2,200 - 2,500 kg.[10] All variants feature four clipped-tip delta wings and four rear delta control fins. BrahMos can carry a 200 or 300 kg high-explosive semi-armour-piercing warhead or a 250 kg submunitions warhead.[11] It can be launched from vertical launch systems, ramp launchers, aircraft, and submerged barges and has demonstrated potential for deployment from future missile submarines.[12]

Capability, Commitment, and Competitiveness

One of the most enduring lessons of BrahMos lies in the difference between technology transfer and technology absorption. Countries frequently acquire technologies through partnerships, licensing agreements, and procurement arrangements. But acquiring technology is fundamentally different from mastering it. Technology transfer provides access to designs, processes, and technical knowledge, whereas technology absorption, on the other hand, involves developing **S**cientific expertise, **A**dvanced engineering competence, **A**utonomous innovation, **M**anufacturing capability, **A**daptive research ecosystem, **R**esilient institutions, **T**echnological mastery, **H**olistic capabili**y** development, and strategic **A**utonomy (SAAMARTHYA). This requires patience, investment, and a long-term and concentrated commitment to learning.

This distinction between transfer and absorption, however, is not uniform across every subsystem of the missile. Scholars who have examined India's defence technology partnerships have noted that absorption has generally been deepest in areas such as navigation systems, mission software, and platform integration, where DRDO's own institutional strengths already existed, and comparatively shallower in the ramjet propulsion system, which remains substantially rooted in NPOM's original design lineage.[13] This unevenness is not a failure of the programme; it reflects the reality that genuine design-level mastery of a propulsion system as complex as a liquid-fuel ramjet engine takes considerably longer to internalise than systems integration or software development, even within a well-functioning partnership.[14] A precise accounting of which subsystems India has mastered at the design level, and which remain areas of continuing reliance on the original partner's engineering, would offer a more complete picture of what twenty-five years of BrahMos have actually delivered.

The BrahMos programme achieved historic success because India gradually moved beyond mere technology acquisition and focused entirely on indigenous capability creation. Over the years, domestic participation increased steadily as Indian industries, scientists, engineers, and production agencies acquired deep, localised expertise in advanced manufacturing, complex systems integration, rigorous quality assurance, and core missile technologies. More importantly, the program led to the creation of a vast pool of highly skilled human capital and technical knowledge that

extended far beyond the missile itself. The invaluable lessons learned through the BrahMos journey surely contributed to broader advances in Indian aerospace engineering, precision manufacturing, testing infrastructure, and national defence production. This kind of cumulative, generational accumulation of knowledge represents the true, unshakeable foundation of technological sovereignty.

Equally important has been the robust institutional architecture that sustained this highly complex programme over twenty-five years. Strategic technologies differ fundamentally from conventional commercial ventures or standard business projects. They strictly require National commitment, Investment Sustainability, High Tolerance for setbacks, and Harmonised political support (NISHTHA). Furthermore, such deep national endeavours cannot be successfully managed through short-term procurement cycles or rigid quarterly performance metrics. The BrahMos programme benefited immensely from a Directional vision, Resilient Institutions, Strategic leadership, Transformational commitment, and a Harmonised, Integrated long-term planning (DRISTHI). By design, it was treated as a vital national mission rather than a conventional acquisition project.

These hard-earned lessons assume particular significance today as India actively seeks to develop capabilities in critical emerging domains such as hypersonics, advanced propulsion systems, quantum technologies, artificial intelligence, autonomous platforms, and space systems. These advanced technologies will also require decades of sustained effort and institutional patience before delivering operational outcomes, exactly as was seen in the historic case of BrahMos. The frequent temptation to prioritise immediate, short-term results often undermines deep strategic capability development. This program clearly demonstrated that true technological leadership is built through cumulative investments and strategic patience. Nations simply do not become leaders in critical technologies through isolated breakthroughs. Rather, it is through Nurturing institutions, Vital infrastructure, Excellence in human capital, Sustainable innovation, and High-Tech ecosystems (NIVESH) that they do so.

Another defining feature of the BrahMos journey has been the successful creation of a broad industrial ecosystem. Modern defence systems are seldom the product of a single isolated organisation. They would rather naturally emerge from a tightly knit

network of Production Agencies, Research Institutions, Suppliers, Assessment agencies, and Responsible operational users (PARISAR) working in tandem towards a common objective. The ultimate success of BrahMos reflects the emergence of such an ecosystem. Over the years, the programme progressively expanded high-value opportunities for public-sector enterprises, private companies, tech startups, and MSMEs. This widespread participation strengthened domestic supply chains, encouraged long-term investments in advanced manufacturing, and generated a resilient industrial base capable of supporting future strategic programmes.

Innovation through Integration

The role of small and medium enterprises (MSMEs) is vital because true strategic self-reliance cannot be built by a few large corporations alone. These smaller businesses provide the niche technologies, specialised components, and innovative solutions that complex defence systems rely on. By involving MSMEs, a nation strengthens its industrial resilience, protects its supply chains from vulnerabilities, and drives innovation across the entire defence sector. The BrahMos program proved that national capability relies on developing widespread industrial networks that can sustain innovation and production over the long term, rather than focusing solely on high-profile flagship projects.

At the same time, the BrahMos program highlights the importance of aligning technological advancement with actual military needs, since defence systems are ultimately judged by their battlefield effectiveness rather than how much of their content is locally produced. Throughout its history, BrahMos kept technology developers and military users in close contact. This continuous communication enabled steady improvements in the missile's performance, reliability, ease of maintenance, and flexibility, ultimately enabling it to be successfully deployed across land, sea, and air. Keeping the development process firmly tied to real-world operational needs was key to its success.

This user-centric approach is becoming even more important as modern warfare shifts toward connected, multi-domain operations driven by artificial intelligence, autonomous platforms, cyber capabilities, and long-range precision weapons. Because the battlefield environment changes so rapidly, technology must evolve alongside it. Developers and military personnel can no longer work in isolated silos;

instead, they need constant feedback loops to keep new technologies aligned with military demands. The BrahMos experience shows that the best results come from treating military users as active partners in creating new capabilities, rather than just passive consumers of finished technology.

Technology, Exports, and the Strategic Influence

For India, the BrahMos model offers valuable guidance for emerging strategic technologies. A number of critical sectors share characteristics similar to those encountered during the early phases of the BrahMos programme. The critical sectors include aero-engines, hypersonic propulsion, advanced materials, electronic warfare systems, autonomous platforms, semiconductor manufacturing, and quantum technologies, which involve high technological complexity, long gestation periods, significant financial investments, and dependence on specialised industrial ecosystems.

Aero-engine development remains perhaps the most strategically important challenge among these. Even though we have made significant progress in several sectors, propulsion technologies remain a critical vulnerability in India's aerospace ecosystem. The lessons of BrahMos suggest that success will need **S**trategic direction, **A**dvanced talent, **D**urable partnerships, **H**uman c**a**pital development, **N**ational commitment, and **A**pplied innovation (SADHANA). Ultimately, achieving technological mastery is a journey that simply cannot be rushed. Strategic technologies take time to perfect; they mature through a steady cycle of trial and error, learning from mistakes, and long-term institutional persistence.

Beyond self-reliance, BrahMos has also emerged as one of India's most successful instruments of defence diplomacy. For much of its post-independence history, India was known primarily as a major importer of military equipment. The export of BrahMos marks a significant shift in that narrative. The missile has become a symbol of India's growing technological credibility and its emergence as a supplier of advanced defence systems.

It is worth noting that BrahMos's export success cannot be separated from the regulatory architecture that made it possible. The missile's standard variant has long operated at a range of 290 kilometres, a figure that is not incidental but deliberately calibrated to remain within the threshold the Missile Technology Control Regime

applies to its less restrictive category of controlled systems.[15] India's accession to the MTCR in June 2016, as its thirty-fifth member, further strengthened the credibility of BrahMos as an export product, since buyer nations with close defence relationships to other MTCR member states face fewer diplomatic and procedural complications when purchasing from a fellow member than from a non-member supplier.[16] The Philippines deal, concluded in January 2022, was the first instance in which this combination of technical compliance and regime membership translated into a completed contract, and it has since become the template against which subsequent export discussions, including with Vietnam and Indonesia, are measured.[17] Range and regime status, alongside operational performance, together account for why BrahMos succeeded in export markets where comparable Indian systems have not.

The Philippines became the first foreign customer for BrahMos through a landmark coastal defence contract, marking the largest defence export deal (worth USD 375 million)[18] in Indian history at the time. The successful delivery and induction of the missile demonstrated India's ability not only to develop sophisticated technologies but also to support international customers through training, logistics, and lifecycle maintenance. This achievement significantly enhanced India's reputation as a reliable defence partner.

The export momentum has continued to grow. Vietnam has emerged as another important destination for BrahMos (a deal worth USD 629 million),[19] reflecting expanding strategic cooperation between India and Vietnam. Indonesia has also moved closer towards acquiring the system,[20] while several countries have expressed interest. These developments highlight an important evolution in India's strategic posture. Defence exports are no longer viewed merely as commercial transactions but as instruments of foreign policy, regional stability, and strategic influence.

The export success of BrahMos carries important domestic implications as well. Defence exports create economies of scale, sustain production lines, reduce costs, encourage industrial investment, and generate resources for future research and development. More importantly, they validate technological competence. A system capable of meeting the operational requirements of foreign militaries is inherently more competitive and resilient. The international acceptance of BrahMos, therefore,

represents the ultimate validation of the technological ecosystem that India has built over the last twenty-five years.

The next phase of the programme is likely to be even more transformative. The development of BrahMos-NG promises a lighter, faster, and more versatile missile capable of deployment across a wider range of platforms, including fighter aircraft, naval vessels, and mobile launchers. Simultaneously, work on hypersonic technologies under the BrahMos-II concept reflects India's ambition to remain at the forefront of future missile development. These initiatives demonstrate that the programme continues to evolve rather than merely sustain past achievements.

Is the BrahMos Model Replicable?

The BrahMos experience is generally cited as a template for India's next frontier of aero-engines, hypersonics, and advanced materials. The instinct is understandable, but the assumption deserves closer scrutiny before it hardens into policy. A joint venture structure and a national mission framing are necessary conditions for a programme like BrahMos to succeed; they are not, by themselves, sufficient.

Three features of the original partnership were not generic to joint ventures as such but specific to the India-Russia relationship at that particular moment. Russia's defence industry, including NPOM, faced acute commercial pressure in the immediate post-Soviet years and had a genuine incentive to seek foreign capital and markets through a deeper partnership rather than arm's-length sales.[21] Western suppliers, by contrast, have historically operated under tighter export licensing regimes that favour the sale of finished systems over the transfer of underlying design knowledge, a distinction that scholars of export control architecture have long identified as structural rather than incidental.[22] The equity structure of BrahMos Aerospace- DRDO and NPOM each holding a genuine ownership stake- created a commercial alignment of interest that licensing arrangements or government-to-government sales do not typically replicate.

These conditions do not automatically recur with a new partner. India's deepening defence cooperation with the United States, France, and Israel has produced valuable co-production and assembly arrangements, but analysts of India's technology partnerships have noted that few of these have yet reached the depth of design-level absorption that BrahMos achieved in propulsion.[23] This is not a failure of intent on

India's part; it reflects the reality that most prospective partners are not similarly positioned, commercially or strategically, to share their most sensitive engineering the way NPOM did.

There is also the question of time. The programme's own milestones- moving from roughly 15% indigenous content in 2015 to nearly 70% in 2024- illustrate how long genuine absorption takes even within a single, well-functioning partnership.[24] A future aero-engine or hypersonics partnership modelled on BrahMos would need to be judged on a similarly long horizon rather than be expected to deliver comparable depth within a single defence planning cycle.

None of this diminishes BrahMos as an achievement. It does mean that what is transferable from the experience is the underlying architecture, genuine equity partnership, sustained institutional commitment, and deep industrial integration, rather than any guarantee that a similar partner, willing to share at a similar depth, will be found for every sector India wishes to master. The more honest lesson for policymakers is that BrahMos proves the model can work when the right partner and the right patience converge. It does not prove that either can be assumed in advance.

DISHA: Guiding India's Technological Future

The BrahMos experience offers several lessons for policymakers.

- First, future strategic partnerships must prioritise technology absorption rather than technology transfer alone.
- Second, complex technology programmes should be organised as national missions with stable institutional frameworks and multi-decade planning horizons.
- Third, deeper integration of industry, startups, MSMEs, academia, and research institutions should become a central feature of future programmes.
- Fourth, user feedback mechanisms must be institutionalised throughout the capability development cycle.
- Fifth, India should leverage the industrial and institutional knowledge created through BrahMos to accelerate indigenous efforts in propulsion, hypersonics, advanced materials, artificial intelligence, autonomous systems, and quantum technologies.

- Sixth, procurement frameworks should be redesigned to encourage co-development, innovation, and long-term capability creation.
- Finally, sustained investments in human capital, advanced manufacturing, testing infrastructure, and research ecosystems must remain central to India's self-reliance agenda.

Conclusion

Twenty-five years after its inception, BrahMos stands as one of India's most important strategic achievements. It has demonstrated that technological sovereignty is not achieved through isolated policy interventions or short-term initiatives. Instead, it emerges through the convergence of institutional continuity, industrial participation, operational relevance, technology absorption, and strategic patience. Its greatest contribution lies not merely in the capabilities it has delivered to the armed forces but in the model, it provides for the future. As India prepares for the technological competitions of the twenty-first century, the BrahMos story offers both proof of what has been achieved and a roadmap for what remains possible. In that sense, BrahMos is no longer simply a missile programme; it is a national blueprint for strategic self-reliance.

Declaration

I declare that this manuscript is being submitted exclusively to CENJOWS for publication consideration, is original, and has not been published or submitted elsewhere. I further certify that it contains no classified, restricted, or sensitive information and is based entirely on open-source material suitable for publication in the public domain.

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