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Leveraging Technologies for Enhancing Self-Reliance in Defence Manufacturing in India

ORIGINAL ARTICLE

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Abstract

This research paper aims to explore the potential of leveraging cutting-edge technologies to enhance self-reliance in India's defence manufacturing sector. As one of the world's largest defence importers, India seeks to foster self-sufficiency and reduce dependence on foreign suppliers for strategic and economic reasons. The study will provide an overview of India's current defence manufacturing landscape, including existing policies, initiatives, and challenges. It will examine the role of emerging technologies such as artificial intelligence, robotics, additive manufacturing, advanced materials, and cyber security in revolutionizing defence production processes, products, and capabilities. The paper will also discuss indigenous technology development and adoption, emphasizing Government initiatives, R&D infrastructure, and case studies of successful indigenous defence technologies. Furthermore, the study will explore strategies for fostering collaboration, innovation, and technology adoption among Government, industry, and academia stakeholders. Finally, the paper will propose recommendations for overcoming barriers to technology adoption and leveraging these technologies to strengthen India's defence manufacturing sector, ultimately bolstering national security and strategic autonomy.

Key Words

Cutting-edge Technology, Artificial Intelligence, Robotics, Defence Manufacturing.

Introduction

India's strategic and economic interests have been deeply influenced by its position as one of the world's largest defence importers. Over the years, this reliance on foreign suppliers has raised concerns about the nation's ability to maintain a robust and self-sufficient defence manufacturing sector. Recognizing these challenges, the Indian Government has initiated several policies and programs aimed at fostering self-reliance in defence manufacturing, with a strong emphasis on indigenous development and adoption of advanced technologies. The global defence landscape is currently undergoing rapid transformations driven by the emergence of cutting-edge technologies such as artificial intelligence, robotics, additive manufacturing, advanced materials, and cyber security. These technologies present immense potential for revolutionizing defence production processes, products, and capabilities, thereby offering India an opportunity to significantly enhance its self-reliance in this critical domain.

In today's defence industry, cutting-edge technologies like AI, 5G, robotics process automation, quantum technology, advanced materials, advanced computing, semiconductor technology, hypersonic technology, and blockchain play an important role. In particular, technologies that enhance Underwater Domain Awareness (UDA) and space technology are essential for defence purposes. By 2025, the military robots market is predicted to grow to $24.2 billion. The defence industry is keen to harness the potential of AI, which is already estimated to be worth $6.4 billion globally, with projections indicating that it will reach $13.15 billion [1]

Raksha Mantri, Rajnath Singh has stated that "Artificial Intelligence can contribute greatly to Atmanirbhar Bharat. PM Modi has emphasized the need for AI to work for India. India has created a Defence AI Cell (DAIC) to provide necessary guidance to enable and effect development of operating framework, policy level changes and structural support for AI adoption. The Services and Research Organisations are working together in close coordination with industry and Start-ups to develop state of the art AI solutions. I call upon all stakeholders to join hands to make India a world leader of AI in defence to support the armed forces and work for the security of the nation".[2]

In this context, this paper aims to explore the potential of leveraging advanced technologies to boost self-reliance in India's defence manufacturing sector. It will provide an overview of the current state of the industry, focusing on existing policies, initiatives, and challenges faced by the country in achieving self-sufficiency. It will delve into the role of emerging technologies in transforming the defence manufacturing landscape and their potential impact on India's journey towards self-reliance. Additionally, the paper will examine indigenous technology development and adoption, emphasizing the Government's initiatives, R&D infrastructure, and successful case studies of indigenous defence technologies. Furthermore, the study will propose strategies for fostering collaboration and innovation among key stakeholders, including Government, industry, and academia, in order to create a thriving ecosystem that facilitates technology adoption and advances India's defence manufacturing capabilities. Ultimately, this paper seeks to contribute to a deeper understanding of the role of technology in enhancing self-reliance in defence manufacturing, with the aim of bolstering India's national security and strategic autonomy.

Overview of India's Defence Manufacturing Sector

Current State of the Industry: India's defence manufacturing sector has historically been dominated by public sector undertakings (PSUs) and ordnance factories, with limited participation from private enterprises. However, recent reforms have opened doors for private firms and foreign investment, contributing to a more diverse and competitive industry landscape. India is among the top defence spenders globally, but it still imports a significant portion of its defence equipment, leading to a persistent focus on achieving self-reliance in this sector[3]. Efforts have been made to promote indigenous design, development, and manufacturing through the "Make in India" initiative, leading to an increase in domestic production capabilities across various defence platforms.

Policy Framework and Initiatives: The Indian Government has introduced numerous policies and initiatives to support the growth of the defence manufacturing sector. The Defence Production Policy (DPrP) 2018 aims to promote self-reliance, reduce import dependence, and create a robust domestic ecosystem. The Defence Procurement Procedure (DPP) 2020, renamed as the Defence Acquisition Procedure (DAP) 2020[4], encourages domestic manufacturing by prioritizing indigenous products and technology transfer. The "Strategic Partnership" model has been introduced to foster collaboration between Indian and foreign firms, ensuring technology transfer and capacity building. Furthermore, the Government has set up defence corridors and relaxed foreign direct investment (FDI) norms to attract investment in the sector.

Challenges and Constraints: Despite progress, India's defence manufacturing sector faces several challenges. Limited R&D investment and inadequate infrastructure hinder indigenous technology development[5]. Additionally, complex and time-consuming procurement processes can deter private sector participation and

delay critical projects[6]. The lack of a skilled workforce and insufficient collaboration between industry and academia also pose challenges to technology adoption and innovation. Lastly, the sector's over-dependence on PSUs limits competitiveness and efficiency, further impeding the growth of a robust, self-reliant defence manufacturing industry.

Role of Emerging Technologies in Defence Manufacturing

Artificial Intelligence and Robotics: Artificial Intelligence (AI) and robotics are revolutionizing defence manufacturing by streamlining processes, enhancing production efficiency, and reducing human error[7]. AI can optimize supply chain management, improve predictive maintenance, and enable faster decision-making. Robotics enhances precision in manufacturing, assembly, and inspection, while also improving worker safety in hazardous environments.[8] India has started investing in AI and robotics for defence applications, such as the development of the Autonomous Unmanned Ground Vehicle (AUGV) by the Defence Research and Development Organization (DRDO). The Indian Government has established the Centre for Artificial Intelligence and Robotics (CAIR) to develop AI and robotics technologies for military applications, such as surveillance, reconnaissance, and target acquisition.[9] Rs 100 Crore has been allocated to each Service for AI implementation. Each service HQ is creating AI infrastructure for storage and computing.

AI-based Surveillance System: The Indian Army has implemented 140 surveillance systems based on artificial intelligence (AI) to obtain real-time video footage along the borders of Pakistan and China. These advanced surveillance systems have been installed along the Line of Control with Pakistan and the Line of Actual Control with China, providing state-of-the-art monitoring capabilities.[10]

Additive Manufacturing (3D Printing): Additive manufacturing, or 3D printing, allows rapid prototyping, customization, and on-demand production of complex components at reduced costs. It has the potential to revolutionize spare parts management and significantly reduce lead times for critical defence equipment.[11] India has made progress in this area, with DRDO developing 3D-printed components for missile systems and the Indian Navy exploring 3D-printed spare parts for ships.[12] The Indian Government has also initiated the establishment of the Centre for Additive Manufacturing in Defence (CAMD) to promote the use of 3D printing technology in the defence sector and strengthen collaboration between academia, industry, and the military.[13]

Advanced Materials and Nano Technology: Advanced materials and nanotechnology can substantially enhance the performance and capabilities of defence equipment. For instance, lightweight, high-strength materials can improve the fuel efficiency and payload capacity of military vehicles. India's DRDO has been actively researching advanced materials for various applications, such as stealth technology and bulletproof jackets[14]. Nano technology offers potential applications in areas like energy storage, sensors, and smart textiles for military uniforms. The Advanced Centre for Energetic Materials (ACEM) in India is focused on research and development of advanced materials for defense applications, such as explosives, propellants, and pyrotechnics.

Cyber security and Quantum Computing: Cyber security is critical for protecting sensitive defence data and systems from cyber threats. Quantum computing, an emerging technology, has the potential to revolutionize cryptography and secure communications for defence applications. India has recognized the importance of these technologies and launched the National Mission on Quantum Technologies & Applications (NM-QTA) in 2020 with an allocation of INR 8,000 crore (approximately $1.08 billion) to boost research in quantum technologies[15]. In addition to the NM-QTA, India has also established the Indian Cyber Coordination Centre (I4C) to enhance the nation's cybersecurity capabilities and protect critical infrastructure from cyber threats4. The Indian Army has established the Defence Cyber Agency (DCA) to develop cyber warfare capabilities and protect critical infrastructure from cyber attacks[16].

Indigenous Technology Development and Adoption

Importance of Indigenous Technologies for Self-Reliance: Developing indigenous technologies is

crucial for achieving self-reliance in defence manufacturing in India. By fostering local innovation, the country can reduce its dependence on foreign suppliers, enhance national security, and stimulate economic growth. Additionally, indigenous technologies can be tailored to address the unique operational requirements of the Indian armed forces, ensuring better compatibility with existing systems.[17] Finally, investing in local research and development (R&D) can create skilled jobs and contribute to the development of the broader technology ecosystem.

Government Initiatives and R&D Infrastructure: The Indian Government has taken various initiatives to promote indigenous technology development in the defence sector. One key effort is the establishment of the Defence Research and Development Organisation (DRDO), which oversees a network of laboratories and research centers dedicated to defence technology development. The Government has also introduced policies such as the Defence Procurement Procedure (DPP) and the Defence Production Policy (DPrP) to encourage domestic manufacturing and technology transfer. Furthermore, the "Make in India" initiative aims to attract foreign investment and promote collaboration between Indian and international companies in the defence industry.

Successful Indigenous Defence Technologies

Tejas Light Combat Aircraft (LCA): Developed by the Aeronautical Development Agency (ADA) and manufactured by Hindustan Aeronautics Limited (HAL), the Tejas LCA is a supersonic, multi-role fighter aircraft designed for the Indian Air Force and Navy.[18]

Arjun Main Battle Tank (MBT): Designed by the DRDO and produced by the Ordnance Factory Board (OFB), the Arjun MBT is a state-of-the-art armored fighting vehicle tailored to India's specific combat conditions.

Akash Surface-to-Air Missile (SAM) System: Developed by the DRDO and Bharat Electronics Limited (BEL), the Akash SAM system is a domestically designed and manufactured air defence system capable of engaging aerial threats up to a range of 25 km.

Fostering Collaboration and Innovation Ecosystem

Government-Industry Collaboration

Government-industry collaboration is crucial for promoting innovation in defence manufacturing. Initiatives like the Technology Development Fund (TDF) provide financial support to private sector companies, including MSMEs, for developing and indigenizing defence technologies1. The Technology Development Fund (TDF) has a budget allocation of INR 100 crore (approximately $13.3 million) per financial year to support private sector companies in developing defence technologies. Another effort is the iDEX (Innovations for Defence Excellence) framework, which facilitates collaboration between innovators, startups, and the defence establishment. iDEX has launched four Defence India Startup Challenges (DISC) since 2018, with over 750 startups participating and 58 winners receiving grants for their innovative defence solutions. The Defence Procurement Procedure (DPP) also encourages domestic private sector participation through the "Make" and "Buy and Make (Indian)" categories.

On 11 Jul 22, Raksha Mantri Shri Rajnath Singh launched 75 newly-developed Artificial Intelligence (AI) products/technologies during the first-ever 'AI in Defence' (AIDef) symposium and exhibition, organised by Ministry of Defence in New Delhi. The products, launched as part of 'Azadi Ka Amrit Mahotsav' celebrations included "AI Platform Automation; Autonomous/Unmanned/Robotics systems; Block Chain-based Automation; Command, Control, Communication, Computer & Intelligence, Surveillance & Reconnaissance; Cyber Security; Human Behavioural Analysis; Intelligent Monitoring Systems; Lethal Autonomous Weapon Systems; Logistics and Supply Chain Management, Operational Data Analytics; Manufacturing and Maintenance; Simulators/Test Equipment and speech/voice analysis using Natural Language Processing."[19]

Academia-Industry Partnership

Academia-industry partnerships are essential for fostering innovation in defence technology. Institutions like the Indian Institutes of Technology (IITs) and the Defence Institute of Advanced Technology (DIAT) collaborate with defence industries to develop cutting-edge technologies[20]. The Defence Research & Development Organisation (DRDO) has signed over 180 Memorandums of Understanding (MoUs) with various academic institutions to promote R&D collaboration in defence technologies. In 2018, IIT Madras and the Indian Army Research and Referral Hospital jointly developed a lightweight, load-carrying exoskeleton for soldiers to reduce fatigue and improve their operational efficiency. Joint research projects, technology incubators, and skill development programs help bridge the gap between academic research and practical applications in the defence sector. Moreover, collaborations between academia and industry facilitate the transfer of knowledge and expertise, accelerating the development and adoption of indigenous technologies.

International Cooperation and Technology Transfer

International cooperation plays a significant role in enhancing India's defence manufacturing capabilities. Joint ventures, technology transfer agreements, and collaborative R&D projects with foreign partners can help India access advanced technologies, expertise, and best practices in defence manufacturing[21]. The Strategic Partnership (SP) model, introduced in the DPP, promotes joint ventures between Indian and foreign firms for manufacturing defence equipment in India. Additionally, India has signed defence cooperation agreements with several countries, such as the United States, Russia, and Israel, which facilitate technology transfer and collaborative projects. India and Russia have a longstanding partnership in defence manufacturing, including joint ventures like BrahMos Aerospace, which produces the BrahMos supersonic cruise missile. Under the Indo-US Defense Technology and Trade Initiative (DTTI), both countries have identified several collaborative projects, including the development of air-launched small drones and lightweight small arms technology.[22]

Overcoming Barriers to Technology Adoption

Regulatory and Policy Challenges

Regulatory and policy challenges impede the rapid adoption of advanced technologies in India's defence manufacturing sector. Cumbersome procurement processes, bureaucratic red tape, and complex licensing requirements often slow down the introduction of new technologies1. To overcome these challenges, recent policy reforms, such as the Defence Acquisition Procedure (DAP) 2020, focus on simplifying processes and promoting self-reliance in defence manufacturing. Additionally, policies like the Atmanirbhar Bharat initiative emphasize the need to boost indigenous production and reduce reliance on imports. The Defence Acquisition Procedure (DAP) 2020 introduced a new procurement category, "Buy (Global - Manufacture in India)," which requires a minimum of 50% indigenous content on cost basis of the total contract value.

Infrastructure and Investment Constraints

Inadequate infrastructure and limited access to capital hinder the growth of India's defence manufacturing sector. To address these constraints, the Government is establishing defence industrial corridors, which provide a dedicated ecosystem for defence production, including infrastructure, logistics, and testing facilities. India's two defence industrial corridors, one in Uttar Pradesh and the other in Tamil Nadu, have attracted investment commitments of over INR 3,700 crore (approximately $493 million) and INR 3,100 crore (approximately $412 million), respectively. The Government is also encouraging private sector participation through Foreign Direct Investment (FDI) and public-private partnerships to attract investments in defence manufacturing. In 2020, the Government increased the FDI limit in the defence sector from 49% to 74% under the automatic route, subject to certain conditions.

Human Capital Development and Skill Building

A skilled workforce is essential for the adoption of advanced technologies in defence manufacturing. However, India faces a skill gap in areas such as aerospace engineering, materials science, and cybersecurity.

To overcome this challenge, initiatives like the Skill India campaign aim to train millions of young Indians in specialized skills, including defence manufacturing. The Government is also working to strengthen ties between academia and industry, fostering collaboration and knowledge exchange to develop a skilled workforce in the defence sector[23]. The Skill India campaign, launched in 2015, aims to train over 400 million people in various sectors, including defence manufacturing in next decade.

The Defence Institute of Advanced Technology (DIAT), a premier Deemed University under the Department of Defence Research & Development, offers specialized courses in aerospace engineering, materials engineering, and applied electronics to develop skilled human capital for the defence sector.

Recommendations for Leveraging Technologies in Defence Manufacturing

Strengthening R&D and Innovation Ecosystem

To boost self-reliance in defence manufacturing, India must strengthen its R&D and innovation ecosystem. The Government should allocate more funds for defence R&D, focusing on emerging technologies like AI, robotics, and advanced materials. Developing technology incubation centers and testbeds in partnership with academia and industry can help in nurturing and validating new ideas[24]. Additionally, increasing engagement with global innovation networks can facilitate knowledge exchange and technology absorption. India's defence R&D expenditure was around 0.9% of its defence budget in 2018, compared to the global average of 2.5%.India's first Defence Innovation Hub was set up in 2019 in Coimbatore, aiming to foster innovation and technology development in the defence sector.

Encouraging Public-Private Partnerships

Public-Private Partnerships (PPPs) can play a crucial role in promoting indigenous defence manufacturing capabilities. The Government should create an enabling policy environment that encourages private sector investment in defence R&D and manufacturing. Streamlining procurement processes and providing incentives for domestic manufacturing can foster private sector participation. Furthermore, collaboration between public sector defence organizations and private firms can help leverage the strengths of both sectors, leading to synergistic growth[25]. In 2020, the Indian Government announced plans to corporatize the Ordnance Factory Board, which operates 41 factories, to improve efficiency and encourage private sector participation in defence production.[26] Private sector participation in defence production has increased significantly in recent years, with the share of private sector defence licenses increasing from 32% in 2001-2010 to 80% in 2011-2020.

Promoting Technology Transfer and Collaboration

Promoting technology transfer and international collaboration can help India access advanced defence technologies and enhance its self-reliance in defence manufacturing. The Government should explore joint ventures and co-development projects with foreign partners, focusing on technology transfer and sharing of intellectual property[27]. India should also consider joining multilateral forums like the Wassenaar Arrangement and the Australia Group to facilitate cooperation and exchange of best practices in defence and dual-use technologies. The Indo-Russian BrahMos missile, a joint venture between India's Defence Research and Development Organisation (DRDO) and Russia's NPO Mashinostroyeniya, is a successful example of technology transfer and collaboration in defence manufacturing. India's entry into the Missile Technology Control Regime (MTCR) in 2016 has facilitated access to critical missile technologies and cooperation with other MTCR member countries.

Implications for India's National Security and Strategic Autonomy

Leveraging advanced technologies and building indigenous capabilities in defence manufacturing can significantly impact India's national security and strategic autonomy. By developing and incorporating these technologies, India can reduce its dependence on foreign suppliers, ensuring uninterrupted supply of critical equipment during times of crisis. Moreover, it helps India maintain a technological edge in the region, asserting its strategic autonomy and shaping regional security dynamics.

Future Research Directions

Future research can focus on the potential of specific emerging technologies in India's defence manufacturing sector, such as hypersonic technologies, directed energy weapons, and biotechnology. Additionally, research can delve into the development of comprehensive policies and frameworks for technology transfer, intellectual property protection, and export control management in the defence sector. Furthermore, research can evaluate the effectiveness of various public-private partnership models in promoting indigenous defence manufacturing and technology development.

The incorporation of AI-based technology has the potential to transform the Indian military and establish India as a significant player in the defense product market. The Indian Government's support and plan to modernize the military through AI is the culmination of years of groundwork. This groundwork includes implementing bold policies, dedicating budgets, altering policies, and promoting indigenization. Together, these initiatives have fostered an environment of cutting-edge innovation and collaboration among public and private industry, research organizations, academic institutions, start-ups, and innovators.

The collective efforts of these entities have resulted in the creation of numerous unique technological products based on AI, spanning a wide range of applications such as data, logistics, surveillance, weapons, and more. With the introduction of autonomy in weapon systems, ISR (intelligence, surveillance, and reconnaissance), and data management, AI has the potential to be a significant asset in preventing terrorism, establishing counter-terrorism measures, and safeguarding soldiers. In fact, AI in defense could alter the nature of combat and conflict on a fundamental level.

As India continues to invest in advanced defence technologies and forge collaborative partnerships, it will strengthen its defence manufacturing capabilities and contribute to the country's overall economic growth and technological prowess on the global stage.

References

1. Indian Defence and Aerospace Blog. (2023, February 7). Military AI, ML & Robotics Market Booming: Can India Capitalise? Retrieved from https://www.iadb.in/2023/02/07/military-ai-ml-robotics-market-booming-can-india-capitalise/
2. Department of Defence Production. (2021). Artificial Intelligence in Defence: A Roadmap for 2020s [PDF]. Retrieved from https://www.ddpmod.gov.in/sites/default/files/ai.pdf
3. Stockholm International Peace Research Institute. (2021). SIPRI military expenditure database. Retrieved from https://www.sipri.org/sites/default/files/2021-04/fs_2104_milex_0.pdf
4. Defence IQ. (2020). India unveils new defence acquisition procedure. Retrieved from https://www.defenceiq.com/defence-technology/news/new-defence-acquisition-procedure-india
5. Swaran, S. (2020). India's defence manufacturing: Self-reliance– The way ahead. Observer Research Foundation. Retrieved from https://www.orfonline.org/research/indias-defence-manufacturing-self-reliance-the-way-ahead-74130/
6. Ubhi, J. P. S. (2021). Indigenisation of defence manufacturing in India. Institute for Defence Studies and Analyses. Retrieved from https://idsa.in/idsacomments/indigenisation-of-defence-manufacturing-in-india_jps-ubhi_020121
7. Defence IQ. (2017). How AI and robotics are transforming the defence industry. Retrieved from https://www.defenceiq.com/defence-technology/articles/how-ai-and-robotics-are-transforming-the-defence-industry
8. Robotic Industries Association. (2017). Robotics in defense manufacturing. Retrieved from https://www.robotics.org/content-detail.cfm/Industrial-Robotics-Industry-Insights/Robotics-in-Defense-Manufacturing/content_id/6454

9. Centre for Artificial Intelligence and Robotics (CAIR). (n.d.). About CAIR. Retrieved from https://www.drdo.gov.in/labs-and-establishments/centre-artificial-intelligence-robotics-cair

10. India AI. (n.d.). Ministry of Defence. Retrieved from https://indiaai.gov.in/ministries/ministry-of-defence

11. Patil, A. G., & Kelkar, A. (2018). Additive manufacturing in defence sector: Challenges and opportunities. Materials Today: Proceedings, 5(5), 14490-14495. Retrieved from https://www.sciencedirect.com/science/article/pii/S2214785318308699

12. Financial Express. (2018). 3D printing: Indian Navy shows the way; 3D printed drone and marine diesel engine parts showcased. Retrieved from https://www.financialexpress.com/defence/3d-printing-indian-navy-shows-the-way-3d-printed-drone-and-marine-diesel-engine-parts-showcased/1279666/

13. Press Information Bureau, Government of India. (2020). Defence ministry to establish CAMD in Coimbatore. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1667265

14. Defence Research and Development Organisation (DRDO). (n.d.). Stealth material: DRDO working on radar-absorbing material. Retrieved from https://www.drdo.gov.in/labs-establishment/drdo-media-coverage/stealth-material-drdo-working-radar-absorbing-material

15. Press Information Bureau, Government of India. (2020). National Mission on Quantum Technologies & Applications (NM-QTA). Retrieved from https://pib.gov.in/PressReleasePage

16. India Today. (2019). Cyber warriors: Indian Army's new defence agency to fight virtual threats. Retrieved from https://www.indiatoday.in/mail-today/story/cyber-warriors-indian-army-s-new-defence-agency-to-fight-virtual-threats-1546182-2019-06-12

17. Ray, A. (2019). Indigenous defence technologies: The way ahead for India. Defence ProAc Biz News. Retrieved from https://defproac.com/?p=8115

18. Aeronautical Development Agency (ADA). (n.d.). LCA-Tejas. Retrieved from https://www.ada.gov.in/ada/lca/lca.html

19. Press Information Bureau. (2022, April 18). NITI Aayog and UNDP launch Sustainable Development Goals (SDG) Action Agenda for India 2030 [Press release]. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1840740

20. Defence Institute of Advanced Technology (DIAT). (n.d.). About DIAT. Retrieved from http://14.139.111.180/Web/AboutUs

21. Mehta, A. (2018). Enhancing India's defence capabilities through international cooperation. ORF Occasional Paper. Retrieved from https://www.orfonline.org/research/enhancing-indias-defence-capabilities-through-international-cooperation/

22. U.S. Department of State. (2019). Joint Statement on the Inaugural India-U.S. 2+2 Ministerial Dialogue. Retrieved from https://2017-2021.state.gov/joint-statement-on-the-inaugural-india-u-s-22-ministerial-dialogue/index.html

23. Sridhar, K. R. (2020). Building partnerships: Industry-academia collaboration in Indian defence R&D. Indian Defence Review. Retrieved from http://www.indiandefencereview.com/news/building-partnerships-industry-academia-collaboration-in-indian-defence-rd/

24. Chaturvedi, S., & Chakraborty, D. (2019). Leveraging innovation ecosystems for enhancing India's defence manufacturing capabilities. *Journal of Defence Studies*, 13(2), 87-106.

25. Kumar, A. (2020). Public-private partnerships in India's defence sector. The Diplomat. Retrieved from https://thediplomat.com/2020/08/public-private-partnerships-in-indias-defense-sector/

26. Press Information Bureau, Government of India. (2020). Corporatisation of Ordnance Factory Board. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1649241

27. Kumar, A. (2020). Public-private partnerships in India's defence sector. The Diplomat. Retrieved from https://thediplomat.com/2020/08/public-private-partnerships-in-indias-defense-sector/

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