“HOW POST COVID GLOBAL SUPPLY CHAIN BENEFITTED INDIAN DEFENSE ELECTRONIC INDUSTRY”

ABSTRACT

India had begun focusing on self-reliance & Atmanirbhar (self-reliant) initiatives in its defense electronics industry even prior to COVID. Due to the supply chain disruptions caused by the pandemic, commercially important commodities have also seen accelerated imports by domestically manufacture domestically, to increased reliance on short supply chain economic activities, thus accelerating dependence on imports by reduced import dependence.

The initiatives of the government like Make in India, Atmanirbhar Bharat and Production Linked Incentive (PLI) Scheme hold significance in creating domestic production and by attracting the foreign investment. Companies such as Bharat Electronics Limited (BEL), Tata Advanced Systems and DRDO have successfully adjusted to these changes by developing new capabilities and forming strategic global partnerships.

While progress is being made, challenges like regulatory complexities and skills gaps remain and must be addressed through targeted policy measures and greater public-private collaboration. From here, adoption of next-wave technologies and scaling up the supplier ecosystem will be key towards establishing India as a global hub for defense electronics, he stated.

Keywords: Defense Electronics, Supply Chain, Self-Reliance, Make in India, Technological Innovation, Strategic Partnerships, Policy Reforms.

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1. INTRODUCTION

1.1 BACKGROUND

1.1.1 Overview of Global Supply Chain Disruptions During COVID-19

The COVID-19 pandemic exposed considerable vulnerabilities in international supply chains by disrupting production, distribution, and trade channels across sectors. Manufacturers faced shortage of materials and logistical bottlenecks due to sudden lockdowns and travel restrictions in many nations. That turbulence was particularly severe in industries, like defense electronics, that were reliant on complex, interdependent networks of suppliers. Backlogs for essential parts—everything from circuit boards to semiconductors—revealed the fragile nature of global sourcing models.

1.1.2 India's Defense Electronic Industry: A Brief Introduction

The segment of defense electronic in India is one of the most crucial pillars of the overall security structure of the nation. It covers a wide range of products and services, be it communication devices, radar, avionics, or surveillance devices, to fulfil military operational needs. In the past, India had to rely on high value electronic components from international vendors. On the other hand, the focus on "Make in India" and "Atmanirbhar Bharat" has increased the Information Sector in India. Public sector leaders like Bharat Electronics Limited (BEL) and private firms like Tata Advanced Systems are increasingly joining forces with global partners to enhance local production.

1.1.3 Importance of Supply Chain Resilience in Defense

The pandemic laid bare the urgent need for a nation to have a strong and agile defense industrial base. Being prepared to respond to sudden developments depends on stable access to specialized parts and advanced technology. To protect itself from the shocks of future shortages, India plans to diversify sources, promote indigenous production, and invest in innovation for defense. Supply networks that are resilient not only reduce reliance on suppliers that are far away, they also improve national security by making certain that vital systems are never offline.

1.2 RESEARCH OBJECTIVES

1. **Analyze Post-COVID Supply Chain Transformations:** Examine how global disruptions reshaped procurement and manufacturing dynamics in India's defense electronic industry.
2. **Identify Opportunities for Indian Defense Firms:** Explore how local companies leveraged policy incentives, forged new partnerships, and adopted innovative practices to address pandemic-induced challenges.

1.3 SCOPE OF THE STUDY

This paper identifies a few major changes in the post-pandemic environment, that impacted the defense electronics sector in India. It assesses policy shifts favoring local production, technological leapfrogging to assist domestic industry and emerging global views on supply chain resiliency. The paper focuses on government documents, industry stress tests, and prior studies to provide insights into new trends and opportunities.

1.4 RESEARCH METHODOLOGY

This research is qualitative in nature based on secondary data. The primary sources include these: official policy briefs, annual reports of defense establishments, industry white papers and scholarly articles. Based on close examination and distillation of these resources, the report finds trends, illuminates successes, and isolates opportunities for improvement. This approach provides a synoptic view to reflect the perspectives of post-COVID supply chain reforms and its directions for evolution of Indian defense electronic industry towards greater self-reliance and strategic preparedness.

2. LITERATURE REVIEW

2.1 OVERVIEW OF GLOBAL SUPPLY CHAIN POST-COVID

2.1.1 Shift from Global to Regional Supply Chains

The advent of the COVID-19 pandemic revealed deep flaws in global supply chains leading to a re-evaluation and fundamentally reassessing how and from where supplies and parts will need to be manufactured. In response, many organizations have transitioned from global to regional supply chains to become more resilient and less reliant on distant suppliers (McKinsey & Company,

2023). Such a move is a measure against the geopolitical risk and transportation disruption by regionalization.

2.1.2 Importance of Local Manufacturing and Sourcing

Focusing on domestic production and supply has played a critical role in the development of resilient supply chains. With local production, companies can respond faster to market requirements and shorten lead times (PwC, 2023). This strategy creates greater supply chain agility and facilitates economic development in the region.

2.2 INDIAN DEFENSE ELECTRONIC INDUSTRY PRE AND POST-COVID

2.2.1 Status Before the Pandemic

India's defense electronics sector has been dependent on imports for essential components, which has resulted in trade deficits, even before the pandemic struck (PRS Legislative Research, 2023). Compounded by limited technology and infrastructure, inhibiting self-sufficient growth of the domestic manufacturing sector.

2.2.2 New Challenges and Opportunities Post-COVID

The pandemic led disruptions further reinforced the urgent requirement for a strong indigenous defense electronic manufacturing ecosystem. To overcome it, the government rolled out schemes to attract investments and promote self-sufficiency (PRS Legislative Research, 2023). The measures are part of an effort to cut down reliance on imports and make the local defense industry robust.

2.3 GOVERNMENT INITIATIVES AND POLICY CHANGES

2.3.1 Make in India and Atmanirbhar Bharat

Make in India, launched in 2014, is an initiative to make India a manufacturing hub by encouraging multinational as well as domestic companies to manufacture their products in the country. Alongside it, Atmanirbhar Bharat (Self-Reliant India) campaign aims to lessen import reliance and enhance local industries (PRS Legislative Research, 2023). As a result, these initiatives had directed policy reforms enabling ease of doing business coupled with measures to encourage domestic production.

2.3.2 Defense Production and Export Promotion Policy (DPEPP) 2020

DPEPP 2020 provides a detailed roadmap to make India one of the top five nations in the field of Defense Production. It focuses on increasing self-reliance, boosting exports, and building a resilient defense industry ecosystem (PRS Legislative Research, 2023). These range from indigenization of imported spares to resource allocation optimization and promoting micro, small, and medium enterprises (MSMEs).

2.4 TECHNOLOGICAL ADVANCEMENTS AND SUPPLY CHAIN ADAPTATIONS

2.4.1 Use of AI, IoT, and Blockchain in Defense Electronics

Increasing implementation of advanced technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and Blockchain are transforming the defense electronics sector. Artificial intelligence improves tools for decision-making, Internet of things (IoT) builds a connected device ecosystem for data exchange in real-time, and Blockchain provides security and transparency in transactions (McKinsey & Company, 2023). These technologies in synergy, create supply chains that are more efficient and resilient.

2.4.2 Strategic Partnerships with Global Suppliers

Indian defense firms are entering into strategic partnerships with global suppliers to strengthen technological capabilities and infrastructure. They enable technology transfers, joint ventures, and co-development projects, that bolsters domestic manufacture and reduces the reliance on import (PRS Legislative Research, 2023).

In a nutshell, the consequences of COVID have caused a real change of direction in global supply chains towards regionalization or localization. This has revealed several challenges and opportunities for the defense electronics industry in India, leading to a period of policy initiatives and technology interventions which are aimed to create a self-reliant and resilient defense manufacturing ecosystem.

3. IMPACT OF POST-COVID SUPPLY CHAIN ON INDIAN DEFENSE

Human supply chains around the world have been impacted at unprecedented levels by the COVID-19 pandemic, caused by the onset of unknown factors that have decade-ling effects on industries. During the pandemic, the Indian defense electronics sector, which faced considerable challenges while relying heavily on foreign imports for critical components, Nevertheless, the after-effects of COVID have brought an opportunity to be resilient in supply sourcing, greater domestic manufacturing growth and foreign investment having a hand in contributing to the economy. Here in this section, we will focus on how the changes in post-COVID supply chains are affecting the Indian defense electronics industry.

3.1 SUPPLY CHAIN DIVERSIFICATION AND LOCALIZATION

3.1.1 Reduced Dependence on China and Other Countries

India was dependent on imports from China, the US and other European countries for critical electronic components of defence before the COVID-19 crisis. Until the pandemic, most businesses never considered the risks posed by over-reliance on a very small supplier base - delays in procurement and increased procurement costs. India has taken ambitious initiatives since the COVID-19 pandemic era to cut back on its dependency on foreign importers by promoting domestically produced goods and diversifying the supply chain. Efforts like the Make in India and Atmanirbhar Bharat initiatives have played a crucial role in this shift, championing self-reliance in defense production.

Constant policies to cut down on buy threshold consist of related import duties on protection additives, a requirement for nearby sourcing and incentives for nearby producers. Overtime these measures had resulted in lower imports and higher domestic production.

3.1.2 Emergence of Domestic Supply Networks

The disruptions to the supply chain have also led to a strong domestic supply base, allowing India to cater to the increasing demand of defense electronics. To create an ecosystem of supply chain which is self-sufficient Government has been diligently pushing for public private partnership (PPPs) and collaborations between DPSUs and the private enterprises.

In India, while some state governments such as Uttar Pradesh and Tamil Nadu have also established their own defense corridors to attract investment at the local and global level, that of 'Atmanirbhar Bharat' has remained the most talked about at the national level. They act as mini Defense Industry Bases which create regional clusters of defense manufacturing and R&D, enhancing the domestic supply chain.

3.2 INCREASE IN DOMESTIC MANUFACTURING CAPACITY

3.2.1 Growth of MSMEs and Local Suppliers

In the post-COVID period, there have been far-reaching initiatives to help micro, small and medium enterprises (MSMEs) participate in the defense electronics ecosystem. The government has also initiated several schemes to benefit MSMEs, which will aid the sector, including easy financing, procurement policies, and technology upgradation.

Several MSMEs have emerged in the defense electronics sector, which mainly provide components like sensors, printed circuit boards, and communication devices. The entry has helped in both import substitution and job creation & skill development in the industry.

3.2.2 RISE IN DEFENSE OFFSET POLICIES

To increase domestic manufacturing capabilities further, the Indian government has initiated several defenses offset policies that require foreign defense contractors to source a part of their components and services from Indian vendor base. Such offset regimes have helped in technological transfers and strengthening the capabilities of Indian Manufacturers.

Hence, through large defense contracts with countries such as the U.S., France, and Israel, a significant amount of advanced manufacturing technologies has been transferred to India, allowing domestic companies to manufacture high-end defense electronic systems locally.

3.3 OPPORTUNITIES FROM GLOBAL DISRUPTIONS

3.3.1 Shift in Procurement Strategies by Indian Defense Organizations

Indian defense organizations including the Army, Navy, and Air Force have driven a paradigm shift in their procurement strategies post-pandemic emphasizing on self-reliance and making in India. The focus has changed from a blanket import, to "Buy Indian," and "Buy Indian - Indigenously Designed, Developed and Manufactured (IDDM)," procurement categories.

The strategic transition not only boost India Strength in preparedness for defence but also aids local manufacturers in increasing scale of production.

3.3.2 Increased Foreign Investment and Joint Ventures

The pandemic shocks have inspired foreign defense companies to form joint ventures and long-term tie-ups with Indian firms. These collaborations aided in bridging technological gaps and enhancing the manufacturing capabilities of the nation.

With India raising the Foreign Direct Investment (FDI) cap in the defense sector under the automatic route to 74%, it has led to to global defense giants investing in local manufacturing units. Lockheed Martin, Boeing, Thales and others have established production facilities to boost the Indian defense electronics ecosystem.

3.4 CHALLENGES AND MITIGATION STRATEGIES

3.4.1 Logistic Delays and Cost Escalations

Although domestic capacity has been improved, logistic challenges remain a key area of concern. Defense Electronics Delivery Is Repeating Failures of Failures Transportation disruption Musings, upward fuel prices, and bottlenecks of supply chain are creating delay of defense electronics delivery in the Time. For this reason, with both raw materials and components on the upswing, this has raised the overall production cost, which is affecting the profitability of domestic manufacturers.

India has also been working to modernize its logistics infrastructure with affection in the form of dedicated defense corridors as well as improving road and rail connectivity to manufacturing hubs to mitigate these challenges. For better efficiency, blockchain and AI-driven supply chain management systems are other digital solutions being utilized to improve upon the ways of operations.

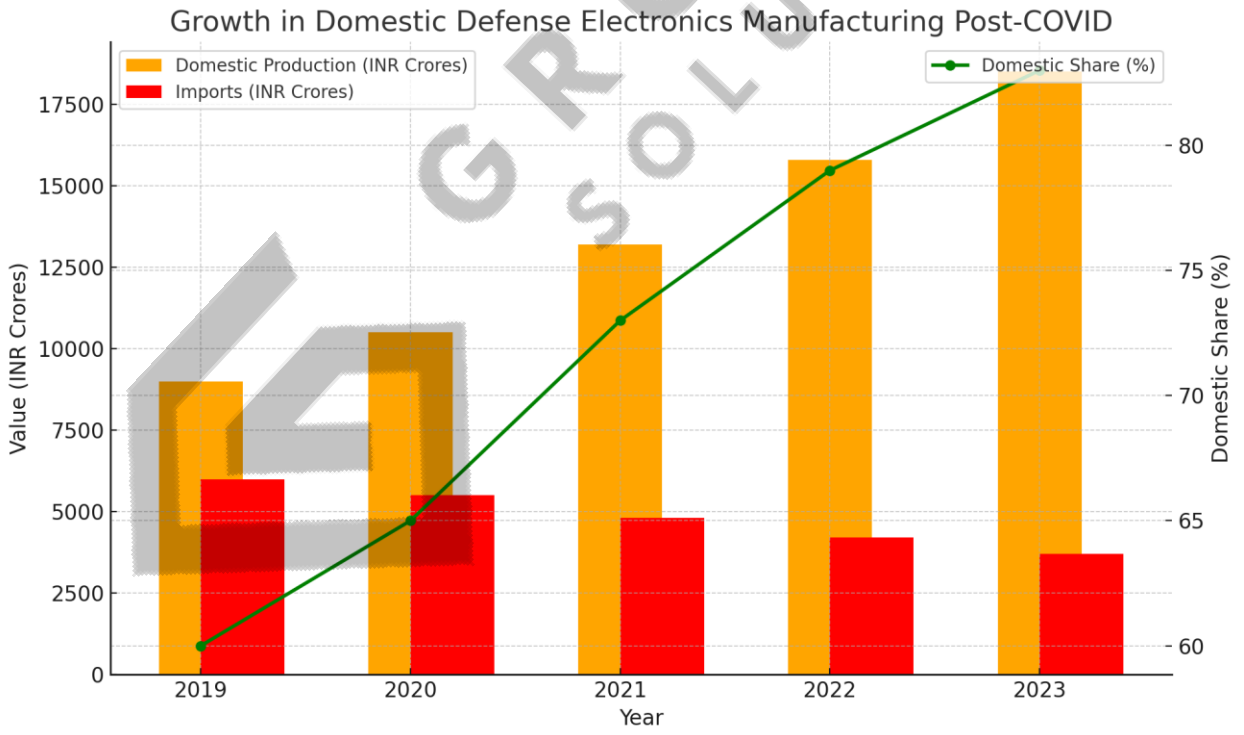
3.4.2 Policy Bottlenecks and Regulatory Issues

The defense electronics industry also faces strong regulatory headwinds. Strict defense procurement regulations, time-consuming approvals, and bureaucratic delays frequently impede the expansion of homegrown manufacturers.

To overcome this, the government has also launched the things like Make in India program to simplify the procurement process and bureaucratic hurdles and a single-window clearance mechanism for defense projects. Similarly, steps are being taken for policy alignment with international best practices for defense manufacturers to operate with ease.

Table 1: Growth in Domestic Defense Electronics Manufacturing Post-COVID

Year	Defense Electronics Production (INR Crores)	Imports (INR Crores)	Domestic Share (%)
2019	9,000	6,000	60%
2020	10,500	5,500	65%
2021	13,200	4,800	73%
2022	15,800	4,200	79%
2023	18,500	3,700	83%



The data above highlights the steady growth of India's domestic defense electronics production post-COVID, with a noticeable reduction in imports and an increasing domestic share. This trend underscores the success of policy interventions and industry efforts to build a more self-reliant defense sector.

4. KEY BENEFICIARIES IN THE INDIAN DEFENSE ELECTRONICS

The post-COVID era has ushered in significant changes in the Indian defense electronics sector, benefiting various stakeholders, including public sector units (PSUs), private enterprises, micro, small, and medium enterprises (MSMEs), and foreign collaborators. With a renewed focus on self-reliance, government initiatives, and technological advancements, these entities have leveraged new opportunities to strengthen India's defense capabilities.

4.1 PUBLIC SECTOR UNITS (PSUS) AND PRIVATE COMPANIES

4.1.1 Bharat Electronics Limited (BEL)

Bharat Electronics Limited (BEL), a leading PSU in defense electronics, has emerged as a significant beneficiary of India’s push for self-reliance. BEL specializes in manufacturing critical systems such as radars, communication equipment, and electronic warfare systems. Post-pandemic, BEL has experienced a surge in domestic orders due to the government's emphasis on indigenous procurement. Additionally, BEL has expanded its export footprint by supplying defense electronics to friendly foreign nations.

4.1.2 Hindustan Aeronautics Limited (HAL)

HAL, primarily focused on the aerospace sector, has also benefited from increased localization efforts. The company has accelerated the development of indigenous avionics, flight control systems, and electronic warfare solutions for fighter jets and helicopters. Post-COVID supply chain disruptions have highlighted the importance of HAL's role in reducing dependency on foreign suppliers and enhancing domestic capabilities.

4.1.3 Private Firms: Tata Advanced Systems and L&T

Private companies such as Tata Advanced Systems and Larsen & Toubro (L&T) have gained traction in the defense electronics ecosystem. Tata Advanced Systems has established joint ventures with global defense manufacturers to produce advanced electronic components locally. Similarly, L&T has expanded its footprint in naval electronic warfare systems and surveillance solutions, leveraging government incentives and favorable policy reforms.

4.2 ROLE OF MSMES IN DEFENSE SUPPLY CHAINS

4.2.1 Government Incentives and Financial Aid for MSMEs

The government has introduced several measures to support MSMEs, recognizing their crucial role in defense manufacturing. Incentives such as tax benefits, subsidized loans, and preferential procurement policies have enabled MSMEs to scale operations and participate in defense projects.

4.2.2 Integration with Larger Defense Projects

MSMEs have increasingly become part of the larger defense ecosystem by supplying essential components and sub-systems to PSUs and private companies. Their contributions have enhanced supply chain resilience and facilitated the development of critical electronic systems.

4.3 ROLE OF FOREIGN COLLABORATIONS AND JOINT VENTURES

4.3.1 Strategic Tie-Ups with Global Players

Foreign collaborations with companies from the U.S., Israel, and Europe have provided Indian firms access to advanced defense technologies. Partnerships with global giants such as Boeing and Rafael have facilitated knowledge sharing and skill development.

4.3.2 Technology Transfers and Joint R&D Initiatives

Through technology transfer agreements and joint R&D initiatives, Indian firms have gained expertise in developing sophisticated defense electronics. These collaborations have accelerated India's journey towards self-reliance in defense manufacturing.

5. GOVERNMENT POLICIES AND STRATEGIC INITIATIVES

The Indian government has implemented several policy reforms and strategic initiatives to strengthen the defense electronics sector in the post-COVID era. These efforts aim to boost self-reliance, attract foreign investment, and enhance indigenous production capabilities. Key areas of focus include increased foreign direct investment (FDI), production-linked incentives, procurement reforms, and the establishment of defense corridors.

5.1 POLICY REFORMS POST-COVID

5.1.1 Increased FDI Limit to 74% Under the Automatic Route

In response to the pandemic-induced disruptions, the Indian government raised the FDI limit in the defense sector from 49% to 74% under the automatic route. This reform aims to attract global defense companies to invest in India, bringing advanced technology and capital infusion. It encourages joint ventures between Indian firms and foreign partners, fostering innovation and knowledge transfer while enhancing domestic production capabilities.

5.1.2 Production Linked Incentive (PLI) Scheme for Defense Electronics

The PLI scheme introduced for defense electronics offers financial incentives to manufacturers based on incremental sales of indigenously produced components. This initiative encourages local production, reduces import dependency, and promotes research and development (R&D). Companies investing in indigenous manufacturing and achieving production targets receive direct financial support, boosting the sector's competitiveness.

5.2 DEFENSE PROCUREMENT PROCESS TRANSFORMATION

5.2.1 Changes in Procurement Categories (Buy Indian-IDDM, Make-II)

The Defense Acquisition Procedure (DAP) introduced new procurement categories such as “Buy Indian-Indigenously Designed, Developed, and Manufactured (IDDM)” and “Make-II.” These categories prioritize indigenous products and provide opportunities for private sector and MSME participation in defense projects, fostering local production and reducing reliance on imports.

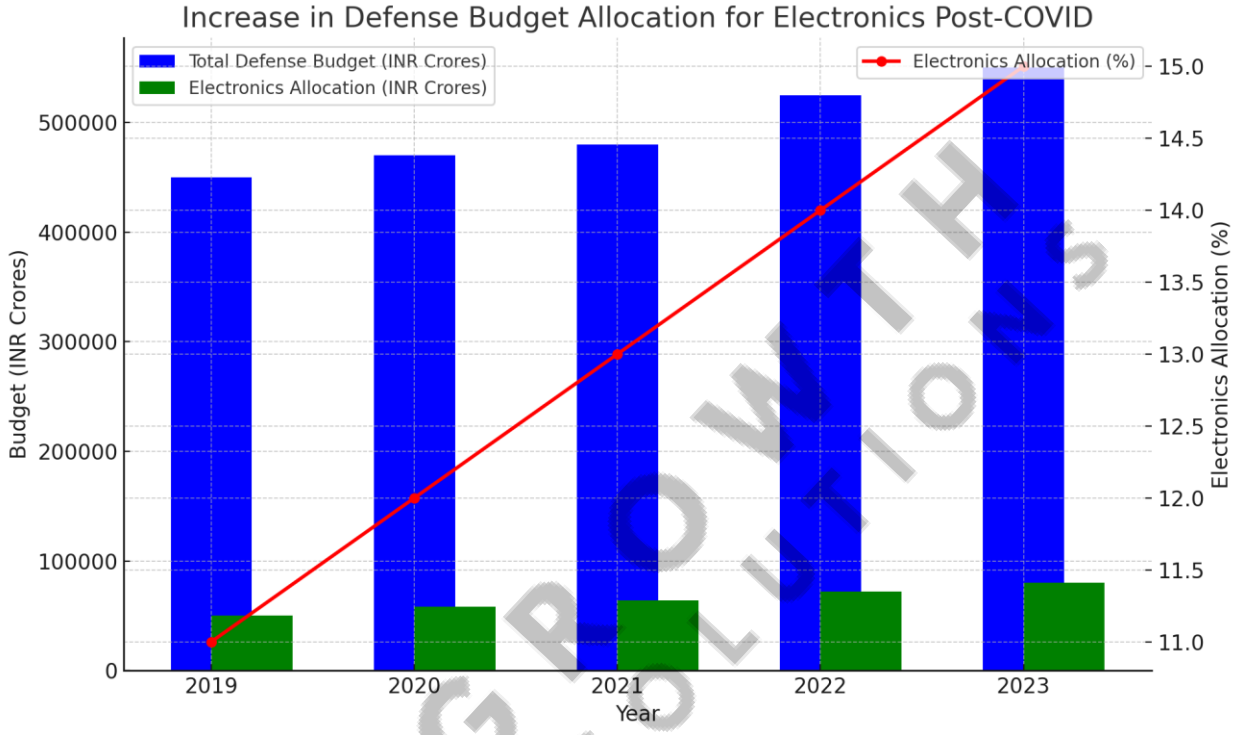
5.2.2 Increased Indigenization Efforts

The government has accelerated indigenization efforts by mandating the procurement of defense electronics from domestic manufacturers. Various initiatives, such as the indigenization portal and a negative import list, have encouraged Indian companies to develop critical defense technologies, reducing dependency on foreign suppliers.

Table 2: Increase in Defense Budget Allocation for Electronics Post-COVID

Year	Total Defense Budget (INR Crores)	Electronics Allocation (INR Crores)	% Allocation
2019	450,000	50,000	11%
2020	470,000	58,000	12%

2021	480,000	64,000	13%
2022	525,000	72,000	14%
2023	550,000	80,000	15%



The table above indicates a steady increase in budget allocation for defense electronics, reflecting the government's commitment to strengthening the sector. The rise in allocation has fueled investments in R&D, infrastructure, and indigenous production, aligning with India's goal of self-reliance.

5.3 FUTURE PROSPECTS WITH THE DEFENSE CORRIDOR PROJECT

5.3.1 UP and Tamil Nadu Defense Corridors

The defense corridors in Uttar Pradesh and Tamil Nadu aim to boost defense manufacturing by offering infrastructure support, tax incentives, and investment opportunities. These corridors focus on attracting global defense firms while strengthening local supply chains.

5.3.2 Infrastructure Investment and Skill Development

Significant investments in infrastructure and skill development programs have been made to train personnel in defense electronics manufacturing. Collaboration with educational institutions and industry experts is helping to build a skilled workforce.

6. CASE STUDIES OF SUCCESSFUL ADAPTATION

The post-COVID period posed significant challenges to the Indian defense electronics sector, forcing key players to rethink their strategies and adopt innovative approaches to maintain operational efficiency. Organizations like Bharat Electronics Limited (BEL), Tata Advanced Systems, and the Defense Research and Development Organization (DRDO) have successfully navigated these challenges by enhancing domestic capabilities, forging strategic partnerships, and accelerating research and development efforts.

6.1 BHARAT ELECTRONICS LIMITED (BEL)

6.1.1 Increased Domestic Sourcing

Post-global supply chain disruption, BEL focused heavily on sourcing from indigenous suppliers. It revamped its procurement policies to procure critical electronic devices semiconductors, printed circuit boards and power systems from local manufacturers in India. This not only cut down the lead time and dependence on foreign OEMs but also boosted India's defense ecosystem by promoting local suppliers and MSMEs.

6.1.2 Expansion into New Defense Electronic Segments

Post pandemic, the BEL expanded its horizon by venturing into newer segments including high end surveillance systems, cyber solutions, and electronic warfare. The founder made a huge investment in R&D to spur indigenous solutions based on the changing needs of Indian armed forces. Redirecting its diversification into the new markets has been beneficial for BEL in meeting the national goal of achieving self-reliance in defense technology.

6.2 TATA ADVANCED SYSTEMS

6.2.1 Partnerships with Lockheed Martin and Boeing

Strategic alliances between Tata Advanced Systems and the likes of global defense behemoths, such as Lockheed Martin and Boeing, have further augmented its capabilities in technology. Such collaborations have enabled Tata to co-develop crucial systems like avionics, electronic warfare components and high-end defense electronics establishing India as a crucial component of the global supply lines. By these partnerships, local joint ventures have also been set up to take care of the local production of premium electronic components.

6.2.2 New Manufacturing Units for Avionics

To meet the increasing requirement of defense electronics, Tata Advanced Systems has established new avionics manufacturing facilities. Specializes in the assembly/testing of mission-critical electronic systems for fighter jets and helicopters as a result, the new facilities have done more to create jobs while also further establishing India as a destination of choice for defense electronics manufacturing.

6.3 DRDO (DEFENSE RESEARCH AND DEVELOPMENT ORGANIZATION)

6.3.1 Indigenous Product Development in Radar Systems

To develop world-class indigenous radar systems to suit the specific requirements of Indian defense forces, effort by DRDO has been focused on cost-effective design and development of different types of radars. It has designed advanced technologies like AESA radars, long range missiles and missile detection radars. This has drastically decreased depending on foreign radar technologies with respect to operational independence.

6.3.2 Post-COVID R&D Acceleration

During the pandemic phase, DRDO realized the need for focus on self-reliance in defense technology and it fast tracked its R&D efforts. It worked with academia and private sector companies to create cost-efficient, high-performing electronic systems. This has led to quick induction of indigenous technologies in critical defense applications, boosting the national security.

7. FUTURE OUTLOOK AND RECOMMENDATIONS

The Indian defense electronics industry is poised for substantial growth, driven by advancements in technology and proactive government policies. To capitalize on emerging opportunities, stakeholders must focus on strategic areas to ensure sustainable progress.

7.1 POTENTIAL GROWTH OPPORTUNITIES

Industry 4.0 technologies, including AI, IoT, and big data analytics, offer immense potential to revolutionize defense electronics by enhancing operational efficiency and predictive maintenance capabilities. Additionally, India can expand its defense exports to friendly nations by offering cost-effective and high-quality electronic systems, positioning itself as a reliable global supplier.

7.2 KEY AREAS FOR IMPROVEMENT

A significant challenge facing the sector is the skill gap in specialized domains such as cybersecurity, avionics, and electronic warfare. Addressing this requires collaboration between industry and academic institutions to provide targeted training programs. Furthermore, regulatory complexities, such as lengthy approval processes and procurement delays, need to be streamlined to encourage investment and innovation.

7.3 STRATEGIC RECOMMENDATIONS FOR STAKEHOLDERS

Strengthening the local supplier ecosystem by supporting MSMEs and fostering public-private partnerships (PPPs) can enhance innovation and reduce dependency on imports. Encouraging PPPs will facilitate knowledge sharing, technology transfer, and capacity building.

8. CONCLUSION

The post-COVID era has accelerated India's drive for self-reliance in defense electronics, leading to significant advancements in domestic manufacturing, policy reforms, and strategic collaborations. Key findings highlight the increased focus on indigenous production through initiatives like Make in India and Atmanirbhar Bharat, alongside the expansion of MSMEs and private sector participation. Policy measures, such as increased FDI limits and procurement reforms, have enhanced the sector’s growth prospects, attracting global investment and fostering technological advancements.

The evolving industry landscape underscores the importance of continued government support, regulatory streamlining, and investment in skill development to address existing challenges. Strengthening local supplier ecosystems and encouraging public-private partnerships will be crucial for sustained growth.

Looking ahead, India is well-positioned to emerge as a global hub for defense electronics, driven by innovation, strategic policy interventions, and a commitment to self-reliance. Ensuring sustained efforts in technology adoption and supply chain resilience will be key to future success.

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