From Import Dependency to Export Competency

India's Path towards Self-Reliance in Ammunition Manufacturing

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In today's geopolitical landscape, achieving self-reliance in critical sectors like ammunition manufacturing is paramount for nations worldwide. This article explores the journey from import dependency to export competency in ammunition manufacturing, highlighting challenges, strategies and transformative initiatives. It delves into understanding ammunition manufacturing intricacies, analysing ammunition export/import trends, and emphasises the role of defence exports in promoting self-reliance. Moreover, it discusses the significance of technological innovations, investments and collaborative partnerships in driving self-reliance and competitiveness. By fostering a conducive environment for innovation and collaboration, nations can navigate towards self-reliance, resilience and strategic ascendancy in the defence sector.

Keywords: *Ammunition Manufacturing, Export/Import Trends, Defence Sector*

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Introduction

> Self-reliance is not an option but a necessity, as India is facing a double threat on its borders, along with new dimensions of warfare that are emerging in today's fast-changing world, stated Defence Minister of India, Rajnath Singh.[1]

In the realm of national defence, the concept of 'self-reliance' stands as a fundamental element of sovereignty and security. It encapsulates the ability of a nation to independently safeguard its interests, uphold its values, and protect its citizens without undue reliance on external entities. Self-reliance in defence is paramount as it guarantees nation's sovereignty and simultaneously promotes resilience and strategic adaptability in response to evolving geopolitical dynamics. A nation can safeguard its national interest and preserve integrity by developing indigenous defence capabilities. Self-reliance enhances a nation's security by mitigating vulnerabilities associated with dependency on foreign arms supplies or military assistance. In an interconnected world where geopolitical alliances can shift unpredictably, relying solely on external support exposes a nation to the risk of strategic vulnerability and manipulation.

Speaking at the 'Atmanirbhar Bharat' defence dialogue hosted by the STRIVE think tank in June 2024, Raksha Mantri Rajnath Singh emphasised the need for self-sufficiency in the defence manufacturing sector, particularly given that India is currently dealing with a double threat on its borders and evolving forms of warfare. He continued by saying that India must create its own cutting-edge technology platforms and equipment if it is to safeguard its sovereignty.[2] A country can strengthen its defences, lessen its dependency on outside actors, and guarantee that operations continue even during periods of geopolitical unrest by cultivating its defence industries and technological capabilities.

Understanding Ammunition Manufacturing

The word 'ammunition' means: (i) ammunition for any firearm, and includes rockets, bombs, grenades, shells [and other missiles]; (ii) articles designed for torpedo service and submarine mining; (iii) other articles containing, or designed or adapted to contain, explosive fulminating or fissionable material or noxious liquid, gas or other such thing, whether capable of use with firearms or not; (iv) charges for firearms and accessories for such charges; (v) fuses and friction tubes; (vi) parts of, and machinery for manufacturing,

ammunition; and lastly (vii) such ingredients of ammunition as the Central Government, by notification in the Official Gazette, specify in this behalf.[3]

Ammunition manufacturing involves a multi-stage process encompassing design, raw material procurement, production, quality control, testing and distribution. In India, this crucial aspect of defence production has traditionally been the responsibility of government-owned entities, notably the Ordnance Factories under the Indian Ordnance Factories Board (OFB). The roots of Ordnance Factories can be traced back to 1775 when the British authorities sanctioned the establishment of the Board of Ordnance in Fort William, Kolkata. The factories initially were under the direct supervision of Ministry of Defence in 1948 but in 1962, the Department of Defence Production was established which led to the formation of OFBs in 1979. However, seven new defence public sector undertakings (DPSUs) were carved out of OFBs on 15 October 2021[4] to enhance efficiency, functional autonomy and nation's defence preparedness. Each DPSU is classified according to its specific production focus such as ammunitions and explosives, troop comfort items, etc. Notably, Munitions India Limited (MIL) emerged as the state-owned defence company responsible for ammunition manufacturing, with its headquarters situated in Khadki, Pune, overseeing operations across 12 Ordnance Factories.[5] This strategic restructuring underscores the government's commitment to modernising and optimising the defence manufacturing ecosystem, thereby bolstering India's self-reliance and capabilities in ammunition production.

In a significant move towards bolstering indigenous defence capabilities, the Ministry of Defence (MoD) in 2023 undertook the selection of five domestic ammunition manufacturers to supply approximately 2,000 155mm terminally guided munitions (TGMs) for the Army's in-service 155mm guns of 39/45/52 calibre artillery.[6] Each domestically manufactured 155mm TGM projectile is estimated to cost around Rs 80 lakhs, making it not only the most advanced but also the most cost-effective option globally. Typically, comparable Western and Russian TGM projectiles cost twice as much, while US-made artillery ammunition is three times more expensive.[7] This move is particularly significant as the Army has historically relied solely on imported advanced artillery ammunition, highlighting the strategic importance of developing domestic capabilities in this critical area.

To meet the increasing ammunition demands of the armed forces and paramilitary forces, which were previously monopolised by the government-controlled Ordnance Factory Board, the MoD is actively encouraging private sector involvement in setting up new production facilities. Private companies

are now invited to address critical shortages in various types of ammunition, and long-term demand contracts will be awarded to these companies.

Five domestic companies have been issued Project Sanction Orders (PSOs) by the Army under the Make-II procurement scheme *vis-à-vis* Munitions India Ltd, and private sector companies Adani Defence Systems and Technologies Ltd (ADSTL), Bharat Forge Ltd, Economic Explosive Ltd, Premier Explosives and SMPP Ltd. These companies are tasked with developing 25 rounds of 155mm TGMs and four fire control systems within one year, and they will participate in trials on a cost-no-commitment basis. The prototypes must incorporate at least 50 per cent indigenous technology. The Expression of Interest (EoI) for 155mm TGM indicates that the demand for this ammunition will increase significantly as most of the artillery regiments transition to the 155mm calibre, aligning with the upgrade of Indian artillery capability.[8] Thus, the sustained demand for this ammunition will ensure the continued viability of the domestic defence industry. This initiative underscores India's commitment to achieving self-reliance in defence production and reducing dependency on imports, thereby enhancing national security and strategic autonomy.

Overview of Global Ammunition Market

The global ammunition market is a crucial sector within the defence industry, driven by military needs, geopolitical tensions and technological advancements. Over the past five years, the market has seen fluctuations in trade volumes and values due to various factors such as regional conflicts especially the Russia–Ukraine conflict, allocation of defence budgets and regulatory changes in the domestic policies of various countries. With the rise of global challenges, countries all around the world are enhancing their manufacturing facilities, investing in R&D and establishing partnerships to secure a steady supply of ammunition.

Figures 1 and 2 depict a comprehensive overview of the global and Indian markets from 2023 to 2032 based on the data derived from IISS Database, KPMG Research and Analysis. This forecast has divided the ammunition market into five segments *vis-à-vis* small calibre, medium calibre, heavy calibre, grenades, mines and mortars and loitering munitions. According to Observatory of Economic Complexity, there has been an increased demand for military hardware and ammunition and the ammunition market has experienced substantial growth in the past few years.[9]

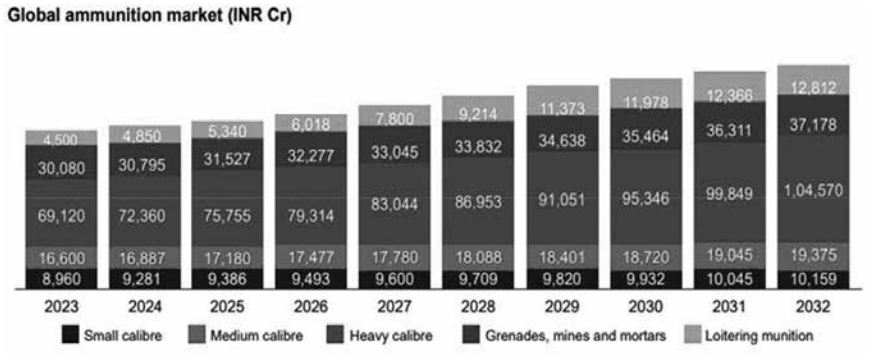

Figure 1 Global Ammunition Market—Current and Forecast

Source: IISS Database (2023), KPMG Research and Analysis, Inputs from Subject Matter Experts (SMEs).

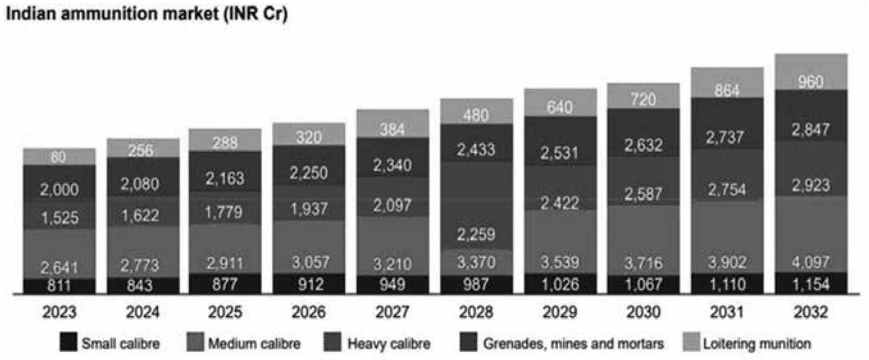

Figure 2 Indian Ammunition Market—Current and Forecast

Source: IISS Database (2023), KPMG Research and Analysis, Inputs from Subject Matter Experts (SMEs).

Figure 1 forecasts significant increase in the demand and production in almost all categories of ammunition market especially in heavy calibre and loitering munition. This indicates a significant enhancement of military capabilities through integration of technologically advanced systems in contemporary warfare. Small calibre exhibits a steady growth which implies a consistent need for smaller weapons for both military and civilian use. Additionally, medium and heavy calibre also demonstrate significant growth which indicate substantial investment in weapons for conventional warfare. While grenade, mines and mortar section remain relatively stable, loitering munitions represents the highest percentage rise which means the countries

across the world are increasingly opting for autonomous and remote-controlled systems in modern-day combat.

Figure 2 on the other hand depicts that the Indian market no matter how small still demonstrates considerable growth across all categories which highlights India's consistent efforts in modernising its military capabilities and becoming *atmanirbhar*. The comparative analysis of global and Indian ammunition markets presents that while the global data could be affected by various nations upgrading their military capabilities, India's growing presence in this market is mostly focused on securing strategic autonomy and bolstering defence capabilities. Another significant trend that comes across is the significant rise of loitering ammunitions which mark a shift towards advanced warfare technology. This transformation calls for the necessity to invest in R&D and innovation so that nations can tackle security threats in this evolving geopolitical environment. With respect to India, initiatives such as 'Make in India' help India position itself as a potential player in the global market.

'Make in India' Initiative in Defence

The 'Make in India'[10] initiative was inaugurated by Prime Minister Modi in 2014 to transform India into a manufacturing hub across various sectors. Among the 25 sectors earmarked for development, Defence Manufacturing emerged as a pivotal area of focus, alongside others such as Aviation, Construction and Chemicals.[11] This initiative aimed to foster self-sufficiency within India's defence sector, prompting the implementation of a comprehensive set of reforms to bolster indigenous design, development and production capabilities. Central to the 'Make in India' initiative were a series of strategic measures. First, the Defence Acquisition Procedure (DAP) 2020 prioritised the procurement of capital items from domestic sources, underscoring the government's commitment to bolstering indigenous defence manufacturing. Second, the announcement of 18 major defence platforms for industry-led design and development underscored the government's efforts to promote innovation and collaboration within the domestic defence industry. Third, the introduction of 'Positive Indigenisation Lists' for both Services and Defence Public Sector Undertakings (DPSUs) signalled a clear intent to reduce dependence on imports, with embargoes placed on specified items beyond designated timelines. A recent example of it is the unveiling of the fifth 'Positive Indigenisation List' which contained 98 critical items such as Futuristic Infantry Combat Vehicles, Unmanned Aerial Systems, etc., at the 'Swavlamban 2.0' event organised by the Naval Innovation and

Indigenisation Organisation (NIIO).[12] Additionally, the simplification of the industrial licensing process and the liberalisation of the Foreign Direct Investment (FDI) policy, allowing up to 74 per cent FDI under the automatic route, aimed to create a more conducive environment for domestic and foreign investment in the defence sector. Further initiatives include the streamlining of the Make Procedure, the launch of the Innovations for Defence Excellence (iDEX) scheme to engage start-ups and Micro, Small and Medium Enterprises (MSMEs), and the implementation of the Public Procurement Order 2017, all of which were designed to stimulate domestic production and innovation. Moreover, the establishment of an indigenisation portal named SRIJAN and reforms in the Offset policy, focusing on attracting investment and Transfer of Technology, reflected the government's commitment to foster collaboration and technology transfer within the domestic defence industry. Lastly, the establishment of two Defence Industrial Corridors, located in Uttar Pradesh and Tamil Nadu, aimed to create dedicated manufacturing ecosystems to support the growth of the defence manufacturing sector. Complementing these initiatives, the Department of Defence Production, Ministry of Defence, introduced the Draft 'Defence Production & Export Promotion Policy (DPEPP) 2020', serving as an overarching guiding framework to enhance defence production capabilities, promote self-reliance and facilitate exports within the defence sector, including aerospace and naval shipbuilding.[13]

The significance of the defence sector is underscored by various economic indicators. In the fiscal year 2023–24, the share of GDP allocated to defence expenditure reached 3.3 per cent, reflecting a substantial allocation of resources to national security.[14] Moreover, there has been a notable 13 per cent increase in the defence budget from the fiscal year 2022–23, indicating a continued commitment to strengthen the country's defence capabilities. Additionally, India's defence exports increased to US$ 160 billion in 2022–23,[15] however, India's disposition in the global arms trade paints a different picture. India is the largest importer of arms globally, but it does not find place in top 25 when it comes to export. Russia, France and USA are primary suppliers of arms to India wherein Russia accounted for 36 per cent of all imports, which was followed by France (33 per cent) and the US (13 per cent).[16] One of the major reasons for India's substantial imports is its geopolitical tensions with its neighbours, particularly Pakistan and China. These tensions call for a strong defence framework with strengthened defence capabilities which can ensure national security.

Addressing Ammunition Manufacturing Challenges in India

Among the various challenges that the ammunition manufacturing ecosystem confronts, the major challenge is to develop a self-reliant ecosystem for production. The present defence manufacturing system is underdeveloped, with inadequate production line and short supply of skilled labour. These deficiencies can lead to delays, inefficiencies and increased expenses, hindering the growth and competitiveness of the domestic defence industry.[17] Since independence, ammunition production has fallen under the purview of Ordnance Factories (OFs),[18] yet they have faced numerous challenges that have impacted their operations. Consequently, India remains the world's top importer of defence equipment. Various factors contribute to the failure of OFBs, including frequent production delays[19] and concerns regarding product quality. OFBs operate on a no-profit, no-loss basis, selling products at a price determined solely by production costs, including material, labour and overhead charges. However, this cost-plus pricing mechanism is widely considered inefficient.[20] Despite India's ambition to become a major defence exporter, particularly through the 'Make in India' programme, OFBs historically neglected exports, delaying progress in this regard. India today is indeed looking forward to developing itself as a major defence exporter, especially under the 'Make in India' programme, but this took so long because exports were never the primary focus of the OFB.[21]

OFBs' relevance as a prime supplier of arms and ammunition, particularly to the Army, has been eroded by poor management and gross inefficiency. Due to their record of poor focus on R&D and product development, high overhead costs, low labour productivity, quality concerns, and delays in order execution, the OFB underwent dissolution and transformation into seven distinct Defence Public Sector Undertakings (DPSUs) in 2021.[22]

Moreover, the technological advancement across the world in the global defence landscape also pose significant challenges. For instance, military powers such as US, Russia and China have already developed fifth-generation platform with cutting-edge feature such as stealth, high speed and autonomous capabilities powered by AI and Machine Learning systems. These niche technologies require significant investments in R&D, skill upgradation and collaboration with other nations which boost efficiency. Along with this, a conducive policy environment provides an opportunity for the private sector to involve itself in the defence manufacturing which will ultimately enhance national security.

Defence Minister Rajnath Singh has been urging private companies to invest in R&D, so that India is always aligned with global advancements. He emphasised the criticality of indigenous innovation stating that, 'While there is merit in adoption or acquiring technology from elsewhere, it's insufficient for us to solely rely on these means to progress as a developed nation. We must cultivate and patent our innovations, which demands substantial investment in R&D'.[23] He further noted that while investing in R&D might impact short-term profits, it's essential for the industries' and the nation's long-term growth and competitiveness.

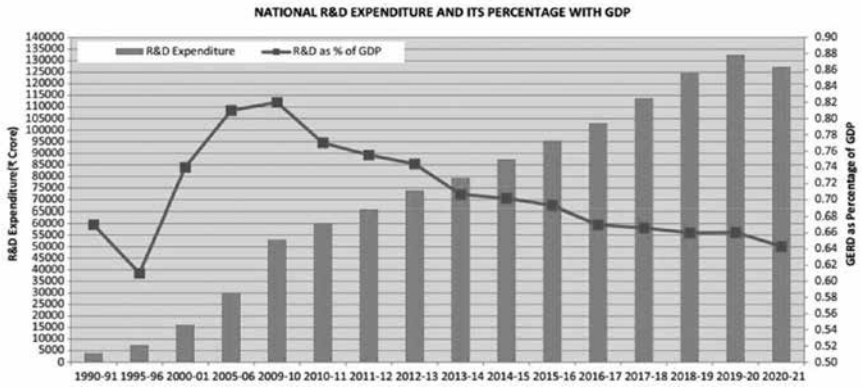

Figure 3 National R&D Expenditure and its percentage with GDP

Source: NSTMIS, Department of Science & Technology, Government of India.

As depicted in Figure 3, India's Gross Expenditure on Research and Development (GERD) has exhibited a consistent upward trajectory over the years. However, despite this significant increase, the percentage of GERD relative to the Gross Domestic Product (GDP) remained relatively stable, at 0.66 per cent and 0.64 per cent during the years 2019–20 and 2020–21.[24] In contrast, many developed nations allocate a much higher proportion of their GDP to R&D expenditure. For instance, Israel allocated over 5 per cent of its GDP to R&D in 2020, while the Republic of Korea allocated close to 5 per cent. Similarly, countries such as the US, Japan, Germany and Sweden allocated more than 3 per cent of their GDP to R&D. This stark contrast underscores the critical importance of prioritising investment in R&D.[25]

India's ascent as an emerging superpower mandates the modernisation and augmentation of its weapons and weapon delivery platforms, essential for safeguarding territorial security and advancing national interests globally.

While the Armed Forces are increasingly turning to Indian Original Equipment Manufacturers (OEMs) and MSMEs for the design and manufacture of fifth-generation systems, these projects are notably lagging behind the induction schedule.[26] The indigenous development of high-end technology faces myriad challenges, including the non-availability of critical technologies, high R&D costs, scarcity of skilled engineers and funding constraints. Hence, it becomes imperative for DPSUs to assume responsibility for the design, development and integration of next-generation defence equipment in collaboration with MSMEs and start-ups.[27]

In addition to R&D, another challenge that India faces is its challenging exports. S.V. Singh highlights several significant obstacles obstructing India's aspirations for defence exports, underscoring the need for concerted action to overcome them effectively.[28] Firstly, the structure of the defence market presents difficulties due to fluctuating demand from the Indian Armed Forces and a lack of repeat orders, causing uncertainty for manufacturers. Furthermore, the market operates as a monopsony, primarily dominated by DPSUs, limiting competition and innovation. Second, the export of indigenous defence products is affected by lack of coordination and communication breakdowns among major stakeholders *vis-à-vis* the Indian Armed forces, DPSUs, private manufacturers and the Ministry of Defence. Third, the defence export system has been affected by institutional neglect since independence, however, new initiatives like the DPEPP 2020 point towards a policy of change.[29]

Technological Innovations and Investments in Ammunition Manufacturing

Technological innovation and investments are critical drivers of self-reliance in the defence manufacturing sector as this helps a nation to develop defence products of superior quality and position itself as a significant power in global defence market. Niche technologies such as automated logistics using robotics and drone swarms, AI-assisted projection and planning, and augmented soldiers can transform operations both on and off the battlefield. This aligns seamlessly with the goal of 'atmanirbharta' which aims to reduce dependency on imports as highlighted in the defence budget. Encouraging emerging start-ups to develop solutions in areas like AI-powered satellite analytics, automated logistics drones and secure quantum communications systems can address specific military challenges and problem statements, driving innovation and self-sufficiency in defence technology.[30]

A recent example of it is the launch of the Acing Development of Innovative Technologies with iDEX (ADITI) scheme at Def Connect 2024 and the corpus fund of Rs 750 crores for three years beginning from FY 2023–24 to develop about 30 deep-tech critical and strategic technologies in a proposed timeframe for capability enhancement of tri-services and Defence Space Agency.[31] The Ministry has also enhanced the funding from Rs 10 crores to Rs 25 crores for start-ups for research, innovation and development of defence technologies. The aim of ADITI under iDEX is to create a 'technology watch tool' to bridge the gap between the expectations and requirements of the modern armed forces and the capabilities of the defence innovation ecosystem. To motivate young innovators, iDEX was expanded to iDEX Prime, with the assistance increasing from Rs 1.5 crores to Rs 10 crores. The 11th edition of the Defence India Start-up Challenge (DISC) was also launched at the event, rolling out a new chapter in the collaboration between the defence establishment and the start-up ecosystem.[32]

Investing in defence technology in India presents lucrative opportunities for both domestic and international investors. The 'Make in India' initiative stimulates domestic defence production, fostering innovation and self-reliance while providing access to a vast market.[33] Representing a paradigm of 'Atmanirbhar Bharat', the collaboration between the Indian Institute of Technology Madras (IIT Madras) and Munitions India Limited, a key player in defence manufacturing, marks a pivotal stride in India's quest for self-reliance. Together, these institutions, operating under the auspices of the Ministry of Defence, Government of India, are spearheading the development of the nation's inaugural domestically engineered 155 Smart Ammunition. With the primary objective to achieve a Circular Error Probable (CEP) of 10 meters, this partnership holds the promise of substantially enhancing precision in defence operations.[34]

In the past, ammunition manufacturing was primarily carried out by state-owned entities such as the Ordnance Factories Board (OFB) and DPSUs. However, the landscape underwent a significant shift with the inauguration of two private ammunition and missile manufacturing facilities by Adani Defence and Aerospace in Kanpur in February 2024.[35] These facilities, expected to rank among the largest integrated ammunition manufacturing complexes in South Asia, signify a pivotal development in enhancing India's indigenous defence capabilities especially as they manufacture ammunition for the police, paramilitary and the armed forces. Even the former Army Chief General Manoj Pande emphasised on consistent domestic ammunition supply to sustain during protracted wars and maintain

operational preparedness at all times. He noted that, 'Strategic prudence dictates that indigenous capacities in ammunition production are a crucial factor in maintaining operational readiness and tempo during conflict'.[36] The inclusion of private sector to bolster domestic ammunition manufacturing reflects India's commitment to enhance its strategic autonomy and reduce dependency on external sources.

India's Self-Sufficiency in Ammunition Manufacturing through Exports

In order to foster self-reliance in the defence sector, exports play a very significant role. First, it allows the nation to demonstrate its technical know-how and manufacturing competence in ammunition manufacturing sector and for that, consistent efforts by the government are critical. According to India Brand Equity Foundation, defence exports reached US$ 2.63 billion in FY24 which is 32.5 per cent more than last year. India's defence budget which was US$ 74.7 billion was ranked fourth highest globally in 2024. The government of India allocated US$ 2.9 billion to the Defence Research and Development Organisation (DRDO) while US$ 12 billion was for Deep Tech companies to boost innovation in defence technologies during its Interim Budget 2024–25. In fact, in the regular budget of FY25, Ministry of Defence was allotted US$ 75 billion which was the highest amongst the ministries.[37]

Second, the revenue generated from defence exports can be reinvested into domestic defence research, development and procurement programmes. A study published in the *Journal of Strategic Studies* in 2018 underscores how defence exports can contribute to the funding of domestic defence initiatives, thereby reducing dependency on external sources.[38] This reinvestment not only enhances technological innovation and capability development, but also ensures a more sustainable defence industrial base over the long term.

SV Singh delineates three pivotal factors propelling the expansion and diversification of India's defence exports.[39] First, the bolstering of domestic defence manufacturing, notably through initiatives like DAP 2020 and positive indigenisation lists, emerges as a cornerstone. These frameworks prioritise indigenous defence industry development, thereby enhancing domestic manufacturing capabilities and subsequently fuelling export growth. Second, the adoption of liberalised licensing and certification procedures marks a significant shift. This shift empowers both private and public manufacturers to select export markets independently, moving away

from previous government-directed approaches. Nonetheless, government clearances remain imperative to ensure adherence to regulatory standards. Lastly, the adoption of a whole-of-government approach stands out as another critical enabler. India has expanded the scope of its defence export framework by promoting diplomatic endeavours and providing lines of credit to countries across the world who are seeking military equipment from India. From the largest importer, India is on the path towards becoming a key defence manufacturer and exporter, for instance, by pitching itself as a manufacturer of 'affordable and reliable equipment' to African nations during Africa–India field training exercise (AFINDEX-2023).[40] Therefore, in order to realise its export ambitions, an integrated strategy is the need of the hour.

Notably, a self-sufficient ecosystem for ammunition manufacturing necessitates substantial investment in technology and expertise. Through increase in exports, the manufacturers would be able to distribute the defence equipment over fixed costs on a much larger scale. This augmented production capacity as a result will allow firms to streamline their operations, lower per-unit expenses and improve cost-competitiveness both locally and globally. This results in interconnected network of suppliers and service providers which lead to the development of robust and resilient supply chains thereby strengthening efficaciousness, reliability and responsiveness of the process as a whole. A thriving export-oriented manufacturing ecosystem encourages the stakeholders to invest in R&D and innovation which are the pillars of a long-term, self-sufficient defence ecosystem that would further help achieve stringent quality and performance requirements of the international markets as well. Innovation and investment in R&D help develop sophisticated technologies for both domestic and export market needs which in turn results in overall advancement of defence ecosystem of a country.

Lastly, to become a self-sufficient nation in defence, it is important to note that the international markets often impose strict quality standards and certification procedure. In this regard, India needs to adhere to these guidelines if it aspires to be a global exporter in defence. Adherence to the standards ensures improvement in manufacturing practices, product quality and access to global markets. This results in increased reliability and customer satisfaction, but also creates a culture of innovation and excellence within the ecosystem. A strong defence export ecosystem not only translates to a nation which is self-reliant for its needs in defence, but also strengthens strategic capabilities and increases the geopolitical influence of the country through alliances and agreements in defence with the importing countries. In a nutshell, a robust ammunition export industry strengthens self-reliance and

resilience of domestic defence industry, minimises dependency on foreign suppliers and ensures the supply of critical munitions during times of crisis.

Conclusion and Way Forward

In the face of evolving security threats, geopolitical uncertainties and economic vulnerabilities, it is essential to build a robust policy framework that enhances defence resilience and fosters self-reliance in defence manufacturing, with special focus on ammunition. A comprehensive and strategic approach encompassing policy formulation, technological innovation, infrastructural development, and human resource advancement must be adopted for the ammunition manufacturing industry to be self-reliant as well self-sufficient. At the core of this vision is the establishment of a comprehensive national policy that delineates long-term objectives, allocates tasks and establishes timelines. The policy should outline the aims which would help in transitioning from import dependent to self-reliant in various sub-fields of ammunition production such as smart munitions and precision-guided ammunition. Prioritising these key technologies and aligning them with future defence operational requirements will ensure that India's defence sector remains at the forefront of modern warfare.

An essential component of ammunition self-sufficiency is the establishment of a strong R&D ecosystem that integrates public sector and the private sector. By strengthening public R&D institutions such as DRDO would guarantee they are equipped with requisite resources and expertise to innovate advanced ammunition technologies. In particular, within domains like electronics, material science and precise-weapons systems, collaboration with academia is essential for driving innovation among the industry. This partnership could lead to advancements that improve domestic capability to produce advanced ammunition. Additionally, the involvement of private sector in R&D is promoted by financial incentives such as tax reductions and subsidies, designed to boost innovation in smart and precision-guided munitions.

Developing indigenous manufacturing capabilities is another essential component for becoming self-sufficient. Enhancing current production facilities, including those operated by the government and private sectors, is necessary to modernise infrastructure and incorporate advanced manufacturing technologies. The implementation of automation, digitalisation and use of advanced materials in the production process will improve efficiency and quality. Moreover, in the areas where production gaps

are present, the policy framework recommends setting up new, state-of-the-art facilities capable of producing a broad range of ammunition, from small arms to heavy artillery. Public–Private Partnerships (PPP) are advocated to leverage the expertise of both domestic and international players in the field of ammunition manufacturing, expediting technology transfer and growth of local competence. This cooperative approach can ensure that the country builds a diverse, resilient industrial base capable of meeting its defence needs.

The indigenisation of critical ammunition components forms a core aspect of the effort to reduce dependency on foreign suppliers. This encompasses the development of key sub-systems such as fuses, casings, propellants and warheads through domestic innovation. Hence, strengthening these local supply chains, particularly by encouraging participation from MSMEs can further drive indigenisation initiatives. Additionally, local sourcing of raw materials, advanced technological devices and precision-machined equipment not only reduces costs, but also contributes to national security by minimising exposure to external supply chain disruptions. To increase the effectiveness and cost efficiency of domestically produced ammunition, advances in material science are advised, such as the use of lightweight composites and smart materials.

It is crucial to maintain good production standards for both domestic consumption and potential exports. In order to maintain standards, advanced ammunition testing and certification facilities are required, which can perform a variety of tests, including environmental impact assessments, failure analysis and performance validation under different conditions. Also, by adopting the international military standards, such as NATO specifications, the domestic ammunition industry can enhance its credibility and tap into global markets. In addition, rigorous quality assurance procedures will help to ensure the reliability and safety of ammunition, reducing the risk of malfunctions or accidents during production and operations.

Human resource development is a crucial facilitator of the ammunition manufacturing ecosystem. To meet the technical demands of modern ammunition production, specialised training programmes must be established to educate the engineers, scientists and skilled labour in the fields of design, production and quality control. To foster an ecosystem of skilled workers and qualified professionals, there is a need to collaborate with technical institutes, defence universities and international experts. Also, encouraging young talent to pursue careers in defence-related fields through scholarships, internships and research fellowships will contribute to the long-term sustainability of the workforce.

Lastly, for fostering a culture of innovation and entrepreneurship, defence innovation hubs and incubators should be established. These hubs could support start-ups and small businesses working on niche ammunition technologies, such as smart ammunition, AI-driven targeting systems and environmentally sustainable explosives. The creation of ground-breaking technology would be further encouraged through national competitions, innovation challenges and defence grants. As the domestic industry evolves, regulatory frameworks should be streamlined to accelerate licensing, manufacturing and procurement processes, so that it is easier for private enterprises to enter and thrive in the defence sector. Furthermore, focussing on exports, especially after achieving self-reliance, would enable the country to position itself as a global supplier of advanced ammunition, contributing to economic growth and enhancing its geopolitical influence.

In conclusion, attaining self-reliance in ammunition manufacturing and production requires a multifaceted strategy that integrates policy formulation, investment in R&D, infrastructure development, indigenisation of components and human resource development. By implementing the aforementioned recommendations in a coordinated manner, India can realise its vision of becoming self-reliant in ammunition manufacturing and bolster its defence preparedness in line with the principles of 'Atmanirbhar Bharat'.

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