

Drone Technology

India's Leap Towards Defence Atmanirbharta

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The emergence of Unmanned Aerial Vehicles (UAVs) or drones as a potent tool for tilting the balance of power during military conflicts has brought the focus of major countries around the world to strengthen their drone technology. As India aims to become a global hub of the drone industry by 2030, drone technology will play an integral role in bolstering India's defence and security systems to achieve the goal of 'atmanirbharta' in defence. Beginning with tracing the emergence and evolution of drones in modern warfare, this article analyses India's growing leap in developing drones and counter-drone systems, especially for defence purposes and examines the security concerns that necessitate the development of the drone sector to augment India's military capabilities. It also discusses the measures taken by New Delhi to strengthen and develop the technology architecture for drone production in the country and analyses the hurdles and challenges that exist. This article argues that given the unholy nexus between India's two hostile neighbours, it no longer remains a matter of choice but becomes a matter of conviction for India to bolster its drone capability and become atmanirbhar. Therefore, it is imperative that India utilise its pool of talent in innovation and technology through the synergy

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among the industry, academia and government to work towards achieving the objective of self-sufficiency in designing and manufacturing world class drones which could propel India's defence sector to new heights, thereby helping it become atmanirbhar to face any adversity in future.

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INTRODUCTION

The modern nature of warfare has revolutionised the way technology can be used for military purposes. As the nature of warfare undergoes tremendous changes, so do the weapons and tools deployed during warfare. Among the technologically sophisticated military instruments, drones, also known as Unmanned Aerial Vehicles (UAVs), have emerged as a key component in the field of defence and security in the present era of warfare, which is driven by Industrial Revolution 4.0 and is marked by the advancement in Artificial Intelligence (AI), cyber security and machine learning among other latest technologies. From being a supporting player in the war to becoming a major component of warfare, the usage of UAVs has evolved to a great extent, making them an integral part of any country's warfare arsenal in modern times. Besides being force multipliers in counterinsurgency and border and battlefield surveillance, drones can effectively deploy AI, operate as swarms, gather electronic intelligence and provide airborne early warning on the modern battlefield.¹ Their effectiveness, precision and accuracy make them an indispensable technology to be deployed for harnessing Intelligence, Surveillance and Reconnaissance (ISR) capabilities. The decisive role played by drones in the Azerbaijan–Armenia war and in the ongoing conflicts such as the Russia–Ukraine crisis and the Israel–Hamas conflict indicates that the possession and application of drone technology in warfare has the potential to determine the trajectory of the conflict in favour of the party that has a technological edge in drones. This is one of the major reasons why the drone market has proliferated significantly worldwide over the years. Compared to the year 2010 when only 60 countries had military drones, today nearly a hundred countries possess military drones.² As India aspires to become *atmanirbhar* or self-reliant in defence, developing the technology architecture and strengthening the indigenous capability of manufacturing UAVs and counter-UAVs and their components becomes of utmost importance to realise this objective. This is evident in India's drone industry's long strides in the past few years. However, despite taking

measures such as incentivising indigenous manufacturing of drones and banning drone imports, among others, India remains dependent on foreign countries to acquire drones of the highest quality and standards best suitable for military and strategic purposes. This article first traces the evolution and adaptation of drone technology in modern warfare. Second, it analyses the distribution of drones and its market in India *vis-à-vis* other countries. Third, it sheds light on the significance of achieving self-reliance in drones for enhancing India's defence security apparatus. Last, it highlights the policy initiatives taken by New Delhi and other stakeholders to achieve this objective of 'atmanirbharta' in defence.

EMERGENCE OF DRONES AS A VITAL COMPONENT IN MODERN WARFARE

Drones are defined as those aerial systems that are operated either by automated technology or by a remotely controlled pilot on the ground. They come in all shapes and sizes, depending on their applications and are often categorised based on their types of sensors, speed, weight and cost. Based on weight, which includes the payload they carry, they can range from Nano UAVs (which weigh less than or equal to 250 grams) to Large UAVs (which weigh more than 150 kilograms).³ The smaller ones can carry something small such as a camera while the biggest ones, which look more like aeroplanes and are generally used by the military, can carry heavy payloads.⁴ Some of the more extensively used drones by militaries worldwide are 'fixed-wing drones, fixed-wing hybrid drones, micro drones, tactical drones, large combat drones, target and decoy, reconnaissance drones, and GPS drones'.⁵ Drones have been a part of modern warfare since the 19th century. Their ability to adapt to different terrains and climates and their proven efficiency in striking the target with precision, reducing the risk of both civilian and military casualties makes them a vital arsenal in modern warfare. The attached camera in drones that captures visuals of destruction also helps deployers to fight the adversary in the psychological space by setting the narrative and propaganda in its favour by disseminating the visuals as some sort of victory.

The attack on the city of Venice by Austrian soldiers in 1839 with explosive-laden unmanned balloons is considered as the first known instance of the use of UAVs in history. Britain and the United States of America (USA) were the first countries to produce UAVs during World War I. In March 1917, Britain tested 'Rustom Proctor Aerial Target', a tiny aircraft controlled by radio and in October 1918, the United States (US) tested the Kettering

Bug, the first UAV of the country. Although neither was used during the war, they showed promise to become a critical tool in warfare. The inter-war period witnessed the continuation of UAV testing. The DH.82B Queen Bee, which is known as the mother of all drones, is credited with inspiring the origin of the term drone.⁶ Later on, drones were first used for reconnaissance during the Vietnam War. Their combat role continued to undergo changes with the advent of the latest technologies and the new models evolved with better capabilities, longevity and ability to fly higher than their previous models.⁷ As Information Communication Technology (ICT) developed further, the 1990s saw the use of UAVs in the Gulf, Afghanistan, Kosovo, Arab–Israel and Iraq wars.⁸ Post 9/11, the period witnessed more extensive usage of drones in combat operations, with the US leading the drone strikes from the front.

In the current Russia–Ukraine conflict, both Ukraine and Russia have used Turkey’s TB2 drones and Iran’s Shahed drones respectively in the warfare. The widespread deployment and effectiveness of drones led President Volodymyr Zelenskyy to create a distinct division within the Ukrainian Armed Forces to specifically focus on drone technology. In 2020, US deployed aerial drones to kill Major General Qassem Soleimani, one of Iran’s most influential figures. Likewise, in 2022, al-Qaeda leader Ayman al-Zawahiri, one of the conspirators of the 9/11 attacks, was slain by a drone strike during an operation conducted by the Central Intelligence Agency (CIA) in Kabul, Afghanistan.⁹ Now countries such as the United Kingdom (UK), Turkey and Nigeria have followed in the footsteps of the US and are also using drones to strike opposition targets. These developments mark a notable change in military strategy, highlighting the changing dynamics of the battlefield where unmanned systems have become crucial (Table 1).¹⁰

However, as drone technology becomes more accessible and affordable, non-state actors, terrorists, militants and other rogue elements have also acquired UAVs, posing a serious security threat to countries. Non-state actors can use automated self-made drones to deliver explosive material and carry out attacks in targeted locations. The gravity of this is reflected in a *New York Times* article dated September 2019, which claims that Boko Haram possesses more sophisticated and superior drone technology than the Nigerian military.¹¹ In the Middle East, drones have emerged as new weapons of geopolitical power projection not only for states but also for non-state actors, with various militant groups using them extensively.¹² In March 2022, Iran-backed Houthi rebels destroyed oil storage facilities,

power stations and water desalination plants in Saudi Arabia with the help of advanced drones. This has led to a rapid growth in various counter-drone technologies such as DroneGun, SkyFence, DroneKiller, DroneCatcher, SkyWall 100, among others, which can detect, destroy and neutralise the effects of drones.¹³

Table I Some of the international incidents involving drones in the recent past

Date	Incident
December 2023	Iran-backed Houthi group launched drone attacks in the Red Sea to disrupt global supply chains
November 2023	Russia launched kamikaze drone attack against Ukraine's capital, Kyiv
July 2023	Drones are being used to smuggle drugs and weapons into India by Pakistan-based groups
May 2023	Two explosive drones targeted the Kremlin in Moscow and were shot down
October 2023	Israel and Hamas used UAVs to bomb each other
November 2020	Turkish-made Bayraktar drone used by Azerbaijan to defeat Armenia
January 2020	American drone attack killed Iranian Major General Qassem Soleimani

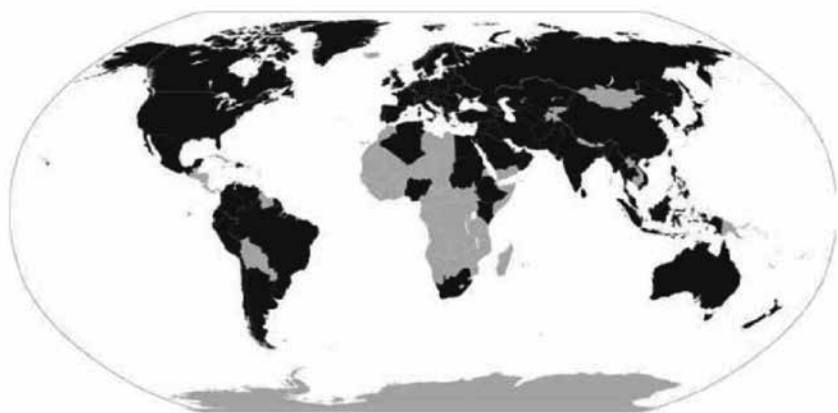
Source: Compiled by authors from various sources

WORLDWIDE DISTRIBUTION OF ARMED DRONES

The surge in the number of military drones being produced has been phenomenal in the last decade. According to Emergen Research's most recent report, the market for military drones worldwide is anticipated to grow with a projected compound annual growth rate of 10.9 per cent to reach US\$ 35.71 billion in 2028.¹⁴ As drones emerge as a pivotal component of any country's military capability, reshaping the dynamics of warfare, what once used to be the monopoly of countries such as US and Israel, drone technology and manufacturing have now developed in various countries around the world, with China and Turkey leading the race in manufacturing and exporting a diverse range of remote-controlled drones.¹⁵ Increasing use of drones in the defence sector in various capacities and the incorporation of advanced technologies such as AI, Infrared Thermography (IRT) and Hyperspectral Imaging (HIS) have facilitated the market growth of military drones like

never before. Additionally, while technological advancement has made the drone-making process cost-effective, thereby increasing their supply, drones’ effectiveness in countering threats and in military deployments has raised their demand quite high. The development of drone technology also adds to the security dilemma among rival countries, pushing the states into Thucydides’ trap and causing a spur in the race to acquire drones.¹⁶ This growth is further fuelled by various other factors that include the rising expenditure by countries in the defence and other sectors related to Research and Development (R&D) and rising cross-border conflicts in several countries, forcing them to increase military spending for procuring drones for improved patrolling across borders (Figure 1).

Figure 1 Countries with an active military drone inventory



Source: Dan Gettinger, *The Drone Databook*, p. viii, available at <https://dronecenter.bard.edu/files/2019/10/CSD-Drone-Databook-Web.pdf>, accessed on 5 March 2024.

The worldwide distribution of armed drones is given in Table 2.

Table 2 List of UAVs (country-wise)

Country	UAVs
USA	MQ-1C Grey Eagles, MQ-9 Reaper, MQ-1 Predator, RQ-4 Global Hawk, RQ-7 Shadow, CQ-10 Snowgoose, RQ-11 Raven, Stalker, ScanEagle, Switchblade, AAI RQ-7, Northrop Grumman X-47A
Israel	Heron TP, Hermes 450, Hermes 900, Mastiff, Searcher, Orbiter, Scout
Turkey	Bayraktar TB2, Taj Anka, Tai Aksungur

China	Aisheng ASN, CASIC HW, CASIC WJ, ChangKong-2, Ehang Ghost, Shenyang BA-5, CH-3, CH-4, CH-92, Beihang BZK-005, Wing Loong I and II, GAIC Xianglong, Harbin BZK-005, HLKX Hawk Eye
Russia	Kamov Ka-137, GLL 8, Yakovlev Pchela, Zala Lancet
India	DRDO Abhyas, DRDO Ghatak, ADE Nishant, India-US Joint ALUAV target drone, Trinetra, RUAV 200
Iran	Shahed-136, Mohajer, Kaman 22
Pakistan	NESCOM Burraq, Shahpar-2 and Uqab
South Africa	Milkor 380
Australia	Boeing MQ-28 Ghost Bat

Source: Manish, 'Drones and Arms Control', *Journal of Defence Studies*, Vol. 16, No. 4, October–December 2022, pp. 125–40.

Another report released by Drone Industry Insights (DroneII) titled 'Global Drone Market Report 2023–2030' forecasts the size of the global drone market to reach US\$ 54.6 billion by 2030, with the commercial market growing at a 7.7 per cent CAGR.¹⁷ The report predicts that mapping and surveying are and will remain the top applications of drones. Asia will dominate the commercial drone market, with China and Japan leading from the front and the countries from Africa and Middle East exhibiting tremendous growth. According to Drone Manufacturers Ranking 2023 released by Drone Industry Insights (DroneII), China's DJI Technology is the world's largest civil drone maker. It is followed by Skydio of USA, XAG of China, Parrot of France and JOUAV of China. While Insitu takes the top spot for dual-use (commercial and military) drones, it is followed by Schiebel, Edge Autonomy, Quantum Systems and IdeaForge. Out of the top 20 dual-use drone manufacturing companies, the majority of them are based in the US (6), while the rest 14 are evenly spread across Czechia, Denmark, Estonia, Germany, India, Austria, Belgium, Israel, Portugal, Switzerland and Ukraine. The ranking shows that dual-use drone manufacturing companies have witnessed more ascendance in their ranking than civil-use drones, indicating the increasing demand for military drones. These companies are spread across the world, thereby implying that drone manufacturing is not limited to just a few big players anymore (Table 3). This is evident in the way how Hamas could penetrate Israel's air defence system, Iron Dome, with the help of relatively cheap and small commercial drones, killing more than a thousand people.¹⁸

Table 3 Global ranking of companies in dual-use drone manufacturing

Rank	Company	Country
1	Insitu	USA
2	Schiebel	Austria
3	Edge Autonomy	USA
4	Quantum Systems	USA
5	IdeaForge	India

Source: Drone Industry Insights' 2023 Report.

HISTORY OF DRONE TECHNOLOGY AND ITS DEVELOPMENT FOR DEFENCE IN INDIA

Drones or UAVs have been used by the Indian Army since the 1990s to augment its capability and efficiency in surveillance, intelligence gathering, reconnaissance, search and rescue, precision strikes and various combat operations, especially during counter-terrorism operations. The first instance of using military drones by India was seen during the 1999 Kargil war with Pakistan, where IAI Heron and Searcher drones, which were supplied by Israel, were used for reconnaissance.¹⁹ India's journey towards building drones started in 1990 with Defence Research and Development Organisation (DRDO) developing UAV Nishant, which was designed for intelligence gathering, target designation, surveillance and reconnaissance, artillery fire correction, damage assessment and obtaining other intelligence-based inputs. The army received its first four UAVs in 2009 after more than a decade since the development of Nishant UAV. However, due to frequent crashes, the army had to shelve the entire Nishant UAV programme. Not long ago, DRDO's biggest-ever project to develop an advanced UAV, Tapas-BH-201, which was started in 2011 as a 'Mission Mode' project, had to be downgraded from its high priority status due to its inability to meet essential military requirements in operations and military endurance.²⁰ That said, the recent decision by the Indian Air Force and Indian Navy to acquire six and four Tapas UAVs respectively from DRDO comes across as a positive development.²¹ DRDO has been working on several drone projects along with its production partners to give a push to the indigenisation of drones, which include DRDO Lakshya, DRDO Rustom-1, DRDO Rustom-2 (Tapas-BH-201), DRDO Ghatik, DRDO Imperial Eagle, DRDO Kapothaka, NAL/ADE Golden Hawk, NAL/ADE Pushpak, etc.²² However, these DRDO programmes

have not been successful due to several challenges. A few of these challenges, which resulted in redesign and development delays, were technical issues with stability, payload capacity and endurance, along with development hold-ups and shifting operational requirements. This led to changes in project scope and specifications in the development stage. These issues were exacerbated by anomalies in funding and resource distribution. Bureaucratic inefficiencies and external competition further hindered decision-making and project implementation.

Despite all such efforts over all these years, it is pertinent to note that India is highly dependent on countries such as Israel and the US to meet its drone requirements.²³ Many of these projects have not achieved the anticipated outcomes due to factors such as technical complexities, inordinate delays, budgetary constraints and over dependence on foreign countries, among others. A report released by Stockholm International Peace Research Institute (SIPRI) ranked India at the third place, after UK and France, in terms of countries that have imported the highest number of military-grade UAVs by the end of 2020.²⁴ The Indian Army has acquired drones manufactured in Israel, including Heron, Searchers, Harpies and Harops, for use in a variety of military operations.²⁵ India has deployed many of these Israeli Heron drones in the eastern Ladakh sector along the India–China border. Even the recent Israel– Hamas conflict over Gaza didn't affect India's status of being the top buyer of military hardware from Israel, which includes buying radars, surveillance and combat drones and missiles, among others. The Hyderabad-based Adani–Elbit Advanced Systems India Ltd. is the first company outside of Israel to produce the Hermes 900. These drones' major components that are produced in India include: (a) aerostructures, which are made of carbon composite and are essential for the drone's body and wings because they provide a sturdy yet lightweight design; and (b) high-performance sensors that enable the drones to identify objects. India's vital import dependence on Original Equipment Manufacturer (OEM) Elbit Systems spans multiple important domains through its joint venture with Adani–Elbit Advanced Systems India Ltd. To augment indigenous capabilities, Elbit must transfer its cutting-edge drone technology, including the complex aerodynamics, avionics and integration methods, which are essential to Hermes 900's performance. To ensure the efficient use and upkeep of the drone, the joint venture also depends on Elbit for technical assistance and training. This joint venture between Israel's Elbit Systems and India's Adani Defence & Aerospace indicates an evolution in India's defence relationship with Israel from solely being an importer of technology to an

important collaborator in various ventures; this is especially significant at the time when, in the words of Avi Bleser, 'The world is looking for unmanned capability and solutions'.²⁶

Considering the requirements of modern warfare, India has been accelerating its indigenous capacity to build and harness drone technology so that its dependence on foreign countries is substantially reduced. The display of swarm drones during the Army Day celebrations in 2021, which have been manufactured by Bengaluru-based NewSpace Research & Technologies, is indicative of a significant augmentation in indigenous drone weaponry.²⁷ Furthermore, Gurutvaa Systems, an Indian private company, has developed an indigenous counter-drone system called 'Dronnam', which was displayed by the Indian Navy at the Swavalamban 2023 exhibition.²⁸

India's Counter-Drone System

Counter-drone technology warrants serious attention and significant development because the conventional radar systems and the ground-based air defence system are usually not effective in 'detecting, identifying and neutralising' threats posed by UAVs. Furthermore, because of the unique nature of drones regarding its size, speed and resemblance to birds, no other standalone sensor system can match up to counter-drone systems' capability to detect, deter and destroy incoming drone threats.²⁹ Conventional air defence systems possessed by India currently are effective only against large, fast-moving aerial objects and are ineffective in providing security against small, low flying and slow-moving drones.³⁰

India's DRDO and Bharat Electronics Limited (BEL) have recently produced a D4 Drone System, commonly known as the Drone Detect, Deter and Destroy System. Detection is done through radar, deterrence through jammer and destruction through laser.³¹ DRDO has completed the Transfer of Technology (ToT) process for this drone to private companies, such as Adani Defence Systems, Larsen & Toubro (L&T), Astra Microwave Products Ltd, ICOMM Tele Ltd and Electronics Corporation of India Limited (ECIL).³² This D4 System is capable of unleashing soft kill (cutting off the drone's communication with its pilot or source) and hard kill (physically destroying the drone with the help of Laser Directed Energy Weapon) attacks on all types of drones, including nano, micro and mini drones, thereby making it effective in neutralising and detecting drone attacks of the kind that took place in Jammu's air force base camp in 2021. In addition to this, the D4 System has a multi-layered defence mechanism, over a 4-km long range within a radius of 1.25 km and with flexibility in

deployment.³³ This development is a significant step towards *atmanirbharta* in India's defence sector, as it is the first indigenously built counter-drone system to be inducted into the Indian Armed Forces. The Indian Army has also inducted seven new 'indigenous integrated drone detection and interdiction systems (IDD&IS)' along the border with China in the north.³⁴ In a ground-breaking advancement, a Hyderabad-based private firm 'Grene Robotics' claims to have created the world's only anti-drone system, named 'Indrajaal', that can protect against micro, mini, small, large and extra-large drones.³⁵ IIT Jammu has also developed a first-of-its-kind anti-drone system that can detect drones based on their sound.³⁶ Its main architect Professor Karan Nathwani argues that this system can be inducted into the Indian Army after it is modified as per the data received from the army to adapt it to familiar conditions. Zen Technologies, a Hyderabad-based company, has delivered a counter-drone system with soft kill technology and hard kill technology to the Indian Air Force and Indian Army respectively.³⁷ Similarly, as stated before, Gurutvaa System's Dronnam has been inducted into the Indian Navy. Under the Innovations for Defence Excellence (iDEX) scheme, another Indian company, Big Bang Boom Solutions Private Limited (BBBS), has been awarded the largest contract by the Ministry of Defence (MoD) for developing a counter-drone system.³⁸

Although these developments carried out by the government, industry and academia seem promising, India's drone industry requires more innovation, investment and integration of technologies to take it to the world-class level at par with countries such as Israel, France, USA and China. India's talent in the IT sector, which is aided by cost-effective labour and its gradual advancements in fields considered as prerequisites for drone making such as materials engineering, avionics and specialised manufacturing augurs well for the country's defence *atmanirbharta*, with drone manufacturing becoming one of its major drivers.³⁹ However, the country needs to cultivate specialised expertise and advanced technology to reduce its dependence on imported design, testing and validation software. Therefore, India needs to tap into its potential and opportunities to drive its drone industry at a fast pace.

INDIA'S DRONE INDUSTRY AND ITS ATMANIRBHAR POTENTIAL

The Indian drone market is said to be at a nascent stage. However, it has made long strides in the last couple of years and is expected to move ahead at a fast pace in times to come. Even though military needs of standardised high-quality drones to augment India's security apparatus presently drives

the Indian drone industry, diverse use of drones in healthcare, infrastructure monitoring, agriculture and delivery services has also given it an incredible boost. Furthermore, the drone industry has got a huge push from both the demand and supply sides, with the Government of India liberalising the drone rules and starting schemes such as the Production Linked Incentive (PLI) under its 'Atmanirbhar Bharat' vision to promote the manufacturing of drone and its components. The PLI programme has significantly increased production capacity, drawn investments, produced employment and encouraged innovation among start-ups and Micro, Small & Medium Enterprises (MSMEs) in India's drone industry. Compared to 2020, when India's drone market size was just 29 billion rupees, these numbers are forecast to reach 2.5 trillion rupees by 2030 with the defence sector expected to continue its contribution as the largest sector in the Indian drone market.⁴⁰ India also has a significant opportunity to tap into the almost 1.8 lakh crore of total domestic manufacturing by introducing and implementing drone indigenisation initiatives in defence, commercial, homeland and counter-UAV sectors.⁴¹ This potential was displayed in 'Bharat Drone Shakti 2023', a first ever drone exhibition collaboratively hosted by the Indian Air Force and Drone Federation of India (DFI), which showcased the full potential of India's drone industry consisting of various types of military and civil drones, at Air Force Station Hindan in Ghaziabad, Uttar Pradesh, in September 2023.⁴²

The recent report released by FICCI in collaboration with Ernst & Young LLP (EY) titled 'Making India the drone hub of the world' comes up with an action plan that is worth emulating for all the stakeholders. Some of the suggestions given in the report to achieve *atmanirbharta* in drones are as follows: First, encourage demand creation with the Central Government as a market maker and with states and Union Territories introducing necessary policy interventions. Second, boost manufacturing capacity by providing 'collateral-free and Personal Guarantee-free Credit Guarantees' and localisation of components. Third, support anchor investors who commit themselves to drone manufacturing. Fourth, set up an 'inter-ministerial committee on Drones and Counter Drones' to create better synergy and coordination. Lastly, focus on skill and academic development.⁴³

The vision of *Atmanirbharta*, as enunciated by Prime Minister Narendra Modi, envisions making India self-reliant in various sectors such as economy, healthcare, technology, infrastructure and defence, among many others. Drones for defence hold a prominent role in defence *atmanirbharta*, especially at a time when drones have emerged as the lynchpin of the defence sector

because of their effective use in the technologically transforming modern-day warfare, thereby compelling countries around the world to resort to their usage in an unprecedented manner. One of the significant obstacles confronting the Indian drone industry is the lack of adequate components such as batteries, motors, sensors and microelectronics, among others, used in drone manufacturing. This is evident by the fact that the government's decision to put a ban on drones' imports in order to promote indigenisation doesn't extend to the components. The inadequacy can be attributed to various factors such as a restrictive regulatory environment, inadequate investment and incentives, lack of advanced technology and expertise and insufficient R&D focus on related fields. However, many of the sub-components used in drones such as motors, payloads, communication modules, propellers, airframes, etc., are also used in other industries such as automobiles, robotics, electronics, mobile phones, etc. Therefore, as the FICCI report also highlights, 'the latent availability of components within multiple elements of Indian Industry makes it feasible for the concerned industry expertise to be re-oriented towards manufacturing of drones'.⁴⁴ To achieve self-sufficiency in manufacturing the components, India needs enhanced R&D capabilities with specialised research centres that can encourage advances in drone component technologies,⁴⁵ a strong supply chain, skilled labour force that is able to propel the sector forward and congruence between the research of academia and the practical requirements of the industry.

THE NEED FOR DRONE *ATMANIRBHARTA* IN EMPOWERING INDIA'S DEFENCE

Self-reliance or *atmanirbharta* in general is important for any country that seeks to become a global power. This proves to be even more essential during times of geopolitical turbulence, which often disrupts supply chains and puts dependent countries at the mercy of self-reliant donor countries, thereby taking away their strategic leverage emanating out of autonomous decision-making capability. Keeping this in mind, India has been making strides in achieving self-reliance in drone manufacturing. The application of UAVs is not only limited to defence but also includes sectors such as agriculture, industry, law enforcement, healthcare, disaster management, mining, logistics and aerial photography and cinematography, among others. The critical sub-components used in drones have commonalities with allied industries such as automobile, robotics, aviation, software, electronics, etc. Therefore, the growth in the drone industry, which has been categorised as the sunrise sector

due to its immense possibility of booming, will also spur the growth of sub-component value chain in a direct or indirect way due to technology spillover caused by the boom in the allied industries.⁴⁶

What makes the *atmanirbharta* in drone technology inevitable is increasing drone intrusions into Indian states bordering Pakistan and around the Line of Control (LOC) area in Kashmir. The capacity of drones to carry heavy payloads over long distances while flying at high altitudes makes them effective instruments for supplying weapons, explosives, drugs and other lethal items to faraway terrains, particularly across the border.⁴⁷ The drone attack laden with explosives such as TNT at the air force station in Jammu in 2021 was a wake-up call. In November 2023, alluding to the increasing narco-terror nexus being sponsored to India by Pakistan, *The Indian Express* printed that the Border Security Force (BSF) and Punjab Police had reported 593 drone sightings since 2019.⁴⁸ In the year 2023 alone, BSF recovered '494 kg of heroin, 37 weapons and 601 rounds of bullets', which had come from Pakistan with the help of drones. Moreover, Pakistan's indigenous UAV Burraq has proved its effectiveness in neutralising terrorist activities in the past. Besides, Pakistan's Integrated Dynamics, SATUMA and Global Industrial Defence Solutions (GIDS) have been leading from the front in developing UAVs of all shapes and sizes.⁴⁹ It has also been strengthening its drone capability with the help of countries such as China and Turkey, with whom India has not been in best of the terms lately. In 2021, China-made armed drones CH-4, which Pakistan got from China, were seen over the region bordering Pakistan and India. Next year, Pakistan struck a deal with Turkey to purchase Bayraktar TB2 drones, which were delivered to it in April 2022.⁵⁰ These reports indicate that Pakistan has been using drone technology to intensify its proxy war with India, thereby necessitating self-reliance in drones as one of the inevitable strategic objectives for India to keep its borders secure.

Similarly, UAVs also play a crucial role in preserving New Delhi's security interests along the Line of Actual Control (LAC) against its hostile neighbour, especially when Beijing has the greatest number of UAV development programmes in the world and its ties with New Delhi have nosedived post the Galwan crisis and a longstanding border standoff. Beijing has developed almost 45 different types of UAVs with special emphasis on integrating the latest technology such as AI and Brain-Computer Interface Mechanism (BCIM) into the drone system to make them more advanced, thereby positioning it as the global leader in exporting combat drones.⁵¹ GAIC Xianglong and Ziyang Range, two important UAVs possessed by China, were spotted near

Doklam during the 2017 crisis and along the Sino-Indian border in 2020 respectively.⁵² Chinese People's Liberation Army's (PLA) accelerating use of UAVs across the Sino-Indian border since the 2017 Doklam crisis is now an established reality.⁵³ In 2021, a Chinese legislator called for the increased and enhanced use of UAVs, describing them as essential tools that can 'see what troops can't see, hear what troops can't hear, and go where troops can't go'. China's commitment to bolster its drone capability is evident in the pledge by Chinese President Xi Jinping to 'speed up the development of unmanned, intelligent combat capabilities' while recognising drones as tools with the potential to profoundly change war scenarios.⁵⁴ The most widely used UAV by China is the GJ-2 reconnaissance/strike model and many drones of this model, among others, have been shared with Pakistan, making China a major exporter of drones to Pakistan. India has been making good strides in strengthening its counter-drone systems, as discussed in an earlier section, however, it remains susceptible to bearing the brunt of having asymmetric drone capability with respect to China.⁵⁵ In the worst possible scenario of a two-front war, the lack of a strong and self-reliant drone programme could jeopardise India's interest by exposing critical infrastructure, including gas pipelines and power distribution plants, at risk of attack.⁵⁶

At a time when Indo-Pacific has come to emerge as new 'power theatre' among the major powers, experts argue that the recent US\$ 4 billion agreement between the United States and India, which entails India acquiring 31 MQ-9B High Altitude Long Endurance (HALE) UAVs, is a calculated strategic move by New Delhi to strengthen the capabilities of the Indian Armed Forces. The purpose of this acquisition is to improve India's strategic posture, especially in light of Beijing's challenges, by enhancing its capacity and withstanding the threats in the Indo-Pacific region.⁵⁷ Precision-guided weapons, such as Hellfire missiles and GBU-12 Paveway II bombs, are fitted on MQ-9B drones, which make them useful for locating and eliminating enemy locations during combat operations.⁵⁸ Even though the MQ-B drone has its own vulnerabilities and limitations, it is an important addition in New Delhi's security arsenal, providing a strong base for India to be able to further strengthen its drone capabilities to counter diverse security challenges. With each country trying to grow its footprints in the region, UAVs have also become a pivotal tool in every country's military arsenal to leverage strategic and competitive edge over others. Countries such as the US, Japan, Australia, India and China have already deployed their drones to secure and expand their maritime activities in the Indo-Pacific region.⁵⁹ Considering that drones prove to be very effective in gathering intelligence and keeping an

eye on suspicious activities in oceans, their role in safeguarding maritime interest is extremely important. Therefore, Beijing's expanding footprint and dominance in the Indo-Pacific that is aided by its superior drone capability rings alarm bells for India.

Another serious concern regarding reliance on other countries for drones and their related components is the risk of increasing security vulnerabilities in the wake of increasing instances of cyberattacks. To assuage such fears, according to four defence and industry officials and documents reviewed by Reuters, India has prohibited domestic manufacturing units from using parts built in China for making military drones.⁶⁰ So that any security concern emanating out of compromising critical military and intelligence-related data by using made-in-China drones or their components can be nipped in the bud. In a similar move, American Security Drone Act (ASDA) 2023 prohibits the purchase of covered UAVs from select foreign entities, particularly those based in China.⁶¹ These developments are a testament to India's growing reliance on UAVs as integral warfare tools to enhance its maritime security and therefore intensifying its need to become 'atmanirbhar' in drone technology.

MEASURES TAKEN BY NEW DELHI TO PROMOTE DRONE MANUFACTURING

New Delhi has taken several measures to increase India's self-reliance in manufacturing drones. Under the umbrella of the 'Atmanirbhar Bharat' policy, the government came up with the Production Linked Incentive (PLI) scheme in September 2021 to provide a boost to the drone manufacturing growth rate in the country. Under the scheme, 'an incentive of Rs. 120 crores have been provided for Indian manufacturers of drone and drone components on the basis of their value addition'. The scheme's coverage includes the developers of drone-related software. Out of the total 23 beneficiaries identified under the scheme in July 2022, 12 were manufacturers of drones and 11 were manufacturers of their components.⁶² The early success of this scheme is evident in the fact that there is a growing demand to increase the PLI outlay so that more companies can get involved in drone manufacturing. However, some of the limitations *vis-à-vis* the PLI scheme that need to be addressed include the limited outlay of 120 crores for three years, strict eligibility criteria to qualify for the scheme (for drone manufacturers, the turnover must be at least Rs 2 crore for MSMEs and Rs 4 crore for non-MSMEs) and a complex application process, among others.⁶³

There is significant support for start-ups to help them work towards manufacturing drones and their components. Indian start-ups have been leading this task of developing world-class drone capability indigenously. As India aspires to rise as a leader in global drone manufacturing by 2030, this is not possible without creating an enabling environment for budding entrepreneurs. In this respect, India's drone industry presents good promises. In FY 2022–23, drone start-ups in India registered 3x growth in investments over three years and fetched US\$ 49.7 million in investments.^{64,65} At present, more than 500 drone start-ups are driving the drone industry in India. Through its initiatives, the Ministry of Defence (MoD) presently supports India's military drone ecosystem. The iDEX project, for instance, offers funding to assist start-ups in the creation of military-grade goods, such as drones.⁶⁶ The Technology Development Fund has also benefitted drone start-ups. This programme provides funding in a similar manner as iDEX in order to modernise armaments and create cutting-edge technology for use in defence.⁶⁷

Indian drone start-ups have been making significant strides in bolstering the drone capability of the armed forces. Gardua Aerospace, a leading Chennai-based drone start-up company with over 40 per cent localisation in drone manufacturing and aiming to increase it to 75 per cent, has developed the Vajra Stealth UAV to help protect Indian soldiers at the LOC and LAC and enhance the capability of the Indian Armed Forces in carrying out surgical strikes, surveillance and border patrolling.⁶⁸ The company also aims to build drones for the armed forces in collaboration with global giants. For instance, the company has inked a Memorandum of Understanding (MoU) with Thales, a well-known French defence and aerospace corporation. The main objective of this collaboration is to make use of Thales' proficiency in Unmanned Traffic Management (UTM) systems and UAV detection technologies. Garuda Aerospace, in turn, will provide its production experience in advanced UAV manufacturing.⁶⁹ It has also launched its flagship border patrol and surveillance drone called 'Trishul'. With cutting-edge technologies such as high-resolution cameras, night vision and AI capabilities for real-time data processing, this drone is specifically made for monitoring India's borders. Even though Garuda Aerospace imports a few crucial components (such as cameras, sensors and AI modules), the design, assembly and customisation of the drone to satisfy the unique requirements of the Indian Armed Forces are completed in India.

Foreign companies such as General Atomics Aeronautical Systems (USA), Boeing (USA), Israel Aerospace Industries (IAI) and Elbit Systems

(Israel) have supplied military drones to India. To incentivise the domestic manufacturing of drones, New Delhi released the 'Drone Import Policy' in 2022, announcing a ban on drone imports with the exceptions of drone components and drone imports for security, defence and R&D purposes.⁷⁰ This ban is aimed at promoting the indigenous manufacturing of drones; at the same time, it will ensure that the transition to becoming completely self-reliant in drone manufacturing doesn't come at the expense of ongoing research work related to defence and security. Consequently, the ban has compelled Indian manufacturers to augment their production capacities while promoting innovation and attracting significant investments. Companies such as Ideaforge Technology and Dhaksha Unmanned Systems have emerged as major participants in the market.⁷¹ This expansion has also been aided by government initiatives such as the creation of drone training institutes and the 'Drone Shakti' mission, which supports drone businesses.

The government has also launched the Digital Sky Platform to make the process related to registration, licensing and approval of drone activities completely online and application-based, thereby making the authorisation process simpler and seamless. Moreover, the New Drone Rules released by the Ministry of Civil Aviation in 2021 are way more liberal than before. These rules declare:

Nearly 90 percent of Indian airspace as green zone for drones flying up to 400 feet and also abolished the requirement of remote pilot licence for nano and micro drones (up to 2 KG) for non-commercial use by education, research and development entities, Start-ups recognised by the Department for Promotion of Industry and Internal Trade and authorised testing entities.⁷²

There is also a significant push for training youths in AI and drone technology under the Pradhan Mantri Kausal Vikas Yojana 4.0. The Industrial Training Institutes (ITIs) in many states are providing training to youths in these emerging technologies. The Ministry of Skill Development and Entrepreneurship has 'developed six short-term skilling courses for manufacturing, assembly, repairing and maintenance of drones as well as to meet the requirement of skilled manpower in the drone sector'.⁷³ IIT Guwahati has opened India's largest 'Remote Pilot Training Organisation (RPTO)' on its premises in collaboration with EduRade, a brand owned by RC HobbyTech Solutions Pvt. Ltd. With a combination of technical expertise

and practical drone operation experience, these RPTOs promote innovation by providing operators with a deeper understanding of the capabilities and constraints of existing technologies. This knowledge base and hands-on experience, bolstered by partnerships between the industry and academia, inspire innovation and promote ongoing technological development and the creation of more advanced, safer drone systems. A major push is also being given to encourage more research and innovation in technologies related to the manufacture of drones and their components. In order to support the research, development and manufacture of drones and other technologies, the Army Design Bureau (ADB), the Indian Army's nodal agency for facilitating R&D efforts with the industry, academia, DRDO and Defence Public Sector Undertakings (DPSUs), has signed an MoU with DFI.⁷⁴ Some of the major provisions of this MoU include, 'provision of testing sites to enable the designing, prototyping, testing and manufacturing of drones and associated components' and 'enabling outreach for Field Trials in collaboration with industry and user groups of the Armed Forces', among others.⁷⁵ Since the signing of the MoU between ADB and DFI, Indian drone manufacturing firms such as IdeaForge and Garuda Aerospace have utilised the army's testing facilities for trials. The drones are being manufactured keeping in mind the specific operational requirements of the Indian Army. Any technological breakthrough post the signing of the MoU is hard to ascertain, which indicates that the progress is at the developmental stage. Even though MoD does provide the facilities for field trials, the MoU intends to create specifically designated zones for drone trials to expedite the process of testing and feedback. This industry-academia-defence collaboration fosters a structured environment to create a bridge and synergy between technology developers and end-users (soldiers), which ultimately accelerates the prototyping cycles using input from real military use cases.⁷⁶ DFI's collaboration with the Indian Army provides the manufacturers, operators and researchers working in the industry with the expertise of the Indian Army, thereby helping them to customise the drones specifically for the army's needs. Furthermore, joint programmes such as the 'Him Drone-a-thon' aims to 'provide focused opportunities to the Indian drone ecosystem to develop path-breaking drone capabilities for meeting requirements of frontline troops' to promote *atmanirbharta* in defence manufacturing.⁷⁷

In response to an unstarred question posed in Rajya Sabha asking for the details of the work being done by the government towards making India a drone manufacturing hub, some key points of the answer given by

Dr Jitendra Singh, Minister of State (Independent Charge) for the Ministry of Science and Technology, are as follows:

To support innovators and entrepreneurs in fostering new innovations in various technological domains, including drone technology, DST has set up NIDHI-PRAYAS (Promoting and Accelerating Young and Aspiring Innovators and Startups) centres, Technology Business Incubators, and NIDHI Seed Fund, through which financial assistance has been provided to innovators and entrepreneurs for Proof of Concept (PoC) and to convert their ideas into prototypes and products.⁷⁸

He further added:

The Department of Science & Technology (DST), under the National Mission on Interdisciplinary Cyber Physical Systems (NM-ICPS), has established 25 Technology Innovation Hubs (TiHs) in institutes of national importance across the country in advanced technology verticals. These TiHs focus on sectors like Deep Tech, Artificial Intelligence, Machine Learning, Robotics, Cyber Security, Data Science, and other related areas...DST's Innovation Hub on 'Autonomous Navigation and Data Acquisition System', established at IIT Hyderabad, has been successful in utilizing autonomous Unmanned Aerial Vehicles (UAVs) for defence and space applications.⁷⁹

Under government efforts such as NIDHI-PRAYAS and NM-ICPS, there has been considerable progress in drone-related research activities. The Technology Innovation Hub on Autonomous Navigation (TiHAN) at IIT Hyderabad has created autonomous navigation systems for drones used in military reconnaissance as part of the NM-ICPS programme. In order to tackle the threats posed by adversary UAVs, IIT Kanpur has developed anti-drone technology that is able to identify and destroy rogue drones. Paramilitary groups and the Indian Army have tested this technology.⁸⁰ While the creation of weapons may fall outside the immediate scope of the innovation hubs and the MoUs signed, the resulting technologies—such as AI, secure communication and autonomous navigation—are essential for military use in the future.

If all such measures taken by the government, industry, academia, armed forces and all the stakeholders are integrated and synergised in their pursuit of strengthening drone technology and its ecosystem, it will turn out to be

pathbreaking for India's vision of attaining 'atmanirbharta' in defence, with the drone sector emerging as its strongest pillar.

While India's vision of becoming a global hub of the drone industry by 2030 is promising, it is certainly not without hurdles and challenges. For the critical components used in drone manufacturing, such as engines and batteries, India is still largely dependent on imports. Lithium Ion-based batteries are being produced by DRDO in association with a private player, however, this activity is still at an infant stage and the cells are still being imported.⁸¹ Moreover, what makes this process more cumbersome are the complexities associated with getting approvals from foreign countries.⁸² While the incentives provided to large drone manufacturing companies by the government are commendable and are likely to yield results, the component manufacturing Small and Medium Enterprises (SMEs) also require equal if not more support to grow.⁸³ SMEs lack a robust manufacturing ecosystem, long-term investments and incentives and adequate critical technology access that are essential for developing components. Experts also point out the need for heavy investment, adequate technology, localised manufacturing and collaboration among the various stakeholders to build what Ajay Bhatt, Minister of State for Defence, describes as 'an ecosystem for indigenisation of defence drones'.⁸⁴ Another concern is related to the less than desired expenditure on harnessing R&D in defence. The Standing Committee on Defence's report that was tabled in Parliament in December 2023 had pointed out the concerns regarding DRDO's declining expenditure as a share of the total defence expenditure in the last decade.⁸⁵ The panel further pointed out that while the current percentage of funding could be sufficient to become *atmanirbhar*, it is not enough to become a global leader. This points to the urgent need for India to develop its own technology and reduce its dependence on importing equipment or products or purchasing licences to build them.

CONCLUSION

In the present era full of technological advancements witnessed like never before, UAVs or drones have emerged as the lynchpin of the defence sector undergoing modernisation around the world. Therefore, it would not be an exaggeration to say that the capability and trajectory of India's drone programme and the related technologies vital for its manufacturing would determine the contours of India's roadmap to becoming an 'atmanirbhar' country in the defence sector. India has the potential to materialise its vision

of becoming a global drone manufacturing hub by 2030, but it is not without challenges and would remain impossible without proper emphasis on its defence segment. Together with the development in drones for commercial sector, this will gradually reduce our dependence on foreign countries.

Considering the unholy nexus between India's two hostile neighbours, it no longer remains a matter of choice but becomes a matter of conviction for India to bolster its drone capability and become 'atmanirbhar'. Therefore, it is imperative that India utilises its pool of talent in innovation and technology and addresses the issues related to coordination, regulation, funding and other related concerns to bring synergy among the industry, academia and government for realising the objective of self-sufficiency in designing and manufacturing world-class drones, which could propel India's defence sector to new heights, thereby helping it become 'atmanirbhar' to face any adversity in future.

NOTES

1. Cdr Gautam Nanda, 'UAV-based Remote Sensing in Defence', KPMG, November 2022, available at <https://kpmg.com/in/en/home/insights/2022/11/uav-based-remote-sensing-in-defence.html#:~:text=Drones%20or%20unmanned%20aerial%20vehicles,drones%20weighing%20almost%20a%20ton>, accessed on 25 February 2024.
2. Dan Gettinger, *The Drone Databook*, The Centre for the Study of the Drone at Bard College, October 2019, available at <https://dronecenter.bard.edu/files/2019/10/CSD-Drone-Databook-Web.pdf>, accessed on 25 February 2024.
3. 'The Drone Rules, 2021 Realising Our Collective Vision of an Aatmanirbhar Bharat', Press Information Bureau, Ministry of Information and Broadcasting, Government of India, 28 January 2028, available at <https://static.pib.gov.in/WriteReadData/specificdocs/documents/2022/jan/doc202212810701.pdf>, accessed on 25 February 2024.
4. Priti Gupta, 'India Gambles on Building a Leading Drone Industry', *BBC*, 4 November 2022, available at <https://www.bbc.com/news/business-62966802>, accessed on 27 February 2024.
5. 'Top 10 Globally Renowned Companies in the Military Drones Industry', Emergen Research, 21 April 2023, available at <https://www.emergenresearch.com/blog/top-10-globally-renowned-companies-in-the-military-drones-industry>, accessed on 28 February 2024.
6. 'A Brief History of Drones', Imperial War Museums, available at <https://www.iwm.org.uk/history/a-brief-history-of-drones>, accessed on 27 February 2024.
7. Ibid.

8. Krutika Patil, 'Drone Warfare: History, Evolution and Future', *Journal of Defence Studies*, Vol. 16, No. 4, October–December 2022, pp. 243–51.
9. Jim Garamone, 'U.S. Drone Strike Kills al-Qaida Leader in Kabul', U.S Department of Defense, 2 August 2022, available at <https://www.defense.gov/News/News-Stories/Article/Article/3114362/us-drone-strike-kills-al-qaida-leader-in-kabul/>, accessed on 1 March 2024.
10. Air Marshal Anil Chopra, 'Lessons from Ukraine: Time for India to Crystallise Military Drone Strategy', *Firstpost*, 29 February 2024, available at <https://www.firstpost.com/opinion/lessons-from-ukraine-time-for-india-to-crystallise-military-drone-strategy-13743470.html>, accessed on 1 March 2024.
11. Dionne Searcey, 'Boko Haram Is Back. With Better Drones', *The New York Times*, 13 September 2023, available at <https://www.nytimes.com/2019/09/13/world/africa/nigeria-boko-haram.html>, accessed on 1 March 2024.
12. 'Drone Proliferation Is On the Rise and So Is the Need for International Regulation', *PaxforPeace*, 30 November, 2023 available at <https://paxforpeace.nl/news/drone-proliferation-is-on-the-rise-and-so-is-the-need-for-international-regulation/>, accessed on 2 March 2024.
13. Mahashreveta Choudhary, 'Top Five Counter-Drone Technologies', *Geospatial World*, 7 December 2019, available at <https://www.geospatialworld.net/blogs/top-five-counter-drone-technologies/>, accessed on 2 March 2024.
14. 'Top 10 Globally Renowned Companies in the Military Drones Industry', no. 6.
15. 'Who Has Armed Drones?', *Drone Wars UK*, February 2024, available at <https://dronewars.net/who-has-armed-drones/#TableB>, accessed on 4 March 2024.
16. Anubha Gupta, 'Game of Drones: Understanding Their Increasing Use', *Indian Council of World Affairs*, 27 March 2024, available at https://www.icwa.in/show_content.php?lang=1&level=1&ls_id=10703&lid=6806, accessed on 5 March 2024.
17. 'Global Drone Market Report 2023-2030', *Drone Industry Insights*, July 2023, available at <https://droneii.com/product/drone-market-report>, accessed on 5 March 2024.
18. Sara Goudarzi, 'Threat in the Sky: How Cheap Drones are Changing Warfare', *Bulletin of the Atomic Scientists*, 6 November 2023, available at <https://thebulletin.org/2023/11/threat-in-the-sky-how-cheap-drones-are-changing-warfare/>, accessed on 5 March 2024.
19. Dhanendra Kumar, 'India's Quest for Aatmanirbharta in Drones', *Hindustan Times*, 25 January 2024, available at <https://www.hindustantimes.com/opinion/indias-quest-for-aatmanirbharta-in-drones-101706184358644.html>, accessed on 10 March 2024.
20. Rajat Pandit, 'India Shelves Biggest Project to Develop Advanced UAV', *The Times of India*, 15 January 2024, available at <https://timesofindia.indiatimes.com/india/tapas-failed-to-meet-altitude-requirements/articleshow/106844470.cms>, accessed on 10 March 2024.

21. 'IAF to Acquire 6 Tapas Drones, Lead Acquisition for Made-in-India UAVs', *Business Standard*, 24 June 2024, available at https://www.business-standard.com/external-affairs-defence-security/news/iaf-to-acquire-6-tapas-drones-lead-acquisition-for-made-in-india-uavs-124062300431_1.html, accessed on 22 August 2024.
22. Pintu Kumar Mahla, 'Military Drones in India New Frontier of Warfare', *Journal of Defence Studies*, Vol. 16, No. 4, October–December 2022, pp. 253–261.
23. Ibid.
24. Chaitanya Mallapur, 'Eyes in the Sky: Exploring India's Evolving Drone Ecosystem', *Moneycontrol*, 22 July 2021, available at <https://www.moneycontrol.com/news/business/eyes-in-the-sky-exploring-indias-evolving-drone-ecosystem-7160921.html>, accessed on 10 March 2024.
25. Liu Zhen, 'China-India Border Dispute: Drones Prove Their Worth at High Altitude', *South China Morning Post*, 20 July 2020, available at https://www.scmp.com/news/china/diplomacy/article/3093806/china-india-border-dispute-drones-prove-their-worth-high?campaign=3093806&module=perpetual_scroll_0&pgtype=article, accessed on 13 March 2024.
26. Manraj Grewal Sharma, 'From UAVs to Refuellers: How Israel is Helping India Keep an Eye on LAC', *The Indian Express*, 18 November 2024, available at <https://indianexpress.com/article/india/from-uavs-to-refuellers-how-israel-is-helping-india-keep-an-eye-on-lac-8272676/>, accessed on 15 March 2024.
27. Snehash Alex Philip, 'Army Gets Its First Set of Offensive Swarm Drone System, IAF Next', *The Print*, 13 February 2023, available at <https://theprint.in/defence/army-gets-its-first-set-of-offensive-swarm-drone-system-iaf-next/1368508/>, accessed on 15 March 2024.
28. 'Navy Displays Dronaam Counter-Drone System at Swavalamban 2023 Exhibition', *Business Standard*, 4 October 2023, available at https://www.business-standard.com/india-news/navy-displays-dronaam-counter-drone-system-at-swavalamban-2023-exhibition-123100400734_1.html, accessed on 15 March 2024.
29. 'Expression of Interest (EoI) for Counter Drone System', DRDO, available at <https://www.drdo.gov.in/drdo/sites/default/files/inline-files/EOI-CDS.pdf>, accessed on 20 March 2024.
30. Ibid.
31. 'DRDO'S D4 Counter Drone System', *Indian Defence News*, 16 January 2024, available at [https://www.indiandefensenews.in/2024/01/drdo-s-d4-counter-drone-system.html#:~:text=D4%20system%20can%20detect%2C%20track,destroy%20them%20\(hard%20kill\)](https://www.indiandefensenews.in/2024/01/drdo-s-d4-counter-drone-system.html#:~:text=D4%20system%20can%20detect%2C%20track,destroy%20them%20(hard%20kill)), accessed on 20 March 2024.
32. Dinakar Peri, 'DRDO Anti-Drone Tech Ready, Handed Over to BEL, Private Firms', *The Hindu*, 8 January 2024, available at <https://www.thehindu.com/news/national/drdo-anti-drone-tech-ready-handed-over-to-bel-private-firms/article67716451.ece>, accessed on 21 March 2024.

33. Aryan Raj, 'DRDO & BEL's D4 Anti Drone System: Guardian of Indian Skies (Features & Impact)', Defence Alert, 22 January 2024, available at <https://defencealert.in/drdo-d4-anti-drone-system/>, accessed on 21 March 2024.
34. 'Army Deploys Advanced Anti-Drone Defense Systems Along China Border', *The Economic Times*, 21 March 2024, available at <https://economictimes.indiatimes.com/news/defence/army-deploys-advanced-anti-drone-defense-systems-along-china-border/articleshow/108664579.cms?from=mdr>, accessed on 3 July 2024.
35. 'World's Only Counter-Drone Tech, Indrajaal, Unveiled in City', *Deccan Chronicle*, 3 September 2023, available at <https://www.deccanchronicle.com/technology/in-other-news/020923/worlds-only-counter-drone-tech-indrajaal-unveiled-in-city.html>, accessed on 23 March 2024.
36. 'IIT Jammu Develops "First Of Its Kind" Anti-Drone System', *NDTV*, 14 February 2024, available at <https://www.ndtv.com/india-news/iit-jammu-professor-develops-first-of-its-kind-anti-drone-system-5058576>, accessed on 23 March 2024.
37. 'Indigenous Anti-Drone Systems Enhance Indian Army's Defence', *Financial Express*, 10 June 2024, available at <https://www.financialexpress.com/business/defence-indigenous-anti-drone-systems-enhance-indian-armys-defence-3519748/>, accessed on 03 July 2024.
38. 'MoD Buys Indigenous Anti-Drone Tech Worth Rs 200 cr from Big Bang Boom', *Business Standard*, 11 March 2024, available at https://www.business-standard.com/external-affairs-defence-security/news/mod-buys-rs-200-cr-of-indigenous-anti-drone-tech-from-big-bang-boom-124031101203_1.html, accessed on 3 July 2024.
39. Mughilan Thiru Ramasamy, 'India As a Global Drone Hub: Wishful Thinking Or Realistic Scenario?', *Business Today*, 11 January 2022, available at <https://www.bnesstoday.in/opinion/columns/story/india-as-a-global-drone-hub-wishful-thinking-or-realistic-scenario-318690-2022-01-11>, accessed on 25 March 2024.
40. Shangliao Sun, 'Market Size of Drone in India 2020-2030', Statista, 26 October 2023, available at <https://www.statista.com/statistics/1365217/india-market-size-of-drone/#statisticContainer>, accessed on 5 March 2024.
41. 'Drone Industry Report', ideaForge, 9 June 2023, available at <https://ideaforgetech.com/uploads/Other/DroneIndustryReport.pdf>, accessed on 5 March 2024.
42. 'Elevating Indian Drones: "Bharat Drone Shakti 2023" Takes Flight', *Financial Express*, 6 September 2023, available at <https://www.financialexpress.com/business/defence-elevating-indian-drones-bharat-drone-shakti-2023-takes-flight-3235089/>, accessed on 6 April 2024.
43. 'Making India the Drone Hub of the World', EY FICCI, August 2022, available at https://assets.ey.com/content/dam/ey-sites/ey-com/en_in/news/2022/09/ey-ficci-drones-report.pdf, accessed on 5 March 2024.
44. Ibid.
45. Abhinav Dutta, 'India's Defence Modernisation: Challenges and Prospects', *Indian Defence Review*, 7 July 2016, available at <https://www.indiandefencereview.com/>

- news/indias-defence-modernisation-challenges-and-prospects/, accessed on 3 July 2024.
46. 'Making India the Drone Hub of the World', no. 43.
 47. Gabriel Honrada, 'India Driving a Drone Race with China in the Himalayas', *Asia Times*, 19 December 2023, available at <https://asiatimes.com/2023/12/india-driving-a-drone-race-with-china-in-the-himalayas/>, accessed on 27 March 2024.
 48. Mahender Singh Manral, 'Narco-Terror Nexus: 593 Drone Sightings by BSF Since 2019 at India-Pak Border in Punjab', *The Indian Express*, 11 November 2023, available at <https://indianexpress.com/article/india/narco-terror-nexus-593-drone-bsf-india-pak-border-9023206/>, accessed on 28 March 2024.
 49. Akshat Upadhyay, 'Counter UAS Technologies for India: A Prognosis', *Journal of Defence Studies*, Vol. 16, No. 4, October–December 2022, pp. 181–202.
 50. 'Who has Armed Drones?', no. 15.
 51. Akshat Upadhyay, 'Counter UAS Technologies for India: A Prognosis', no. 49.
 52. Ibid.
 53. Antoine Bondaz, Simon Berthault, 'China's Use of Drones in the Sino-Indian Border Dispute: A Concrete Example of Civil-Military Integration', Foundation For Strategic Research, July 2023, available at <https://www.frstrategie.org/sites/default/files/documents/publications/recherches-et-documents/2023/112023.pdf>, accessed on 31 March 2024.
 54. Zaheena Rasheed, 'How China Became the World's Leading Exporter of Combat Drones', *Aljazeera*, 24 January 2023, available at <https://www.aljazeera.com/news/2023/1/24/how-china-became-the-worlds-leading-exporter-of-combat-drones>, accessed on 31 March 2024.
 55. Harshini Nag, 'Drone Warfare Capacity Building in Securing India's National Interests', Vivekanand International Foundation, May 2023, available at <https://www.vifindia.org/sites/default/files/drone-warfare-capacity-building-in-securing-india-s-national-interests.pdf>, accessed on 2 April 2024.
 56. Ibid.
 57. 'MQ-9B Drones Will Provide India with Enhanced Maritime Security, Domain Awareness Capability: U.S.', *The Hindu*, available at <https://www.thehindu.com/news/international/mq-9b-drones-will-provide-india-with-enhanced-maritime-security-domain-awareness-capability-us/article67816677.ece>, accessed on 2 April 2024.
 58. Shishir Gupta, '10 Facts About India's MQ9B Predator Drones Deal', *Hindustan Times*, 29 June 2023, available at <https://www.hindustantimes.com/india-news/india-mq9b-predator-drone-deal-defence-ministry-united-states-china-101688039452428.html>, accessed on 4 July 2024.
 59. Commander A. P. Amila Prasanga, 'The Strategic Impact of Military Drone Proliferation on Indo-Pacific Maritime Security', Centre for International Maritime Security, 7 November 2023, available at <https://cimsec.org/the-strategic-impact-of-military-drone-proliferation-on-indo-pacific-maritime-security/>, accessed on 2 April 2024.

60. 'India Bars Makers of Military Drones from Using Chinese Parts', *The Hindu*, 8 August 2023, available at <https://www.thehindu.com/sci-tech/technology/india-bars-makers-military-drones-using-chinese-parts/article67170885.ece>, accessed on 4 April 2024.
61. 'American Security Drone Act of 2023', Congress, 118th Congress, available at <https://www.congress.gov/bill/118th-congress/senate-bill/473/text>, accessed on 3 July 2024.
62. 'A Series of Reform Measures Undertaken to Promote India's Upcoming Drone Industry', Press Information Bureau, Ministry of Civil Aviation, Government of India, 8 December 2022, available at <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1881767>, accessed on 4 April 2024.
63. 'Production Linked Incentive (PLI) Scheme for Drones and Drone Components', India Findings, available at <https://www.indiafilings.com/learn/production-linked-incentive-pli-scheme-for-drones-and-drone-components/>, accessed on 3 July 2024.
64. Manish Pant, 'Indian Drone Industry Flies High with 3x Growth in Investments over 3-years', *Business Today*, 24 March 2023, available at <https://www.businesstoday.in/latest/corporate/story/indian-drone-industry-flies-high-with-3x-growth-in-investments-over-3-years-374728-2023-03-24>, accessed on 8 April 2024.
65. Bhaswar Kumar, 'Everything You Need to Know About the Drone-As-A-Service Model', *Business Standard*, 30 March 2022, available at https://www.business-standard.com/podcast/technology/everything-you-need-to-know-about-the-drone-as-a-service-model-122033000072_1.html, accessed on 8 April 2024.
66. Rahul Bhatia, 'Can India's Military Drone Ecosystem Fulfill its Potential?', Carnegie Endowment for International Peace, 8 May 2023, available at <https://carnegieendowment.org/posts/2023/05/can-indias-military-drone-ecosystem-fulfill-its-potential?lang=en>, accessed on 3 July 2024.
67. Ibid.
68. Agnishwar Jayaprakash, 'Garuda Aerospace: Boosting Defence with Desi Drones', *Raksha Anirveda*, 14 August 2023, available at <https://raksha-anirveda.com/garuda-aerospace-boosting-defence-with-desi-drones/>, accessed on 22 September 2024.
69. 'Thales, Garuda Aerospace Sign MoU for Secure Drone Operations in India', *DTNEXT*, 30 July 2024, available at <https://www.dtnext.in/news/business/thales-garuda-aerospace-sign-mou-for-secure-drone-operations-in-india-797390>, accessed on 22 August 2024.
70. Karunjit Singh, 'Explained: Centre's New Rules for Import of Drones', *The Indian Express*, 10 February 2022, available at <https://indianexpress.com/article/explained/drone-import-rules-india-explained-7765761/>, accessed on 6 April 2024.
71. 'India's Upcoming Drone Manufacturing Sector', India Brand Equity Foundation, 5 August 2022, available at <https://www.ibef.org/blogs/india-s-upcoming-drone-manufacturing-sector>, accessed on 3 July 2024.

72. Ankit Agrawal, 'Vast Opportunities in India's Commercial Drones Market', *Invest India*, 16 August 2023, available at <https://www.investindia.gov.in/team-india-blogs/vast-opportunities-indias-commercial-drones-market>, accessed on 4 April 2024.
73. 'Govt Working on Short-Term Courses for Drone Development, Pilot Certificates', *Livemint*, 8 Aug 2022, available at <https://www.livemint.com/news/india/govt-working-on-short-term-courses-for-drone-development-pilot-certificates-details-here-11659960830384.html>, accessed on 6 April 2024.
74. 'Indian Army Signs a MoU with Drone Federation of India', Press Information Bureau, Ministry of Defence, Government of India, 8 August 2022, available at <https://pib.gov.in/PressReleasePage.aspx?PRID=1849959>, accessed on 8 April 2024.
75. *Ibid.*
76. *Ibid.*
77. 'Indian Army Launches "Him- Drone-a-Thon"', Press Information Bureau, Ministry of Defence, Government of India, 8 August 2022, available at <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1849961>, accessed on 23 September 2024.
78. 'Making India a Drone Manufacturing Hub', available at <https://sansad.in/getFile/annex/262/AU2202.pdf?source=pqars>, accessed on 6 April 2024.
79. *Ibid.*
80. Vikki Davies, 'IIT-K Finds Cyber Security Solutions for Anti-Drone Tech', *Cyber Magazine*, available at <https://cybermagazine.com/cyber-security/iit-k-finds-cyber-security-solutions-anti-drone-tech>, accessed on 23 September 2024.
81. Dinakar Peri, 'DRDO Anti-Drone Tech Ready, Handed Over to BEL, Private Firms', no. 32.
82. Nishant Kumar Verma and Shiril Saju, '5 Hurdles India Needs to Overcome to Become a Global Drone Hub by 2030', *Forbes India*, 18 April 2022, available at <https://www.forbesindia.com/article/iim-bangalore/5-hurdles-india-needs-to-overcome-to-become-a-global-drone-hub-by-2030/75437/1>, accessed on 8 April 2024.
83. *Ibid.*
84. Lavpreet Kaur, 'Challenges Aplenty in India's Defence-Drone Space', *Deccan Herald*, 16 February 2023, available at <https://www.deccanherald.com/business/challenges-aplenty-in-india-s-defence-drone-space-1191603.html>, accessed on 8 April 2024.
85. Rahul Singh, 'India Must Raise Defence R&D Spending to Become Global Leader: House Panel', *Hindustan Times*, 21 December 2023, available at <https://www.hindustantimes.com/india-news/india-must-raise-defence-r-d-spending-to-become-global-leader-house-panel-101703144713429.html>, accessed on 8 April 2024.