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**Innovation Management in
Autonomous Drone Systems:
India's Push for Sustainable
Indigenisation**

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Abstract

This article explores India's evolving strategies in innovation management in its quest to achieve sustainable indigenisation in autonomous drone systems, thereby positioning the country as a key global player in defence technology. In the modern warfare, autonomous drones have become indispensable for surveillance, reconnaissance, and precision strikes, thus making their domestic development a strategic imperative for India's self-reliance. As in early 2026, this study highlights how India's defence sector is undergoing a transformative shift. It is being driven by a confluence of government policies, startup ingenuity, and private sector investments. Notably, all underscored by a commitment to sustainability. We analyse the multifaceted innovation management frameworks at work. These include the integration of advanced AI, novel materials such as multispectral stealth composites, and additive manufacturing techniques. Through the recent case studies of indigenous successes in swarm drones, counter-drone systems, and high-altitude platforms, this article establishes how these efforts have translated towards fostering a resilient defence eco-system. Acknowledging persistent challenges, such as subsystem dependency and funding gaps, an endeavour is being made to outline a futuristic roadmap to 2030 and beyond. Finally, this analysis suggests that effective innovation management will secure India's strategic future, moving it from a net importer to a leading innovator of unmanned military systems.

Keywords: Innovation Management, Autonomous Drone Systems, Sustainable Indigenisation, Additive Manufacturing, Human-AI Teaming

The Unmanned Battlefield: India's Strategic Imperative

In the rapidly evolving landscape of modern warfare and defence technology, autonomous drone systems have emerged as game-changers— they offer unmatched capabilities in surveillance, reconnaissance, and precision strike operations. These assets are fundamentally altering military doctrine, intelligence gathering, and force projection, as evidenced by recent conflicts. As India faces an array of security challenges, the indigenisation of these systems is not just a strategic imperative but a cornerstone of achieving sustainable self-reliance and sovereign capability.

Notably, as we progress into 2026, India's defence sector is witnessing a tectonic shift in drone technology. This is primarily being driven by innovative management strategies that are uniquely blending government policies with startup ingenuity. Furthermore, these are increasingly being coupled with private sector investments. These are also in sync with a noteworthy emphasis on sustainability. This article explores the innovation management frameworks propelling autonomous drones in India. It evaluates their role in fostering a self-sustaining eco-system and endeavours to project a futuristic roadmap for 2030 and beyond. This approach ensures that innovation acts as a force multiplier, providing India with a qualitative edge and guaranteeing self-reliance in niche technologies. The clear aim was to move from being an importer to a global drone powerhouse, thus reinforcing our strategic influence in the Indo-Pacific and beyond.

Autonomous drones, often referred to as Unmanned Aerial Vehicles (UAVs) with varying degrees of autonomy, encompass systems capable of independent navigation, decision-making, and mission execution

through AI integration (Lee et al., 2024; Sahithya et al., 2024; Joshi et al., 2024). From loitering munitions that “loiter” over targets before striking to swarm drones operating in coordinated fleets, these technologies are redefining defence paradigms. In India, the push for indigenisation directly addresses the historical reliance on defence imports. These have previously resulted in significant financial outflows and vulnerabilities in supply chains during geopolitical uncertainties (Likhachev, 2024; Mayfield, 2022; Yadav, 2024). The government’s ₹20 billion incentive program which was launched in 2025, exemplifies this commitment. It aims to boost local manufacturing and software development in order to significantly reduce the reliance on foreign components for critical military hardware.

Interestingly, sustainability extends beyond environmental concerns. It encompasses economic viability, technological resilience, and long-term strategic autonomy. Prioritising on eco-friendly designs, such as hybrid propulsion systems and recyclable materials assists in critically reducing the logistical footprints and energy dependence of military operations. This article argues that effective innovation management can propel India towards becoming a world leader in autonomous drone systems by 2030. This however, can only be achieved through collaborative ecosystems, agile policies, and smart investments. It is anticipated as per open-source estimates that the market for these drones is likely to be worth USD 1.39 billion. Drawing on recent developments, case studies, and data from 2025-2026, we will explore the strategies, challenges, and recommendations that are shaping this trajectory.

India’s Evolving Drone Doctrine: Operational Realities and Strategic Alignment

The origins and use of autonomous drone systems in defence can be traced back to the early 1900s. However, their modern incarnation, powered by AI, sensors, and real-time data analytics, gained prominence only in the 21st century. This has been witnessed in conflicts such as Afghanistan, Iraq, and more recently, the Russia-Ukraine conflict. Globally, nations such as the US, China, and Turkey have dominated the drone market by setting key benchmarks. However, India’s journey has been marked by a transition from ‘importer to innovator’. The catalyst to this has been the “Make in India” initiative and subsequent policy reforms that emphasised on domestic industry participation.

India’s defence procurement has historically relied heavily on foreign suppliers, with drones such as the Israeli Heron and US Predator variants. In the early 2010s, dependence on imported components for some leading defence enterprises was notably high (Likhachev, 2024; Denisov et al., 2020; Weiss, 2018). Overall, India faces significant risks from technology denial regimes and supply chain vulnerabilities (Likhachev, 2024; Denisov et al., 2020; Weiss, 2018). The turning point came with policy reforms post-2020— these included the Drone Rules 2021, the Defence Acquisition Procedure 2020, and the Production Linked Incentive (PLI) scheme which liberalised regulations and incentivised domestic production by startups and private firms (Katekar & Cheruku, 2023; Ghoshray, 2023). These actions were specifically designed to accelerate the introduction of indigenous military systems in the country. By 2025, these efforts catalysed a “silent drone revolution”, with indigenous systems reducing import reliance and boosting exports as was witnessed by the sector’s growth from USD 654 million in 2024 to a projected USD 1,581.5 million in the near term (Bilal & Samad, 2024). This is symbolic of a clear shift from “Buy Global” to “Design & Make in India” as the only mantra which could guarantee future success.

In order to drive technological advancements, the innovation management domain draws on the Triple Helix model— it emphasises collaboration between government, industry, and academia. Initiatives such as the National Innovation Challenge for Drone Application and Research (NIDAR) have empowered graduates

and startups to develop collaborative autonomous drones for defence applications. Pertinently, sustainability theories such as the circular economy approach are increasingly advocating for the indigenisation of supply chains. This in effect will lead to minimising waste and enhance recyclability thereby reducing resource dependency for military assets.

Key gaps, specific to defence, includes a limited focus on sustainable practices such as battery indigenisation and counter-drone systems by the private sector. For example, while international research emphasises AI-driven autonomy, studies specific to India highlights the importance of “autonomics”—a field dedicated to aligning ambition with reliable systems in startup-driven initiatives for military purposes (Maathuis & Cools, 2025; Christen et al., 2023; Negyesi, 2024; Abhinav & Pramod, 2025). This approach ensures that autonomy is controlled, resilient and aligned with national sovereignty objectives and operates within ethical and human-controlled parameters (Christen et al. 2023).

The defence UAV market is projected to expand at an industry estimate of 16.9% CAGR by 2030. It is likely to outpace many peers with innovations in swarm technology and urban air mobility synergies (International Journal of Mechanical Engineering and Robotics Research 2025). Although, India currently stands midway with having achieved significant domestic production, it however needs to address the gaps in advanced components when compared to market leaders.

This background sets the stage for examining current strategies which are redefining defence autonomy. These further enhances the operational capabilities of the tri-services. Each service utilises autonomous systems in unique ways—the Army focuses on ground support and monitoring key areas; while the Navy emphasises maritime intelligence, surveillance, reconnaissance, and anti-submarine operations. The Air Force prioritises air dominance and precision attacks.

Optimising the Edge: Innovation Management for Defence Superiority

Innovation management, in the autonomous drone sector, is being driven by a multifaceted approach that integrates policy incentives, startup-driven R&D, and robust public-private-military collaboration to achieve sustainable indigenisation. The Ministry of Defence's (MoD) ₹20 billion multi-year incentive sets an ambitious target for the domestic manufacturing of drones and software. It sets out to achieve 70-80% indigenisation in critical military subsystems, such as advanced sensors, propulsion systems, and AI processing units, by 2028. This program extends the PLI scheme by offering financial rewards for production milestones. It encourages startups to innovate in autonomous navigation and AI integration for decision-making. It is further being expanded for specialised military services such as drone leasing and advanced counter-drone technologies.

Domestic industry, particularly led by agile startups and established private entities are playing a pivotal role. The iDEX scheme, for instance, has funded over 200 startups in unmanned systems. This has fostered an ecosystem wherein prototypes transitions to production within 12-18 months (International Journal of Mechanical Engineering and Robotics Research, 2025). This agile development cycle is crucial for rapidly meeting the urgent operational needs of the armed forces. For example, Garuda Aerospace has not only expanded its DGCA approved pilot training but has also established a drone battery manufacturing facility in Chennai in early 2026. This factory will focus on sustainable energy solutions which will result in the reduction of logistics for military applications.

Public-private-military partnerships are the fulcrum of this strategy aiding accelerated defence innovations. Companies such as Adani Defence have collaborated on vehicle-mounted counter-drone systems, integrating lasers, radars, and jammers for comprehensive threat neutralisation. Another key player, BotLab Dynamics exemplifies startup innovation with swarm technologies. It is noteworthy to have achieved multiple world records in drone shows. It has also accomplished critical advanced defence applications such as coordinated reconnaissance and offensive swarm attacks. These partnerships align with the “Design Champion Model”, which prioritises design leadership over mere assembly. It further results in enabling the rapid redesign of autonomous drones and counter-UAS systems by domestic firms to counter evolving threats.

Particularly, from a military perspective, sustainability is deeply woven into the fabric of these strategies. The efforts have focused on eco-efficient designs, such as hybrid-electric propulsion and modular architectures for easier maintenance and upgrades. This further results in extending the operational lifespan of military assets. It is noteworthy to mention that circular economy principles are gaining prominence among Indian manufacturers. These initiatives emphasise on material reuse and recyclability to reduce resource dependency on foreign suppliers. The MoD’s 2025 steps primarily focusses on indigenising UAV and C-UAS technologies. These steps aim to eliminate reliance on foreign OEMs and promote local Maintenance, Repair, and Overhaul of these sub-systems. These initiatives, led by private sector participation, enhance longevity, reduce waste, and ensure operational readiness. The innovation pipeline is thus structured to sustain defence priorities.

Table 1: Innovation Pipeline Flowchart

<ul style="list-style-type: none"> • Ideation: Policy schemes → Startup Challenges (e.g. NIDAR) • Prototyping: Domestic R&D → AI/Sensor Integration (tailored for military needs) • Testing: Field Trials → Sustainability Assessments (operational readiness & logistical impact) • Production: Incentives → Indigenised Manufacturing (for armed forces & exports) • Deployment: Integration with Armed Forces → Export Readiness (strategic alliances)

Source: Annotated by the Author

This structured approach has yielded tangible results. The defence production hit a record milestone of ₹1.54 lakh crore in 2024-25. Indigenous drones, counter-drone systems, and related unmanned technologies have contributed significantly to the 12% export growth which was recorded at ₹23,622 crore. The domestic industry is gradually building a resilient ecosystem capable of supplying advanced military drone technologies. This has been possible by managing innovation through data-driven metrics such as engagement in tech discourse and project completion rates. Pertinently, cultivating a talent pool of specialised engineers, AI experts and drone pilots is critical for sustaining this technological edge.

Next-Generation Materials and Advanced Manufacturing for Enhanced Performance and Sustainability

Moving beyond advancements in AI and software, India’s journey towards drone supremacy is profoundly being shaped by breakthroughs in materials science and manufacturing techniques. These innovations are not merely incremental. They represent a fundamental shift in the design, construction, and sustainability of drones. This directly impacts their operational effectiveness and long-term viability.

- Multi-Spectral Stealth for Unparalleled Survivability:*** The future battlefield increasingly demands more sophisticated stealth designs and capabilities. Recent developments have highlighted the integration of multi-spectral stealth materials. These include specialised carbon-based materials for radar-infrared-compatible stealth technology (Tan et al., 2025). These advanced composites are engineered to absorb or deflect detection across multiple electromagnetic spectra, including radar and various infrared bands. This results in making drones virtually invisible to a broader range of adversary sensors. Furthermore, research on high-temperature stealth across multi-infrared and microwave bands with efficient radiative thermal management (Zhao et al., 2025) promises to deliver further on this critical capability. This integrated approach ensures comprehensive protection against diverse detection methods. This feature is vital for operating in contested airspace.
- Novel Energy Solutions and Propulsion Systems:*** A key demand of the present battlefield is to operate for extended hours without increasing the logistic footprint. Notable emerging innovations in energy harvesting and propulsion are gaining traction beyond conventional hybrid systems. Key developments include exploring hydrogen fuel cells for clean high-density power. This is further being coupled with piezoelectric harvesting, wind energy utilisation, and laser charging (Singh & Kumar, 2025; Ahmed et al., 2024). This facet will allow drones to replenish energy during missions. The development of flexible and lightweight solar cell materials integrated into the drone airframe also offers a significant leap (Liu et al., 2024). This enables prolonged flight times, thereby extending the operational range of UAVs for critical reconnaissance and surveillance missions. These advancements align perfectly with India's push for sustainable and self-reliant operations.
- Additive Manufacturing for Agile Indigenisation:*** Additive manufacturing, also known as 3D printing, has aided in accelerating the indigenisation process. This technology enables the low-cost and rapid production of complex, lightweight polymer and thermoplastic components for UAVs. This approach has been significant in reducing lead times and dependence on foreign supply chains (Junaid et al., 2024; Tantawi et al., 2024). By embracing enhanced focus on 3D printing, India can quickly prototype, test, and iterate drone designs. This fosters agility in responding to evolving threats and adapting to mission specific requirements of the armed forces. This also supports the development and utilisation of sustainable resources. The ongoing research into natural fibre composites for sustainable drone construction (Shahar & Sultan, 2024) offers environmentally friendly alternatives to traditional materials. These further reinforces circular economy principles within the defence sector. These advancements in materials and manufacturing are not just limited to building superior drones. They also aid in building a resilient, sustainable, and technologically independent defence eco-system. They empower domestic industries to innovate, reduce vulnerabilities, and ensure that India's autonomous drone systems remain at the forefront of military capabilities.

Case Studies from the Frontlines: Indigenous Defence Drone Successes

In order to illustrate the efficacy of innovation management strategies, we will now examine three recent pivotal case studies. Each of these case studies highlight different facets of autonomous drone development and their implications for sustainable indigenisation in the defence sector. They exemplify the contribution of

the domestic industry towards operational readiness of the armed forces.

Case Study 1: Swarm and Offensive Drones

BotLab Dynamics, a startup backed by iDEX, has pioneered indigenous swarm drone technology. They have demonstrated the capability of deploying fleets capable of coordinated autonomous operations for surveillance, reconnaissance, and precision strike. In 2025, their systems having achieved high levels of indigenisation, integrated AI for real-time decision-making and clinched multiple Guinness World Records in drone shows. Crucially, these capabilities are directly transferable to defence applications. The Nagastra-1 loitering munition, developed by Economic Explosives Ltd., tested in a high-altitude environment, exemplifies offensive capabilities. Inducted in significant numbers by mid-2025, these munitions feature sustainable aspects such as low-emission motors, showcasing reduced environmental impact even in combat systems. The innovation management here involved agile iterations with private sector for technology transfers. This approach resulted in a 40% reduction in costs compared to imports, highlighting cost-effectiveness. However, while a SWOT analysis reveals strengths in combat efficacy and cost-effectiveness, it also highlights the ongoing challenge of scaling production for large-scale military requirements.

Case Study 2: Counter-Drone Systems

The Indrajaal autonomous anti-drone dome, developed by Grene Robotics, secured a ₹100 crore order in early 2026 for protecting critical military infrastructure and sensitive facilities. This sophisticated system employs AI-driven predictive analytics to detect, identify, and neutralise diverse aerial threats. Integrating additional systems such as the Indrajaal Ranger mobile patrol vehicle, launched in 2025, it can provide comprehensive air domain awareness. Sustainability is evident in its energy-efficient radar design, which minimises power consumption. Furthermore, by achieving full indigenisation, it ensures operational resilience independent of foreign supply chains. Management strategies for Indrajaal included intensive collaborative R&D with domestic firms. The SWOT analysis highlights strong export capability thereby positioning India as a provider of advanced counter-UAS solutions. However, persistent threats from cyber vulnerabilities would require continuous mitigation.

Case Study 3: High-Altitude/Stealth Platforms – Strategic ISR and Beyond

Garuda Aerospace has given way for development of high-altitude capable autonomous surveillance drones. These drones incorporate dual-domain capabilities for both civilian and military use. Their designs have prioritised sustainable materials to reduce lifecycle emissions. These innovations are aligned with broader stealth capabilities targeting engine certifications, and collaborations for High-Altitude Long-Endurance UAVs. These platforms will be crucially beneficial in offering significant advantages in prolonged missions. Innovation management leveraged deep private sector involvement which resulted in accelerating development from concept to rigorous military trials. These platforms are likely to significantly enhance border surveillance capabilities, with targeted indigenisation levels of 100% by 2030, thus ensuring complete sovereign control.

Table 2: Operational Impact and Strategic Indigenisation Metrics

Case Study	Innovation Strategy	Key Outcomes	Sustainability Impact	Self-Reliance Metric
Swarm Drones	AI Swarm Coordination	Asymmetric Warfare Capability	Low-Emission Designs	High Indigenisation
Counter-Drone	Networked AI Grid	Protection of Critical Assets	Energy Efficiency	Full Domestic MRO
High-Altitude	Stealth Autonomy	Enhanced Strategic ISR	Recyclable Materials	100% Target by 2030

Source: Annotated by the Author

These cases underscore as to how domestic industry-led innovation translates directly into strategic military gains. The resultant capability fosters a sustainable and self-reliant defence posture.

Navigating the Turbulence: Challenges to Military Drone Supremacy

Notwithstanding the significant progress, critical challenges continue to persist in India's autonomous drone ecosystem. These assume significance as they impede our quest for achieving complete indigenisation.

Confronting Subsystem Dependency and Fortifying Supply Chains

A persistent vulnerability lies in the reliance on foreign suppliers for highly advanced components. These include critical hardware such as high-performance microchips, sensors, miniaturised propulsion systems, and precision optics. Even though such a dependency often represents 20-30% of key subsystems, it exposes India to substantial strategic risks. These can be in the form of technology denial regimes, geopolitical leverage, and severe disruptions to supply chains during international conflicts (Likhachev, 2024). Even with significant indigenisation having been achieved in many areas, this remaining reliance on critical, often single-source, advanced components represents an Achilles' Heel. This facet could undermine the broader ambition of military drone supremacy. To secure its future and proactively overcome this challenge, India must intensify efforts to foster robust domestic capabilities across the entire technological stack. This is not merely about assembling drones locally; it is about mastering the underlying technologies and controlling the intellectual property. The suggested proactive strategies may include the following:

- **Aggressive Domestic Manufacturing for Critical Components:** Inspired by global efforts to secure semiconductor supply chains, India too requires dedicated national missions to boost research, development, and manufacturing in cutting-edge areas such as microchips and advanced sensors (Moktadir & Ren, 2024; Committee on Global Microelectronics Partnerships 2024). This involves significant government investment, similar to initiatives providing grants and incentives for domestic fabrication facilities. This is mandatory in order to reduce dependence on foreign nations for these

essential technologies (Committee on Global Microelectronics Partnerships, 2024; Walker, 2024; Donnelly, 2023). The overall aim, thus, is to localise the supply chain.

- ***Strategic Partnerships with Stringent Technology Transfer:*** While collaborations are vital, future partnerships must ensure genuine, unimpeded technology transfer and control over intellectual property. This would involve moving beyond mere licenced production or assembly lines (McPhillips et al. 2024). Negotiations should explicitly address contractual restrictions that historically limit full technology absorption and prevent the generation from further indigenous innovations (Halkis & Priyanto, 2023; Likhachev, 2024). India must also safeguard itself against extraterritorial controls by foreign entities over IP and exports resulting from funded defence actions (Hoeffler, 2023).
- ***Diversification and Redundancy in Supply Chains:*** To mitigate the risks, India should actively diversify its supplier base. Furthermore, where possible, build redundancy into the production of critical components. This involves promoting multiple domestic manufacturers and exploring alternative international sources. On a parallel, consistent efforts must go in towards reducing overall foreign dependence.
- ***Incentivising Private Sector Investments:*** Existing government initiatives, such as the “Make in India” program, that has encouraged private sector involvement (Likhachev, 2024; Yadav, 2024), needs to be further bolstered. This can be undertaken with targeted incentives for companies willing to undertake high-risk, high-reward investments in manufacturing specialised defence components (Likhachev, 2024). The focus should be on creating a vibrant ecosystem wherein private players are compelled and supported to invest in niche drone technologies.
- ***Accelerated Indigenous Development of Propulsion Systems:*** The propulsion systems, including those for Vertical Take-Off and Landing and high-altitude operations, present complex design and control challenges (Alqudsi et al., 2025). Ongoing research is focused on improving aerodynamic design and material efficiency and developing advanced, often hybrid, propulsion solutions (Ratnaparkhi, 2024). India must significantly invest in R&D to overcome the current limitations in thrust, efficiency, and battery density. This will ensure that the resultant drone fleet is powered by self-reliant and high-performance systems (International Journal of Mechanical Engineering and Robotics Research, 2025).

Funding Gaps and R&D Prioritisation for Defence

While government initiatives provide substantial funding, the sheer scale of R&D required for cutting-edge military technologies, such as stealth materials (Tan et al., 2025; Zhao et al., 2025), quantum-resistant communication (Khan et al., 2024; Sarkar et al., 2025), and AI necessitates even greater and sustained investments. Funding gaps often exist between initial prototyping and large-scale military production. This facet hinders the transition from innovative concepts to deployable solutions. R&D priorities requires to be aligned directly with the future battlefield requirements.

Bridging the Skill Chasm: Human Capital for Future Warfare

Notably, the defence sector is experiencing a shortage of drone engineers, pilots, and AI specialists. It is abundantly evident that the operation, upkeep, and development of sophisticated autonomous systems require a workforce having highly specialised skills. The goal of training “1 lakh FPV pilots by 2030” is quite broad based. However, the specific need for military-trained drone operators, AI combat engineers, and cyber warfare specialists for autonomous systems, is paramount. This specialised human capital is a must in order to

realise the full potential of the advanced hardware.

Cybersecurity and Electronic Warfare Threats

As autonomous military systems become more ubiquitous, the threats from cyber vulnerabilities will also increase proportionally. These systems will remain prime targets for hacking, jamming, and spoofing by adversaries. This could potentially lead to loss of control and data exfiltration. Enhanced cybersecurity measures, including encryption and resilient communication protocols would require to be mandatorily enforced. This would need to be coupled along with sophisticated electronic warfare capabilities.

Integration with Legacy Systems and Interoperability

The introduction of new autonomous drone capabilities often complicates seamless integration with existing systems. The interoperability issues are often witnessed while integrating the drone systems with other military platforms, command structures, and communication networks. Ensuring interoperability between diverse drone categories and older legacy systems is crucial for creating a cohesive and effective joint force. This integration challenge can hinder absorption of advanced drone technologies.

Ethical Considerations in AI Autonomy

The increasing autonomy of drone systems raises ethical dilemmas regarding their use in combat. Questions surrounding “human-in-the-loop” versus “human-on-the-loop”, will require careful consideration. Furthermore, accountability for autonomous targeting decisions, and adherence to international humanitarian law, also assumes importance.

Charting a Dominant Course: Recommendations for India's Military Drone Strategy

To overcome various challenges, a multi-pronged strategic approach is essential. Suggestions on measures that needs to be undertaken in order to secure India's position as a leader in autonomous defence systems are highlighted below: -

- ***Robust IP Protection and Enhanced Defence R&D Funding:*** There is an urgent need to expand incentives to a more ambitious ₹10,000 crore. This would aid in specifically prioritising intellectual property frameworks to safeguard startup innovations and prevent technology leakage. This funding should be directed towards critical military technologies capable of delivering a decisive operational advantage.
- ***Accelerating Military-Academia-Industry Collaboration:*** Programs such as NIDAR needs to be expanded with a focus on defence-specific innovation eco-systems. The objective is to educate 50,000 experts annually in sustainable drone technology as needed by the defence sector.
- ***Sustainability in Military Logistics and Operational Resilience:*** Hybrid propulsion systems and other green innovations in all new defence drone projects needs impetus. The overall aim would be to achieve net-zero emissions by 2035. This aids a reduced logistic footprint and energy independence. Furthermore, it enhances the operational lifespans of military assets.
- ***Projecting Power - Strategic Defence Drone Exports:*** There is a need to set an ambitious target of achieving ₹50,000 crore by 2029 in defence drone exports. Apart from revenue generation, it will aid

in building strategic alliances and position India as a reliable security partner in the region.

- ***Strengthening Supply Chain Indigenisation:*** There is a need to pursue aggressive policies to indigenise the remaining 20-30% of critical sub-systems. This involves encouraging the local production of cutting-edge microchips, sensors, and propulsion components. This can be achieved by implementing specific R&D initiatives with procurement assurances.
- ***Cyber Resilience and Counter-EW Development:*** Substantial investments in the development of state-of-art sophisticated electronic warfare and cybersecurity strategies. These assume importance against growing adversarial threats. Being cyclic in nature, these require constant innovation and investment.

Ethical Considerations: The Human Element in Autonomous Warfare

The use of autonomous drone systems in military has raised a series of ethical and legal questions. As a responsible global power, India needs to actively engage with these dilemmas. There is a need to closely consider and ensure that our technological progress aligns with our values and international obligations.

- ***AI Ethics and Trustworthy Autonomy - Navigating the Moral Compass.*** With a substantial increase in AI integration, the questions of transparency, accountability, and reliability in autonomous decision-making become paramount. India should focus on “autonomics”. These refers to systems that are not only smart but also reliable and self-sufficient. This involves ensuring that AI systems can be audited to follow established ethical guidelines set by human oversight. The debate between “human-in-the-loop” versus “human-on-the-loop” remains a critical factor in future doctrine development.
- ***Targeting and Decision-Making Autonomy - The Laws of Armed Conflict.*** The ability of autonomous systems to detect and engage targets without direct human intervention challenges the laws of armed conflict. How do such systems ensure discrimination between combatants and civilians? How can the proportionality of an attack be assessed? There is a need to ensure responsibility and accountability for erroneous or unintended autonomous actions. These must be clearly defined. As technology advances, India must establish robust legal frameworks and operational guidelines.
- ***Data Privacy and Cybersecurity in Drone Operations:*** Military drones collect vast amounts of data. Much of this can be sensitive in nature. Ensuring data privacy from adversarial exploitation is of critical concern. Furthermore, the security of the data the drone transmits and the network in which it operates is important. Robust protocols are needed to prevent hacking, jamming, and spoofing, which can compromise mission integrity (Sarkar et al., 2025).
- ***The Future of Command & Control and Human-AI Teaming.*** The increasing role of AI in decision-making will impact military Command & Control structures. How can military team leaders effectively manage and trust autonomous subordinates? The development of seamless human-AI teams towards active collaboration remains crucial. Apart from technological integration changes in training, doctrine, and military culture would be needed.

The Battlefield of Tomorrow: A Futuristic Roadmap for 2030 and Beyond

India’s trajectory in autonomous drone systems would need to not only address current needs, but also consider measures required in shaping the future battlefield. A clear roadmap is mandatory as it will aid

investments and R&D efforts.

- **Phase 1: Tactical Dominance and Integration.** This phase focuses on achieving immediate tactical superiority by seamless integration into existing military structures. The goal is to achieve 80% indigenisation in swarm and counter-UAS technologies followed by their extensive deployment. Towards achieving this objective, the integration of 6G technology for ultra-low-latency communication will be paramount. This will enable real-time battlefield data transmission and decision making for autonomous systems. This period will see an expansion of deployed ISR and loitering munition capabilities. Overall leading to enhanced situational awareness and precision-strike capabilities.

- **Phase 2: Strategic Autonomy and Export Prowess.** India aims to achieve strategic autonomy in autonomous drone technology by 2030. This includes deploying advanced stealth Unmanned Combat Aerial Vehicles (Tan et al., 2025; Zhao et al., 2025) thereby achieving full “autonomics” for ethical decision-making in AI. The market is anticipated to reach USD 1.39 billion, with India positioning itself as a prominent exporter of defence drone systems. This further enables expansion of the country’s strategic influence. In addition, collaborations in urban air mobility, initially developed for civilian applications, will be adapted for military logistics in challenging terrain.

Beyond 2030: Quantum Warfare and Hypersonic Interceptors. Looking further ahead, the focus shifts towards maintaining a qualitative military edge. This includes the development and deployment of quantum-secured drones, providing un-hackable communication and navigation capabilities (Tian et al., 2024; Conrad et al., 2025). These will prove to be particularly crucial for countering emerging hypersonic threats (Johnson, 2021). India will also explore space-based drone assets for global surveillance. These will aid rapid response and fully integrated human-AI teaming for multi-domain operations (Abhinav & Pramod, 2025; Johnson, 2021). Overall, this will result in ensuring comprehensive dominance across air, land, sea, cyber, and space.

This roadmap envisages a resilient, sustainable, and technologically superior future for military drone capabilities in India. It emphasises the development and integration of cutting-edge technologies to ensure that drone systems remain robust against evolving operational challenges. This approach is designed to accelerate the deployment of advanced unmanned aerial systems needed to aid diverse mission requirements.

Conclusion: India’s Path to Unmanned Military Supremacy

India’s innovation management in autonomous drone systems exemplifies a strategic pivot towards sustainable indigenisation. It blends technological prowess with policy foresight and stable domestic industry leadership. From startup-driven swarm technologies providing asymmetric advantages to private sector counter-drone solutions protecting critical assets, the ecosystem is poised for exponential growth. This approach will assist in fundamentally reducing dependencies and significantly enhance national security.

As defence exports surge and sustainability is integrated deeper into the design and operational philosophy— the futuristic roadmap to 2030 promises India as a formidable drone powerhouse. India’s robust progress is steadily closing global gaps and moving towards unmanned military supremacy. Continued emphasis on proactive policies and strategic global collaborations will sustain this momentum. Overall, it will ensure the enduring success of the Atmanirbhar Bharat vision in securing India’s strategic future on the unmanned battlefields.

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