'Anusandhan'-led 'Atmanirbhar' UAS Industry in India

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Policy and technology initiatives are important pillars for building high-value, high-technology industries. Information technology and automobile industries, despite their contribution to Indian economy, have remained relatively low-value industries as maximum profits go to foreign companies. The Indian unmanned aircraft systems (UAS) industry, led by start-ups and micro, small and medium enterprises (MSMEs), has the potential to change the trajectory and become intellectual property-led high-value industry. The Drone Rules, 2021, notified on 25 August, has set into motion a series of policy reforms, providing much-needed stimulus to the Indian UAS industry. India is aiming to become a global drone hub by 2030; however, its UAS manufacturing industry faces certain challenges and policy implementation contradictions. An examination of technological initiatives taken by global leaders in UAS technologies and lack of corresponding initiatives in India indicates significant technological gaps. Therefore, 'anusandhan' (research) becomes an important pillar for covering these gaps and building a self-reliant high-technology, high-value globally competitive UAS industry in India.

Keywords: *Amrit Kaal, Anusandhan (research), Atmarnirbhar (self-reliant), Drone Hub-2030, India, UAS*

Introduction

The unmanned aircraft systems (UAS) are transforming warfare due to low cost, ease of operations, dual use, easy availability, and inability of existing air defence systems to detect and neutralise them due to low speed

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and low radar cross section area. The defence forces, intelligence agencies and terrorist organisations are increasingly employing commercially available low-cost UAS for conventional and sub-conventional operations. The UAS are called by various names, such as unmanned aerial vehicles (UAVs), remotely piloted aircraft (RPA) and drones. In this article, the terms UAS and drones have been used interchangeably.

The armed drone attack on 27 June 2021 on Jammu airbase, near India's border with Pakistan in the west, and smuggling of arms, drugs and counterfeit currency across the border indicate conventional and non-conventional threats from Pakistan and elements abetted by its intelligence agencies.[1] China, which has been making progress in UAS technologies, deployed intelligence, surveillance and reconnaissance (ISR) UAS and indicated its intention to deploy swarm UAS against India during the Galwan conflict in 2020.[2] Further, increasing cooperation between Pakistan and the two leading UAS manufacturers, namely, China and Turkey, is adding to India's challenges.[3] India needs UAS not only for military applications but also for humanitarian assistance and disaster relief (HADR), agriculture, power, town planning, mining, surveys, mapping and other commercial applications to meet the aspirations of its large population.

The dual-use nature of the UAS makes civil UAS industry an important player in building defence capability. India's Ministry of Civil Aviation (MoCA) has taken several policy initiatives in the last one year to stimulate domestic drone industry. Meanwhile, the Defence Research and Development Organisation (DRDO) and the Defence Public Sector Undertakings (DPSUs) are developing medium-altitude long-endurance (MALE) UAVs, Combat Air Teaming System (CATS), unmanned combat aerial vehicles (UCAVs) and other UAS to make India self-reliant in unmanned aircraft technologies. However, non-availability of timely funding for development and absence of timelines for the induction of Rustom-I and TAPAS UAS indicate incoherence and inconsistency in indigenous military UAS technology development programmes, which need to addressed on priority. India needs both indigenous civil and military UAS industries as they are interdependent and complementary.

Innovations, niche technology development initiatives and rapid adoption of UAS have been key pillars of the Indian civil UAS industry, which is led by start-ups and micro, small and medium enterprises (MSMEs). The Indian government, which has introduced several policy reforms in the UAS sector recently, has not initiated corresponding technology development initiatives. In the private sector, many big business houses have acquired UAS start-ups and created UAS business verticals, especially in the last two years. However, their investment in research and development (R&D) has been limited, an aspect visible in continued dependence on imports for critical systems, sub-systems and components. On the other hand, promising Indian UAS market has attracted traders, who are leveraging ease of import of components to assemble UAS with little indigenous content. The trajectory of civil and military UAS policies, procurement decisions, development programmes, adoption initiatives and role of stakeholders would have an impact on India's endeavours to achieve self-reliance in UAS technologies.

India has set two stiff but transformational goals for its UAS industry: first, becoming self-reliant in critical technologies, which also applies to UAS; and; second, becoming a global drone hub by 2030. The Indian Prime Minister, in his Independence Day speech in 2022, has called for making India a developed nation by 2047. However, research has been a weak area in India. Therefore, an understanding of global technology development initiatives and India's current capabilities, challenges and technology gaps is essential to anticipate potential impediments and make a realistic roadmap for its UAS industry. This article aims to answer the following questions:

1. Why 'anusandhan' (research) is essential for building intellectual property (IP)-led high-technology, high-value UAS industry in India?
2. What are global research initiatives for developing UAS technologies and their integration in national airspace?
3. What are the research and technology gaps, challenges and way forward for the Indian UAS industry?

This study aims to provide a basic understanding of existing capabilities and challenges, as also propose a way forward for making India a drone hub by 2030 and self-reliant in advanced UAS technologies by 2047. The findings would provide a platform for further research, and for formulating a strategy for building 'anusandhan'-based 'atmanirbhar' globally competitive UAS industry.

Why 'Anusandhan' is Essential for Transforming Indian UAS Industry?

Innovation is critical and it has to be indigenous.
Imported goods can't be a source of Innovation.
—Narendra Modi, Prime Minister of India[4]

The year 2021 can be termed as the year of UAS policy reforms in India. The government introduced several transformational policy reforms in the drone sector, such as: formulation of industry-friendly civil Drone Rules, 2021; launching UAS Traffic Management (UTM); Productivity Linked Incentive (PLI) scheme; Drone Certification and Drone-as-a-Service schemes; and Kisan drone scheme. These initiatives are expected to play an important role in making India a global drone hub by 2030.[5] The launch of several policy reforms in the last one year indicates the importance being accorded to the UAS sector.[6] It is time to follow up the policy reforms with technological initiatives to take India to the next level.

IP Generation by Information Technology (IT) and Automobile Industries

Automobile and IT are the leading industries of India. Global IT and automobile companies have established their research, design and manufacturing facilities in India. Further, Indian IT companies work for global original equipment manufacturers (OEMs) as well as provide services to global and Indian users. The assembly, product support and services set-ups created by global OEMs in collaboration with their Indian counterparts provide employment to a large number of Indian companies and people. However, both industries are relatively low-value industries as there is negligible IP generation in India and a large portion of profit created through sales in India goes to foreign companies.

Global R&D with Indian Talent

One of the contradictions of India has been its highly skilled manpower that has been undertaking cutting-edge research, design and development for global OEMs and yet, its domestic industry has remained a low-technology, low-value industry. Most global technology leaders in aviation, software, semi-conductor, automobile and IT sectors have established their R&D centres in India. The global OEMs employ technical manpower from India to design, improve and upgrade aerospace, IT, aero engine, automobile and other technologies in India.

The foreign OEMs leverage Indian talent to build IP in India for maintaining technological edge and building high-value industry, as well as leverage the large Indian market for progressing their business interests. Most of the IP created by Indian talent goes to the foreign OEMs, with little contribution to creation of IP for India. India is, thus, a laboratory for innovation as well as consumer market for generating revenue by foreign OEMs, in which Indians remain assemblers, distributors, employees and consumers, and not creators and owners.

Promising Indian UAS Industry

Indian companies, in most cases, lack design capability, generate limited IP and remain relatively low-value industries. The goal of self-reliance is important for building India of the 21st century.[7] Indian manufacturers demonstrated their capability to develop niche technologies and supplied indigenously designed and manufactured ISR, armed and swarm UAS to the Indian Army after competing against global OEMs in 2021.[8] However, they have supplied small and medium size UAS and need funding support and handholding by stakeholders to develop large and more capable UAS. Indian UAS industry led by start-ups and MSMEs has the potential to become India's first IP-led high-value manufacturing-cum-service industry; however, it needs policy and technological interventions, and support of stakeholders to achieve this challenging goal.

Significance of Research

India has declared the 25-year time period between 75 years and 100 years of independence (2022–47) as 'Amrit Kaal' (period to start good work) to make the country a developed nation.[9] In terms of the UAS sector, setting a goal of 'Drone Hub–2030' alone would not make it high-value sector. Indian industry remains dependent on drone components and is yet to develop and operationalise UTM, remote tracking and other technologies. Therefore, India should set long-term goals, launch research initiatives and formulate a plan to make the UAS industry its first research, design and IP-led high-value globally competitive industry by 2047.

The research initiatives taken by the United States (US), Europe and China for developing UAS technologies and their integration in each country's national airspace are deliberated in the succeeding section to understand the strengths and gaps in Indian UAS industry.

Global UAS Research and Airspace Integration Initiatives

Research and UAS Integration Initiatives of the US

Research and technology initiatives have been the key pillars of UAS industry and their safe integration in the national airspace of the US. The Federal Aviation Administration (FAA) of the US launched several R&D/technology development initiatives to build a robust high-value UAS industry. A few of these initiatives are as follows:

1. *UAS Operations in Arctic* programme commenced in 2013 and culminated with operationalisation of 10 UAS launch sites for Arctic operations in 2015.[10]
2. *Focus Area Pathfinder* programme was launched in May 2015 to develop and validate concepts for certification, operations and safety. It ended in 2017 after achieving its objectives.[11]
3. *UAS Detection Initiative* was launched in October 2015 and the FAA partnered with the Federal Bureau of Investigation in May 2016 to develop drone detection and tracking technologies in airport environment; facilitate safe operation of unmanned aircraft with manned aircraft; and their integration with stakeholders. A total of 141 test operations were conducted between January 2016 and February 2016 to develop the UAS detection system.[12]
4. *UAS Integration and BEYOND programmes*: The US government conducted a three-year UAS Integration Pilot Programme (IPP) between 25 October 2017 and 25 October 2020 to conduct complex UAS operations in its national airspace. Thereafter, it launched the BEYOND programme to cover Beyond Visual Line of Sight (BVLOS) operations, quantify benefits and address community concerns.[13]
5. *Alliance for System Safety of UAS through Research Excellence (ASSURE)*: The FAA established UAS centres of excellence (COEs) under ASSURE.[14] The ASSURE programme was launched in September 2015 and its focus areas include air traffic control interoperability, detect and avoid, certification, UTM and UAS integration into the US national airspace.[15]
6. *Academic institution funding with UAS integration goals*: In 2022, the US government allocated $18.3 million for UAS research, education and training to 15 universities. The focus of research was on three key areas of UAS technologies and their integration in national airspace:

- UAS electromagnetic compatibility research to assess risks, identify UAS design vulnerabilities and propose measures for safe electromagnetic compatibility.
- Detect and avoid research to assess effects of false or misleading information on detect and avoid capabilities to support BVLOS operations.
- Research on cyber-security oversight and risk management of National Aerospace System.

The funding for each of the three subjects was given to three to four universities depending on the scope of their proposals.[16]

7. *Testing sites*: The US established seven test sites as part of the FAA Modernization and Reforms Act, 2012; and these sites will continue to be operational with defined research, technology development and testing goals at least till 20 September 2023. In addition, these test sites have focused research and testing programmes to develop technologies and concepts related to: detect and avoid; command and control (C2); airworthiness; BVLOS operations; standards for the safe operation of UAS in various airspace classes; air traffic and communication procedures; multiple UAS operations; counter UAS; UTM; test and evaluate UAS standards, processes and procedures; and Urban Air Mobility (UAM).[17]
8. *UTM*: The US established a Research Transition Team comprising the FAA, National Aeronautics and Space Administration (NASA) and industry; and started a three-year UAS Traffic Management Research Transition Team Plan on 31 January 2017 that was completed in 2020. It formulated a UTM vision that aims to enable multiple UAS BVLOS operations, where air traffic services are not provided.[18] The US is conducting field test at two FAA test sites: Virginia Tech Mid-Atlantic Aviation Partnership; and Griffiss International Airport, New York. The flight testing includes testing of UAS operations over populated areas, at night, data correlation, remote identification and cyber-security framework.[19]

European Union Aviation Safety Agency (EASA) Research and Very Large-scale Demonstration (VLD) Programmes

The EASA is undertaking numerous research[20] and VLD projects to deliver strategic and innovative UAS technologies and facilitate their integration in the national airspace of European Union (EU) countries:

1. A €4 million two-year project for design, simulation and real-time demonstration of ground system, 100 hours of flight of UAM, its integration; and assessment of safety, security, sustainability and public acceptance in 2021–22.[21]
2. Approximately €2 million two-year project to develop and validate through simulation and real-time demonstration of UAM medical supply and passenger UAS technologies and their operation with manned aircraft in real-life exercises and their integration with advanced U-space services having advanced detect and avoid system in 2021–22.[22]
3. A €4 million two-year project for integrated UAM–manned aircraft operations in national airspace using different U-space architecture and technologies in 2021–22.[23]
4. *Tactical Instrumental Deconfliction and Inflight Resolution (TINDAIR)* VLD is €3.2 million two-year project, in 2021–22, that is aimed at meeting three requirements: tactical conflict resolution; emergency landing in strategic phase; and change in speed, level and heading or forces landing based on detect and avoid instruments.[24]
5. *U-space for UAM*: This is €4 million two-year project in 2021–22 that involves UTM providers, electric vertical take-off and landing (eVTOL) manufacturers, research centres and technology providers to conduct multinational UAM demonstrations with drones and UAM vehicles all over Europe to study safety aspects, impact on system requirements, and leverage regulation and standardisation to support safe UAM operations.[25]
6. *U-space (UTM) and ATM integration*: EASA launched a two-year approximately €4 million Integrated Urban Airspace VLD project to validate GOF2.0 architecture and demonstrate highly automated real-time separation assurance to UAS, eVTOL and manned aircraft operating in a unified dense urban airspace using ATM and U-space (UTM) services and systems without degrading current airspace operations.[26] The first large U-space demonstration was conducted under the Gulf of Finland (GOF) project amounting to €3.2 million between 2018 and 2020.[27]
7. *Standards*: EASA launched SHEPHERD (UAS Standards), a two-year R&D programme under the EU's Horizon Europe research and innovation programme in May 2022 to develop standards.[28]
8. *Drone collision avoidance*: Drone collision avoidance system is the most important system for collaborative operation of manned–UAS

operations. The EASA published drone collision task force report in 2016 and has been pursuing several R&D projects since then, as has brought out in the deliberations earlier.[29]

China

The Civil Aviation Administration of China (CAAC), over the last few years, has taken a number of policy, research, technology development and validation initiatives to build high-value UAS industry. Some of these initiatives are discussed next:

1. *Drone safety report*: The 'Low-Altitude Connected Drone Flight Safety Test Report' was published on 31 January 2018.[30]
2. *Civil Aviation Law amendment*: The Civil Aviation Law was amended on 21 January 2019. Article 214 was added to authorise the State Council and the Central Military Commission to develop dedicated provisions for UAS operations.[31]
3. *Interim rules for trial operations*: Management Procedures for Trial Operations of Specific Type of UAS (Interim) was issued on 5 March 2019 to encourage and promote orderly trial and demonstration operations of UAS, as well as standardise operation of three categories of UAS weighing between 7–25 kilogram (kg), 25–150 kg and above 150 kg to adopt new technologies.[32]
4. *Delivery trials in urban areas*: The first licence for trial operation of delivery UAS in urban areas was issued to Songba Logistics on 14 November 2019.[33] The UAS are being employed for delivery services in many Chinese cities, including Shanghai, Hangzhou, Zhejiang province, and Shenzhen, Guangdong province.[34]
5. *Experimental and testing bases*: China issued Measures for the Management of Unmanned Civil Aviation Experimental Bases (Test Areas) on 25 March 2021. The CAAC established 13 UAS experimental bases (test sites) in cities (urban) and island territories to support UAS operations in regional logistics and other roles. These sites would have low-altitude airspace coordination, investment, administrative, management and technical infrastructure for research and testing of UAS safety, reliability and compliance verification.[35]
6. China established East China Civil UAS Experimental Base in Jinshan Industrial Zone, Shanghai, in 2018.[36] Liangjiang joined the list of experimental and testing bases on 26 August 2022. Being a mountainous area and having an airport, flight service station and

other facilities, Liangjiang is used for long-range logistics flights of UAS equipped with satellite communication.[37]

7. *UAM laboratory*: The Zhongfa Aviation University of China, in collaboration with Beihang Hangzhou Innovation Research Institute (Yuhang) and Hagzhou Antwork Network Technology Co. Ltd, established the Urban Air Mobility Joint Laboratory in November 2021 to develop and demonstrate urban low-altitude UAS logistics operations and enabling technologies.[38]
8. *UAS logistics (long-range) trials*: The CAAC accorded approval to SF UAS, an affiliated company of SF Express, for operation of UAS logistics on feeder lines in February 2022. The trial will involve long-range transportation of cargo weighing at least 1 tonne.[39]

The scrutiny of UAS technology development initiatives undertaken by the US, Europe and China indicates focused attention towards the development of UAS ecosystem comprising testing sites, standards, standardisation, certification and R&D programmes. The number of technology development initiatives and trials undertaken to develop diverse UAS technologies has played an important role in stimulating domestic manufacturing and facilitating operation of UAS in their airspace. The key technologies that have been developed include UAS detection and tracking system, standards and mechanism for certifying large UAS, technologies for improving safety of UAS, BVLOS operations, UTM, cyber security, UAM and Advanced Air Mobility (AAM) system. The ecosystem building and types of research projects undertaken by the US, Europe and China indicate several similarities in their endeavours. The technology development and validation initiatives had progressive but definite objectives, partners with well-defined work share, real-time demonstrations, specific timelines and assured funding. The UAS ecosystem and technological initiatives give fair indication of research effort needed for building high-technology, high-value UAS industry.

UAS Research and Technology Gaps in India

India lacks research initiatives and enabling ecosystem to build high-value UAS industry. Indian leadership, by adding 'Jai Anusandhan' (Hail Research) to the slogan, 'Jai Jawan (Hail Soldier), Jai Kisan (Hail Farmer), Jai Vigyan (Hail Science)', shows the realisation that the country needs to build research-based industries. It needs to take research, technology development and airspace integration initiatives, as well as strengthen pillars of unmanned aviation technology development, that is, certification, standards, testing and research for building robust high-value UAS industry. Some of the significant UAS research and technology gaps in India are discussed next.

Necessity for Developing Military UTM

The Indian Armed Forces possess Searcher Mk-1, Searcher Mk-II, Heron and significant number of logistics, supply, ISR, swarm and armed strike small UAS. The armed forces and Central Armed Police Forces (CAPF) are likely to acquire about 2,000 small UAS in the next two years.[40] These UAS, weighing between 3–300 kg and operating up to 20,000 feet, would make the Indian airspace congested. The non-availability of collision avoidance and real-time tracking systems on small UAS of the defence forces and the CAPF would enhance the chances of collision between the UAS, helicopters and other manned aircraft. The non-availability of military UTM and enabling technologies could become a cause of attrition during peacetime as well as in war in the coming years. Therefore, there is an urgent need for developing remote identification systems and UAS UTM, and their integration in the air defence system.

Standards and Certification

Standards and certification are important pillars for building domestic UAS manufacturing industry. Indian aviation standards, certification and quality assurance (QA) bodies are accustomed to following global standards and protocols. However, UAS is an emerging domain in which standards, certification and QA mechanisms are still evolving. The formulation of these requires rigorous research, testing and validation. Therefore, India would need to evolve and strengthen its civil as well as military manufacturing, QA standards and certification mechanism to build high-value domestic UAS manufacturing industry.

Civil UAS Standards and Standardisation

There is a need to formulate standards for designing and manufacturing civil UAS, as well as create a certain level of standardisation to make Indian UAS and UAS components manufacturing competitive. The Quality Council of India (QCI), the Bureau of Indian Standards (BIS) and industry would have to work together to develop standards as well as arrive at consensus to achieve certain minimum level of standardisation.

Low-cost Certification for Small UAS of Defence Forces

The military UAS are required to operate in tough conditions amid counter measures by the adversary, and thus need a robust architecture and ability to operate in unfriendly conditions. The defence forces have procured uncertified small UAS, which could create uncertainty or incompatibility issues in future. The standards for design, development and manufacturing[41] and the process of certification of military UAS in India has been formulated in 2021;[42] however, these are still evolving. The small UAS for military need simple and low-cost certification mechanism, on the lines of certification mechanism for civil UAS formulated by the QCI.

Creation of Testing Sites

Aviation manufacturing in India, till now, was undertaken by public sector entities and there was no need for building aviation testing sites for private sector. However, the number of Indian private sector companies involved in UAS design, development and manufacturing has grown with the launch of Innovation for Defence Excellence (iDEX), Mehar Baba Competition, TDF, Start Up India and other initiatives. As a result, requirement of sites to test the UAS has increased significantly. Indian UAS industry is graduating from multi-copters to fixed-wing long-range UAS that would be operating at sea level, high-altitude terrain, urban areas and coastal areas for numerous civil–military applications. The release of Drone Rules, 2021 and the launch of Ude Desh ka Aam Nagrik (UDAN) has reduced the availability of airspace for testing UAS. The paucity of airspace creates challenges for the Indian UAS industry in testing their unmanned systems, which needs to be addressed on priority.

Incoherence in UAS Research and Funding

Global technical institutions have curated curriculum and dedicated technical courses on UAS, like Bachelor of Technology (BTech), Master of Technology (MTech) and Doctor of Philosophy (PhD). For instance, Embry Riddle Aeronautical University, in the US, conducts bachelors, masters and PhD courses on unmanned systems.[43] There are hardly any dedicated MTech and PhD courses on UAS in India. Hindustan University, Chennai, offers an MTech degree in avionics with specialisation in UAVs[44] and UPES, Dehradun, offers MTech in aerospace engineering with UAVs.[45]

Another challenge is the lack of coherence in research funding for UAS technologies and the lack of alignment of these research initiatives with capability gaps of the UAS industry of India. Indian educational institutes and other entities get funding from different sources, including Department of Science and Technology (DST),[46] Ministry of Electronics and Information Technology (MeitY), iDEX, Atal Innovation Mission[47] and others, to undertake research, establish incubation centres and so on. Some Indian educational institutions, like Indian Institute of Technology (IIT) Roorkee,[48] International Institute of Information Technology (IIIT) Hyderabad[49] and IIT Guwahati,[50] and the Government of Karnataka have established CoEs and incubation centres on drone technology.[51] Similarly, Terra Drone, Japan, and IIT Hyderabad signed a memorandum of understanding (MoU) to establish a CoE for drones in India that would involve establishing a sales–service–support model for the drone ecosystem in the country.[52] However, their scope of research and technology development initiatives are incoherent and lack systematic approach followed by global CoEs on UAS; and this disparity becomes glaring when we compare them with ASSURE programme of the FAA[53] and corresponding research programmes of the EASA covered earlier in this article. Also, establishing a CoE without aligning with technological gaps of the Indian industry, and duplication and overlapping in research and technology development programmes, leads to suboptimal utilisation of meagre national resources and negligible technology gains.

Committee on UAS Integration

Rule 45 of Drone Rules, 2021 of India stipulates the establishment of UAS Promotion Council (UPC). The council is yet to be established and as the name suggests, its role is limited to promotion of UAS technology. On the other hand, Advanced Aviation Advisory Committee (AAAC) set up by the FAA provides independent advice and recommendations on technology and capability building, including UAS AAM, their integration in the US national airspace system, related issues, policies, interests and safety and efficiency of UAS integration.[54] The comparison of the UPC with AAAC indicates lack of focus of UPC on technology and capability building. The UPC is not mandated to provide advice or steer transformation of Indian UAS sector through policy and technological initiatives to facilitate development of UAM, AAM, UTM, BVLOS systems and integration of UAS in the Indian airspace.[55] India needs an expert committee that advises stakeholders in the government on developing UAS technologies and integration of UAS in the Indian airspace.

The aforementioned research gaps have an adverse impact on the trajectory needed for making India a global drone hub by 2030 and self-reliant in critical UAS technologies. In addition to the technology gaps, Indian UAS industry faces policy, policy implementation and other challenges.

Indian UAS Industry Challenges

Nodal Ministry for UAS

As discussed earlier, the civil aviation bodies of countries leading in UAS technologies, such as the US, Europe and China, have pursued technology development initiatives to develop and demonstrate UAM, AAM, BVLOS operations, detect and avoid systems, UTM and so on. In India, the MoCA introduced UAS policy initiatives in the last one year, commencing with the promulgation of Drone Rules, 2021, but it did not launch corresponding technology development, UAS integration and ecosystem-building initiatives. The summary of disparities in UAS technological initiatives and their ownership by global leaders and lack of corresponding initiatives in India is given in Table 1.

Table 1

	US/China/Europe				*India*			
	Policy Initiative (Global)		*Technology Initiative (Global)*		*Policy Initiative (India)*		*Technology Initiative (India)*	
	Policy	*Nodal Agency*	*Tech Prog*	*Nodal Agency*	*Policy*	*Nodal Agency*	*Tech Prog*	*Nodal Agency*
UAS Operations/ Safety	Yes	FC&E	Yes	FC&E	Yes	MoCA	×	×
UTM	Yes	FC&E	Yes	FC&E	No	MoCA	×	×
BVLOS	Yes	FC&E	Yes	FC&E	No*	MoCA	×	×
Certification	Yes	FC&E	Yes	FC&E	Yes**	MoCA	×	×
Standards	Yes	FC&E	Yes	FC&E	Yes/ No	MoCA	×	×
UAS Integration in National Airspace	Yes	FC&E	Yes	FC&E	Yes	MoCA	×	×

	US/China/Europe				*India*			
	Policy Initiative (Global)		*Technology Initiative (Global)*		*Policy Initiative (India)*		*Technology Initiative (India)*	
	Policy	*Nodal Agency*	*Tech Prog*	*Nodal Agency*	*Policy*	*Nodal Agency*	*Tech Prog*	*Nodal Agency*
Detect and Avoid	Yes	FC&E	Yes***	FC&E	Yes	MoCA	×	×
UAS Testing Sites	Yes	FC&E	Yes	FC&E	Yes	MoCA	×	×
UAM & its Integration	Yes	FC&E	Yes	FC&E	No	MoCA	×	×
UAS–Manned Operation	Yes	FC&E	Yes	FC&E	No	MoCA	×	×
UAS CoE & Research Programme	Yes	FC&E	Yes	FC&E	No	MoCA	×	×
UAS Integration Committee	Yes	F&E	No	F&E	No	MoCA	×	×
UAS Promotion Council	No***	F&E		F&E	Yes	MoCA	×	×

Note: In FC&E, F: FAA; C: CAAC; and E: EASA; ×: no designated agency/ministry.

* MoCA conducted trials with industry.

** No programmes to develop and validate standards for certification.

*** US established seven testing sites through competitive selection.

Source: Author's own.

One of the reasons for lack of technology development initiatives by the MoCA is the non-availability of R&D structures and research-oriented manpower within the ministry to steer such initiatives. It is therefore felt that there is a need to form a nodal ministry to take ownership and steer development of UAS and enabling technologies, and integrate UAS in the Indian airspace.

UAS Import Ban

The Indian Directorate General of Foreign Trade (DGFT), vide Notification No. 54/2015-2020, dated 9 February 2022,[56] prohibited import of drones that included completely built-up (CBU), semi-knocked down (SKD) and completely knocked down (CKD) forms to support domestic manufacturing, while giving exemption to certain government and academic institutions for R&D. The ban on import of UAS was aimed at stimulating domestic manufacturing; however, exemption granted to government entities and other anomalies could have an adverse impact on domestic UAS manufacturing (discussed in the next section).

1. *Issue of Unique Identification Number (UIN)*:[57] A UIN was issued to imported UAS after the ban on import of UAS came into effect.[58]
2. *Listing of imported UAS on Government e-Marketplace* (*GeM)***:** The UAS whose import is banned were listed on the GeM[59] portal, providing them legitimacy for procurement by Indian government departments.
3. *Import ban exemptions*: Some central and state government entities[60] and academic institutions procured banned small UAS under exemption clause despite availability of domestic UAS.[61] Therefore, there is a need to review grant of exemptions to government and other entities under this clause.

The anomalies between the policy to ban import of UAS and its implementation need to be corrected. Further, the mechanism to implement drone import ban needs to be strengthened to stimulate innovation, indigenous development and domestic manufacturing.[62]

Challenges of Indigenous UAS Components Manufacturers

India's drone import policy of February 2022 bans the import of complete UAS but allows the import of UAS components and makes the process of their import easier.[63] The aim of simplification of the process to import UAS components is to stimulate UAS R&D and manufacturing, as well as provide time to the Indian industry to develop indigenous components.

Indian companies have started manufacturing certain UAS components, including airframes, tubes, sheets, propellers, motors, autopilot, electronic speed controllers (ESCs), Navigation with Indian Constellation (NavIC) receivers and sensors. The manufacturing of UAS components has been predominantly undertaken by start-ups, who are creating IP in India but lack economic strength. The UAS equipped with indigenous components face policy and procurement challenges from the UAS assembled from imported components. Table 2 depicts two UAS certified by the QCI: one is with imported components; and the other is with indigenously designed and manufactured components/ sub-systems.

Table 2

	UAS A	*UAS B*	*Certification*	*IDDM Clause*
Complete UAS	Made in India	Made in India	✓	×
Motors	Imported	Indigenous	×	×
Electronic Speed Controllers (ESCs)	Imported	Indigenous	×	×
Propellers	Imported	Indigenous	×	×
Structure/Airframe	Imported	Indigenous	×	×
Autopilot[64]	Imported	Indigenous	×	×
Software	Imported	Indigenous	×	×
Batteries	Imported	Indigenous	×	×
Battery Cells	Imported	Imported	×	×
Servos	Imported	Imported	×	×
Servo Actuators	Imported	Imported	×	×
Semi-conductors/Chips	Imported	Imported	×	×
Remote Control	Imported	Imported	×	×
Indigenous Content Sub-system/ Components (%)	< 10%	> 60%	–	–
Indigenous Content as per DAP (Cost-wise %)	> 50%	> 50%	–	–
Opportunities				
PLI Benefit	✓	✓	–	–
GeM Enlisting	✓	✓	–	–
Eligibility for Procurement by Government	✓	✓	–	–
Qualifies under IDDM	✓	✓	–	–
Challenges				
Development Challenges	No	High	–	–
Challenges of Scaling Up Production	Low	High	–	–
Certification Challenges	Low	High	–	–

Note: DAP: Defence Acquisition Procedure; IDDM: Indigenously Designed, Developed and Manufactured.
Source: Author's own.

The table indicates that the QCI certifies UAS that use imported as well as indigenously designed and manufactured components. The lack of differentiation between the two becomes a subtle dissuader to UAS components manufacturing in India. The current policy does not discourage low-value assembling of UAS from imported components, despite availability of indigenously developed and manufactured UAS components of comparable performance. The Indian manufacturers are unable to compete with global OEMs with cost undercutting, their established sale and distribution networks in India, false narratives and economic power, who go to any length to make domestic UAS components manufacturing uneconomical or unsustainable. In addition, equal opportunities for procurement of UAS with imported components and Indigenously Designed, Developed and Manufactured (IDDM) procurement on percentage of cost, instead of indigenously designed sub-systems and components, disincentivise indigenous development and manufacturing. These could have an adverse impact on self-reliance in UAS components manufacturing.

Incentivising IDDM in Certification

India has taken a forward step with the launch of a certification scheme for civil UAS weighting less than 500 kg by the QCI. The establishment of certification mechanism is needed for ensuring quality, reliability, safety and security in the small UAS developed and manufactured in India. However, qualification standards and mechanism for certifying medium- and long-endurance civil UAS weighing more than 500 kg are yet to be formulated, which requires active R&D and testing. In addition, the QCI is certifying complete UAS that meets the safety standards. The scheme, however, has certain limitations:

1. The certification process does not differentiate whether UAS are manufactured with indigenous or imported components.
2. There is no IDDM clause in certification to indicate indigenously designed UAS and UAS components.
3. The QCI does not certify UAS components individually, which denies recognition and credibility to indigenously designed UAS components.

Defence UAS Industry

India is building military UAS capability with the development of MALE and combat UAS; upgradion of its Heron UAS fleet; as well as exploring procurement of high-altitude long-endurance (HALE) UAS to strengthen ISR and armed strike capabilities to protect its border with China in the north and the north-east, Pakistan in the west, and large coastal area and ocean in the south, south-east and south-west. India's Aeronautical Development Establishment (ADE), a laboratory of DRDO, is on the verge of completing the development and certification of Tactical Platform for Aerial Surveillance (TAPAS) MALE UAS.[65] The user trials of TAPAS are expected to commence in the last quarter of 2022. The stealth wing flying testbed (SWiFT), a scaled-down version of the jet engine remotely piloted strike aircraft (RPSA)—earlier known as Ghatak—flew its first flight in July 2022, which is an important milestone for developing advanced jet engine combat UAS.[66] The SWiFT was developed from internal funding of DRDO and further development of RPSA would require approval of the project and timely allocation of funds and involvement of users. Also, the Indian Navy (IN) is not yet involved in the RPSA project and it could examine active participation in its development as partner to obviate design reviews at a later stage.

Defence UAS industry, despite its promise, faces challenges of time and cost overruns and dependence on imports for aero engines, sensors and weapons. India is aiming to develop a wide variety of unmanned systems comprising small, tactical, MALE, HALE, combat and loitering UAS, for which it needs batteries and Wankel, internal combustion, turboprop and turbojet engines in large numbers. The country also needs huge quantity of engines for its manned aircraft and missile programmes. The dependence on imported systems makes export of its UAS, manned aircraft and missiles a challenge. Therefore, development of engines, sensors, weapons and components needs to be made a national priority.

Design and Development (D&D) Competitions

Mehar Baba D&D Competition (2018–21), conducted by the Indian Air Force (IAF), not only brought swarm UAS technology in India but also stimulated domestic innovation, which is playing a major role in the development of niche swarm drone technologies and their adoption in civil and military applications in India. The launching of iDEX in 2018,[67] Border Security Force (BSF) High-Tech Undertaking for Maximising Innovation (BHUMI) Grand Challenge in 2021[68] and 75 innovation challenges by the Naval Innovation and Indigenisation Organisation (NIIO) in 2022[69] indicate high enthusiasm for leveraging D&D competitions for technology development. However, these initiatives are in the infancy stage and need to be strengthened, nurtured and made result-oriented and accountable competitions to optimally leverage the potential of Indian start-ups and innovators.

The display of indigenous armed UAS swarm during Army Day on 15 January 2021[70] and Indian start-ups and MSMEs supplying small ISR UAS to the Indian Army at Jhansi in November 2021[71] indicate increasing participation of private industry in UAS development. However, the deliberations here indicate that the Indian civil and military UAS industry faces unique and diverse challenges that comprise: absence of nodal ministry; UAS import ban anomalies; disincentives for indigenous UAS components manufacturing; and continued dependence on import for aero engines, sensors and weapons. These challenges could become a limiting factor in achieving the goal of making India a global drone hub, and thus need to be addressed on priority.

Way Forward for India

Prime Minister Narendra Modi's emphasis on 'anusandhan' highlights the realisation among the Indian leadership to make research a priority for the growth of the nation. In the UAS sector, making India a global drone hub by 2030 and self-reliance in UAS technologies through research are challenging goals, which require building a research-led UAS industry to make it high-technology, high-value globally competitive one. Some of the measures needed to achieve these goals are mentioned next.

Nodal Ministry for UAS Technology Leadership

Globally, civil aviation ministries and departments lead UAS technology development initiatives, while MoCA and Director General of Civil Aviation (DGCA) do not traditionally steer technology development initiatives. Therefore, there is a need to change and adopt research and technology-led approach. To do this, it is important to nominate MoCA or any other suitable ministry as the nodal ministry for UAS technologies. This nodal ministry will be responsible for: formulation and implementation of policies; steering the development of UAS and associated technologies; creation of an enabling ecosystem; and integration of UAS in Indian airspace. The nominated ministry/department would have to be given technology leadership mandate, which in turn would have to create institutional framework, review policies and leverage its technical manpower for technology development to support UAS technology leadership goals of 2030 and 2047.

R&D Directorate in MoCA

Revive R&D directorate in MoCA with enhanced mandate to lead and support civil aviation, airspace integration and associated D&D projects.[72]

UAS Technology and Airspace Integration Advisory Committee

A UAS Technology Development and Airspace Integration Committee may be established to advise the government for developing UAS technologies and integration of UAS in the Indian airspace.

National UAS Research and Manufacturing Road Map

The UAS research initiatives are essential for stimulating domestic manufacturing and facilitating their integration in the national airspace. India's UAS industry, comprising start-ups, MSMEs, private and public sector companies, is pursuing indigenous development of small ISR, armed and swarm UAS; CATS, TAPAS and RPSA; however, incoherence, duplication, inefficiencies and lack of synergy are the major limitations of its UAS development programmes. Therefore, formulation of a national UAS research and manufacturing road-map is proposed to overcome these limitations and transform the promising UAS industry into 'anusandhan'-based IP-led high-value globally competitive industry. The road map will have five-, ten- and twenty-five year plans, which are as follows:

1. *Five-year airspace integration plan*: The plan would focus on developing technologies and systems that would enable collaborative operation of UAS and manned aircraft in non-segregated airspace in India.
2. *Ten-year UAS research and manufacturing plan*: It will focus on developing emerging UAS and associated technologies, including MALE, HALE, UCAVs, UAM and AAM, and internal combustion, turboshaft, turboprop, small and medium turbojet aero engines, battery cells and semi-conductors.
3. *Twenty-five-year UAS research and manufacturing plan*: This plan involves development of advanced long-range logistics supply, unmanned/optionally manned bombers, transport aircraft and large-helicopters, advanced aero engines, reusable unmanned near-space aircraft, advanced sensors, weapons and other next-generation unmanned technologies.

These plans can be made economically viable by generating revenue from export of current-generation indigenously developed fighters, helicopters, transport and trainer aircraft, as well as small, MALE and armed UAS to friendly countries. In addition, India could explore opportunities to establish collaborations with global partners to expand its network of sale, maintenance, repair and overhaul (MRO) and product support. There is a need to take into consideration envisaged requirements of UAS of various users, indigenous manufacturing capabilities and challenges, and formulate a UAS research and manufacturing road map in consultation with MoCA, Ministry of Defence (MoD), Ministry of Home Affairs (MHA), DRDO, DPSUs, academia, industry and domain experts. Also, the aforementioned plans would have to be broken down to systems, sub-systems, components, sensors and weapons that need to be developed; and define timelines, ownership and responsibilities of stakeholders. The DST, MeitY, MoD, MHA, Ministry of Finance and MoCA could articulate UAS technology-related problem statements and allocate funds to designated national CoEs for developing those technologies. The *UAS research and manufacturing road map must have higher oversight* to bring synergy among various ministries to fill policy, technology and synergy gaps.

National CoEs on UAS Technologies

Indian academic and industrial institutions pursue R&D programmes in silos that lead to lack of synergy, duplication and wastage of meagre resources. In line with global best practices, it is proposed to establish national CoEs on UAS technologies with the participation of academia, R&D organisations, industry and users. These centres should be established near UAS testing sites and in dedicated UAS design, development and manufacturing hubs to contribute in capability building. The proposed national CoEs in UAS technologies and their focus areas of R&D are as follows:

1. *CoE for innovative UAS*: Unmanned combat aircraft, manned–unmanned teaming, swarm, near-space and other emerging unmanned technologies.
2. *CoE for transport UAS*: UAM, AAM, medium- and long-range transport and logistics UAS.
3. *CoE for propulsion systems*: Internal combustion and jet propulsion systems and associated technologies.

4. *CoE for airspace management technologies*: UAS traffic management systems, detect and avoid, remote tracking, cyber security and associated technologies for airspace integration.
5. *CoE for sensor technologies*: EO, IR, lasers, multi-spectral and hyper-spectral cameras and other sensors.
6. *CoE for weapon systems*: This centre would focus on developing bombs, missiles, smart munitions, their miniaturisation and other technologies for improving accuracy and effectiveness.
7. *CoE for green technologies*: Batteries, solar and other green technologies with applications in the UAS.
8. *CoE for advanced software*. Develop simulation and other advanced software needed for design, development, testing and validation.

Selection, Ownership and Performance Appraisal

The government may grant rights for establishing CoEs to consortiums on a competitive basis. The consortiums could comprise of R&D organisations, academia, industry, individual innovators and other stakeholders, who would work on developing technologies with well-defined problem statements, timelines, work share and deliverables with clear accountability, to fill research and capability gaps in UAS technologies. A committee of experts would select the consortiums to form CoEs based on their plan, capability, infrastructure, innovative solutions and technical, operational and commercial viability. The committee would take into account risk of failures of complex projects; however, lack of performance would lead to stoppage of funding, derecognition and other measures as deemed appropriate.

Research, Funding and Optimisation

The CoEs would identify technology gaps of Indian UAS industry and propose time-bound plans for developing such technologies, as discussed earlier. All ministries and government entities would take up technology development projects with the CoEs and become partners by providing funding and involving their qualified domain experts as members of design teams of projects. The national CoEs would overcome the problem of stakeholders working in silos, duplication in technology development and wastage of meagre national resources.

Pillars of UAS Technology Ecosystem

India lacks enabling ecosystem and essential pillars, that is, R&D, testing, certification and standards, for building high-value UAS industry, which becomes a hindrance to innovation and development of UAS technologies by private sector and individual innovators. Therefore, India needs to create an ecosystem and establish essential pillars to support innovation and develop research- and IP-based high-technology, high-value globally competitive UAS industry in India. The modalities for creating these pillars are deliberated next.

Academic Courses and Infrastructure for Unmanned Systems

It is essential to introduce dedicated MTech and PhD courses on unmanned systems as per best global academic curriculums. These need to be supported with the creation of UAS laboratories and testing and training infrastructure in academic institutions to prepare Indian engineers for research, design, development and manufacturing of advanced UAS. They need to have result-oriented collaboration with design, development and manufacturing entities for optimally leveraging intellectual potential of students and researchers for developing niche technologies.

UAS Research and Technology Initiatives

India needs to launch following research and technology development initiatives that are to be completed in a time-bound manner to make its UAS industry a technology-led high-value industry:

1. Civil and military UTM systems.
2. Remote identification and tracking, collision avoidance, secure and reliable communication networks for line of sight and BVLOS operations, and other enabling technologies for safe integration of UAS in air traffic and air defence systems.
3. UAM, AAM and logistics UAS development, testing and certification programmes.
4. Propulsion systems for UAS of different sizes and performance, including battery cells and internal combustion, Wankel, turboprop, turbojet and turbofan aero engines under a dedicated programme.
5. Flight controllers, radio, data transmission devices, operating systems, network connectivity and network storage devices.
6. Sensors and weapons.
7. *Ownership and stakeholders involvement*: The critical element in the success of these research initiatives would be ownership by the concerned ministries/organisations and the involvement of

stakeholders in technology development projects. The technological initiatives that need to be launched are given in Table 3.

Table 3

S. No.	*Technology/ Manufacturing Gaps*	*Potential Stakeholders*	*Action Required (D, T)**	*Strategy (D&D, Col and PI)#*
1	UAM and AAM	MoCA, DGCA, Industry, Academia	D&T	D&D
2	UTM	MoCA, DGCA, IAF, MHA, IA, IN	D&T	D&D
3	Real-time Tracking	MoCA, DGCA, IAF, Industry, Academia	D&T	D&D
4	Collision Avoidance	MoCA, IAF, Industry, Academia	D&T	D&D
5	Batteries Cells	Industry, Academia, Ministry of Finance	D&T	D&D, PI
6	Aero Engines	DRDO, HAL, Industry, Academia	D	D&D, PI
7	Semi-conductors	Industry, Academia, MeitY, Ministry of Finance	D	D&D, PI & Col
8	Sensors	Industry, Academia, MeitY, Ministry of Finance, DST	D&T	D&D, PI
9	Weapons	Industry, DDP, IA, IN, IAF	D&T	D&D
10	Flight controllers, radio, data transmission devices, operating systems, network connectivity and network storage devices	Industry, MeitY, IAF, IA, IN & MHA	D&T	D&D
11	Communication	DoT, MoCA, Industry, Academia	D&T	D&D, PI

Notes: IA: Indian Army, HAL: Hindustan Aeronautics Limited, DDP: Department of Defence Procurement, DoT: Department of Telecommunications; *D: development, T: testing and validation; and #D&D: design and development, Col: collaboration with international players, PI: policy interventions.
Source: Author's own.

Establishing Testing Sites

The establishment of following national testing sites is proposed:

1. *High-altitude testing site*: High-altitude and sub-zero temperature flight testing site at an elevation of 10,000 feet and above in states/union territories, like Ladakh, Himachal Pradesh and Sikkim.
2. *Desert testing site*: Deserts and high-temperature flight testing site in desert region of Rajasthan and neighbouring states with summer temperatures higher than + 45°C.
3. *North-east testing site*: High-rainfall and high-wind flight testing site near hilly forest areas of north-east India.
4. *Coastal testing site*: Coastal area flight testing site in southern India.
5. *Central India testing site*: Flight testing site in plain areas of north or central India, like Uttar Pradesh, Madhya Pradesh and Bihar.
6. *Over sea testing site*: Flight testing site over sea, backwaters and island territories for testing indigenously designed, high-speed long-range amphibious and other UAS.

Table 4

S. No.	*Testing Sites*	*Geographical Location*	*Potential Stakeholders*
1	High-altitude Testing Site	Ladakh, J&K, Himachal, Sikkim	IA, IAF, AAI, Centre and State Government
2	Desert Testing Sites	Rajasthan, Gujarat	IA, IAF, CAPF, AAI, Centre and State Government
3	Central India Testing Site	North/Central India	IA, IAF, BSF, AAI, Centre and State Government
4	Coastal Testing Site	Southern States	IA, IAF, IN, Coast Guard, AAI, Centre and State Government
5	Over Sea Testing Site	Coastal States	IN, Coast Guard, IAF, Centre and State Government
6	North-east Testing Sites	North-east States	IAF, IA, Assam Rifles, Centre and State Government, AAI

Note: J&K: Jammu and Kashmir; AAI: Airports Authority of India.
Source: Author's analysis and recommendations.

The given table indicates potential stakeholders for establishing testing sites. These sites should have vertical airspace of at least 5,000 feet, horizontal airspace between 30–50 kilometre (km), minimum 1 km long runway, helipads, hangers, and testing, certification and administrative infrastructure. The sties should function on the principle of 'maximum teeth and minimum tail', with minimum spending on administrative set-up while ensuring maximum operational efficiency. Further, these sites should operate professionally in collaboration with academia and industry to transform promising and innovative technologies into commercially viable systems and products.

Formulating Standards for Certification and QA

Indian standards, certification and QA bodies—that is, Centre for Military Airworthiness and Certification (CEMILAC), QCI, BIS, DGCA, Directorate General of Aeronautical Quality Assurance (DGAQA) and Department of Defence Production (DDP)—need to adopt research, testing and trials methodology for formulating testing, standards and QA mechanisms and bring certain level of standardisation in UAS manufacturing.

D&D Programmes

The D&D programmes, such as iDEX, TDF, BHUMI, Mehar Baba Competitions and device development programmes, should be optimally leveraged for filling technology gaps in the UAS industry, developing enabling technologies and integrating UAS in the Indian airspace.

Policy Measures

The following policy measures are proposed to stimulate domestic UAS and UAS components manufacturing industry and address policy contradictions:

1. *Certification of UAS above 500 kg*: The process of certification of UAS weighing more than 500 kg needs to be finalised and the certification agency nominated.
2. *Standards and certification of defence UAS*: Standards and certification mechanism for small and other UAS acquired by India's defence forces need to be simplified to facilitate interoperability, safety and security of UAS.
3. *QCI certification of indigenously designed UAS components and sensors*: The certification of indigenously designed UAS components and sensors may be introduced to support and encourage domestic design, development and manufacturing.
4. *Certification of import substitutes*: A simple process for substituting imported components with indigenously designed UAS components may be introduced in the certification mechanism by the QCI.

5. *IDDM in UAS certification*: The IDDM clause is recommended to be introduced in type certificate (TC) of UAS and components, systems and payloads.
6. *Preferential procurement of UAS with indigenously designed components*: The UAS with indigenously designed components may be given preference for procurement by all ministries.
7. *Positive indigenisation list*: Indigenously designed UAS components should be identified and included in the positive indigenisation list.
8. *UAS import ban*: The exemption given to government entities for import should be reviewed in view of improved domestic manufacturing capability, and mechanism for implementation of UAS import ban should be strengthened.
9. *Indigenous content assessment policy*: The systems development life cycle (SDLC) audit or other scientific assessment mechanisms as deemed appropriate need to be introduced in Defence Acquisition Procedure (DAP).[73]

The Indian UAS industry is a promising industry led by start-ups and MSMEs. It needs research initiatives, enabling ecosystem, hand-holding and leadership support to build larger and more capable UAS in the country amid challenges from global players. The commercial viability of indigenously designed UAS and UAS components, and survivability of domestic manufacturing industry, would heavily depend on the implementation of the initiatives proposed here, as well as overcoming policy implementation contradictions. Necessary measures are needed to discourage, and if required, penalise, attempts to pass on imported UAS and UAS components as indigenous. The measures suggested here will give a boost to domestic innovation and raise the morale of innovators. Such measures are essential for preventing brain and technology drain, and building research-led high-value UAS industry in India.

Conclusion

The Indian government, encouraged by the promise shown by its start-ups and MSMEs-led UAS industry, took several industry-friendly policy initiatives in the last one year. It set the goal of making India a global drone hub by 2030. The conflict with China in Galwan in 2020, developments in Ukraine–Russia war, India's technological challenges and import dependencies for critical systems convinced the government to pursue the path of self-reliance. The prime minister, in a speech in August 2022, emphasised the need for pursuing 'anusandhan' and called for making India an 'amanirbhar' (self-reliant) and developed country by 2047. However, research has been one of the weak links of India—an aspect which was visible when global research initiatives in UAS and associated technologies were compared with UAS technologies research initiatives of India. The emphasis on research is essential for transformation of Indian UAS industry to innovation and IP-led high-value industry.

The Indian UAS manufacturing industry needs an enabling ecosystem and strong pillars of technology development, comprising research and technology development programmes, testing sites, standards, certification mechanisms and standardisation in UAS and UAS components manufacturing, to become globally competitive. There is a need to review policy on import of UAS components as well as overcome the policy implementation challenges to stay on the path of self-reliance. The certification process needs to incorporate provisions for certifying UAS above 500 kg, as also introduce IDDM clause in UAS and UAS components certification to stimulate indigenous design and development.

The creation of a UAS research and manufacturing road-map, national CoEs on UAS, pillars of UAS technology development; launching research and technology development initiatives; incentivising UAS component manufacturing and other policy measures, all would fill critical technology, capability and policy gaps. India needs to adopt long-term strategy and persist with utmost dedication to achieve excellence in niche technologies. Indian talent, supported by the proposed road map, has the potential to take the country towards its intended path of building 'anusandhan'-led high-technology, high-value globally competitive 'atmanirbhar' UAS industry.

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