

UNMANNED AERIAL SYSTEMS AND COUNTER-UNMANNED AERIAL SYSTEMS: CHALLENGES AND OPPORTUNITIES FOR INDIA

SARANG SUDHIR PRABHUNE AND ABHISHEK JAISWAL

Jai Jawan, Jai Kisan, Jai Vigyaan aur Jai Anusandhan.

- Prime Minister Shri Narendra Modi¹

INTRODUCTION

In August 2021, Union Minister for Civil Aviation Shri Jyotiraditya Scindia stated that the aim of the government was to make India a global drone hub by 2030.² Towards this, the government has taken steps to promote Unmanned Aerial Systems (UAS) and UAS components in India.³ With

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1. <https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=1558459>. Accessed on August 12, 2023.
2. www.ETInfra.com, <https://infra.economictimes.indiatimes.com/news/aviation/india-to-become-global-dronehub-by-2030-jyotiraditya-scindia/>. Accessed on August 11, 2023.
3. These steps include notification of the liberalised Drone Rules 2021, publication of the Drone Airspace Map in September 2021 and promulgation of the policy framework for the UAS Traffic Management System in India in October 2021, National Unmanned Aircraft System Traffic Management (UTM) Policy Framework on October 24, 2021.

The IAF faces the challenge of fulfilling the national vision of enhancing domestic drone applications and production while performing its core functions.

advancements in technology, reducing cost and greater commercial availability, the applications of UAS have increased exponentially; more so in the non-military domain. Easy availability of UAS for anti-national elements, however, has been one of the reasons for the development of Counter-UAS (CUAS).

The Armenia-Azerbaijan War of 2020 and the ongoing Russia-Ukraine War demonstrate further expansion in the combat roles of UAS and CUAS.

The Indian Air Force (IAF) has the experience of operating a variety of UAS for over two decades. The attack by UAS on Air Force Station Jammu in June 21 has highlighted the threat posed by the proliferation of small and commercially available UAS.⁴ This has led to the induction of CUAS in the IAF. The Indian Army and Indian Navy have also enhanced their inventories of UAS and CUAS. As the guardians of the Indian airspace and one of its largest users, the IAF is the stakeholder most affected by developments in the UAS and CUAS domains. The initiative of the IAF in indigenous UAS development is best illustrated in the overwhelming response to the Mehar Baba Competition, indicating the impact the IAF can have on making India the global UAS-making hub. The IAF faces the challenge of fulfilling the national vision of enhancing domestic drone applications and production while performing its core functions. Effective employment of UAS and CUAS towards the execution of the air strategy, as articulated in IAF Doctrine IAP 2000-22, would assist the IAF to enhance its operational capability as well as fulfil the national vision.

4. "Drone Terror Attack on Jammu Airport: A Deadly and Dangerous Dare", ORF, www.orfonline.org. Accessed on August 11, 2023.

SURVEY OF LITERATURE AND RATIONALE OF STUDY

The implications of developments in UAS and CUAS have been studied globally as well as in India.⁵ The importance of drone warfare capacity building in India has been well brought out in a paper recently published by the Vivekananda International Foundation (VIF).⁶ The military technological aspects of UAS⁷ and CUAS relevant to India are well documented. The literature on the IAF's perspective on proliferation of UAS and CUAS, however, is limited. The IAF Doctrine IAP 2000-22 elucidates the air strategy for peace, No War No Peace (NWNP) and war.⁸ The application of UAS and CUAS in the IAF's air strategy shall be impacted by the use of UAS and CUAS by other operators in the country as well as the regulatory framework. The operational stamina to sustain UAS and CUAS through a conflict can materialise only with the help of a robust domestic manufacturing capability.

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EMPLOYMENT OF UAS AND CUAS ACROSS THE GLOBE

'Unmanned Aircraft System (UAS)' means an aircraft that can operate autonomously or can be operated remotely without a pilot on board.⁹ Practically, the UAS range from large aircraft such as the Global Hawk to the nano-drones commercially available for recreational purposes. While larger UAS can be neutralised by existing air defence weapons, CUAS include an hierarchy of counter-measures that encompass regulatory, preventive and

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5. Krutika Patil, "Drone Warfare History, Evolution and Future", *Air Power Journal*, vol. 16, no. 4, October–December 2022, pp. 243–251.
 6. Harshita Nag, "Drone Warfare: Capacity Building in Securing India's National Interests", Vivekananda International Foundation, May 2023, pp 7-29.
 7. S Das, "Emerging Drone Technology Relevance for India", Centre for Joint Warfare Studies (CENJOWS), August 17, 2022, pp 1-12.
 8. Indian Air Force, "Doctrine of the Indian Air Force: IAP 2000-22", 2022.
 9. Ministry of Civil Aviation "The Drone Rules, 2021", Notification, *The Gazette Of India: Extraordinary* [Part II— Sec. 3(i)], August 25, 2021.

reactive counter-measures (kinetic and non-kinetic means) to neutralise smaller UAS.¹⁰

UAS have played an important role in conflicts such as the Vietnam War, Arab-Israel Wars and Iran-Iraq War. Improved materials and reduced size and Radar Cross-Section (RCS) have made it almost impossible to shoot down the UAS by contemporary Air Defence (AD) systems.¹¹ The combat advantage offered by UAS made a strong case for self-reliance in UAS manufacturing. The indigenisation of UAS technology by Iran since then has had far-reaching consequences which are seen in Iran's support to Russia in the current Russia-Ukraine War. Operation Enduring Freedom saw the first combat use of the new Global Hawk [High Altitude Long Endurance (HALE) UAV] and Predator, armed with Hellfire missiles;¹² and also highlighted the ethical and legal issues of their employment. In this operation, the major lesson learnt was that UAS should be improved to reduce their vulnerability to weather, enemy air defences, and mechanical and communication failures.¹³

The operational impact of UAS became the main topic of discussion after the Armenia- Azerbaijan conflict of 2020. The impact of UAS as armed combat systems capable of integrated attacks with air force and artillery units, and independent interdiction missions in a symmetric conflict was demonstrated for the first time.¹⁴ The inability of Armenian AD systems to detect, identify and track the slow-moving UAS brought out the need for specialised CUAS systems. The unprecedented use of UAS and CUAS in the ongoing Russia-Ukraine War demonstrated the application of the lessons learnt so far. This war has highlighted the capability of UAS to undertake deep penetration strikes and Destruction of Enemy Air Defence

10. Apratim Sharma, "Counter-Unmanned Aircraft Systems (C-UAS) Future of Warfare", *Air Power Journal*, vol. 16, no. 4, October-December 2022, pp. 221-241.

11. Nova Science Programming on Air and Online, "Nova Spies that Fly", https://www.pbs.org/wgbh/nova/spiesfly/uavs_13.html. Accessed on August 29, 2023.

12. Benjamin S. Lambeth, "Operation Enduring Freedom: An Assessment", www.rand.org/pubs/research_briefs/RB9148.html. Accessed on August 29, 2023.

13. Ibid.

14. Damir Ilif and Vladimir Tomasevic, "The Impact of the Nagorno-Karabakh Conflict in 2020 on the Perception of Combat Drones", https://www.researchgate.net/publication/351667276_The_impact_of_the_Nagorno-Karabakh_conflict_in_2020_on_the_perception_of_combat_drones. Accessed on August 29, 2023.

(DEAD), undetected Intelligence, Surveillance, Reconnaissance (ISR) and Battle Damage Assessment (BDA) inside enemy territory, saturation of enemy air defences and exhausting costly enemy AD resources by low-cost drones.

The limitations of conventional AD systems in preventing attacks were exposed in the early part of this war. Using conventional weapons to stop these UAS far exceeds their cost. Battles of attrition, with each side attempting to exhaust its enemy's resources by using low cost-low tech UAS are being witnessed increasingly.¹⁵ Both Ukraine and Russia have undertaken extensive measures to counter enemy UAS operations. In recent times, Russia has shown enormous resilience and innovation in employing CUAS.

The growth of CUAS technology is directly tied to mounting concerns about the threat that drones pose in both civilian and conflict environments. In the conflicts in Syria and Iraq, it was reported that US forces had no control of the airspace below 3,500 ft in the area.¹⁶ The conflict in Ukraine is another important case study on the impact of small UAS in modern warfare.¹⁷ The most active cyber/electronic attacks to counter Ukrainian drones have been carried out by the Russians. On the battlefield, CUAS systems have so far most commonly been used for base protection and complementing existing weapons. In the civilian environment, counter-drone technology has primarily been used for airspace protection at airports, providing security cover during large gatherings, major sporting events, VIP protection and counter-smuggling operations. Future common applications could include airspace defence around sensitive facilities, port and maritime security and personal use over private property.¹⁸ During the recently concluded G20

15. Roberto J. González, "Drones over Ukraine: What the War Means for the Future of Remotely Piloted Aircraft in Combat", <https://theconversation.com/drones-over-ukraine-what-the-war-means-for-the-future-of-remotely-piloted-aircraft-in-combat-197612>, Published: February 23, 2023 1.14pm GMT. Accessed on August 29, 2023.

16. Lambeth, n.12.

17. Arthur Holland Michel, "Counter-Drone Systems", CSD-Counter-Drone-Systems-Report.pdf bard.edu, February 2018, pp.1-6. Accessed on August 10, 2023.

18. Ibid.

Summit in Delhi, CUAS developed by the Defence Research and Development Organisation (DRDO) were deployed to counter the rogue drone threat.¹⁹

CAPABILITIES OF INDIA'S ADVERSARIES

The drones are a terrorist weapon; they not only kill targets but also terrorise other people.

– Noam Chomsky²⁰

UAS Inventories of the Pakistan Air Force (PAF) and People's Liberation Army Air Force (PLAAF): Pakistan has made extensive gains in the employment of UAS in recent years. Both the Pakistan Army and Navy have been operating several UAVs for surveillance such as the Scan Eagle and Uqab. The Burraq Unmanned Combat Aerial Vehicle (UCAV), Pakistan's first combat drone, has been used to target Tehrik-e-Taliban Pakistan (TTP) hide-outs in Waziristan.²¹ With China and Turkey supplying it with proven UAS, Pakistan possesses formidable capability in this regard. Similarly, the PLAAF has invested significant time and effort in the domain of UAS.²² It has been developing and deploying various types of UAS for different missions, such as ISR, electronic warfare, and combat.²³ The UAS that the PLAAF operates include the hypersonic UAVs,²⁴ a mix of Medium Altitude Long Endurance (MALE) and HALE platforms, capable of an array of missions, including

19. Harsh Vardhan, "DRDO's Special Counter-Drone System Guards Delhi's Skies for Mega G20 Summit", *India News*, <https://www.republicworld.com>. Accessed on August 10, 2023.

20. <https://www.relicsworld.com/noam-chomsky/the-drones-are-a-terrorist-weapon-they-not-only-kill-targets-but- author-noam-chomsky>. Accessed on August 16, 2023.

21. Aritra Banerjee, "Pakistan 'Races Ahead' of India in Drone Technology; Is 4th Country To Deploy UCAVs In Combat Ops", *The Eurasian Times*, September 8, 2021. Accessed on August 10, 2023.

22. Elsa Kania, "The PLA's Unmanned Aerial Systems New Capabilities for a 'New Era' of Chinese Military Power", China Aerospace Studies Institute, August 29, 2018, <https://www.airuniversity.af.edu/>. Accessed on September 10, 2023.

23. Elsa Kania and Kenneth Allen, "The Human and Organizational Dimensions of the PLA's Unmanned Aerial Vehicle Systems", Jamestown Publication, *China Brief*, vol, 16 issue: 8, <https://jamestown.org/>. Accessed on September 10, 2023.

24. Paul Bernstein and Dain Hancock, "China's Hypersonic Weapons", *Georgetown Journal of International Affairs*, January 27, 2021. Accessed on September 13, 2023.

Manned-Unmanned Teaming (MUM-T). The indigenous capability of China to manufacture UAS is formidable.

CUAS Capabilities of Pakistan and China: Pakistan has installed anti-drone systems in some of its naval bases such as Karachi, Gwadar and Turbat. These systems are developed by the National Radio and Telecom Corporation (NRTC) and can detect and jam drones up to 4 km away.²⁵ The PAF has a number of imported CUAS such as the Kestrel, a Turkish-made anti-drone system that uses Radio Frequency (RF) jamming and net guns; Sky Warden, an American-made anti-drone system that uses a combination of RF jamming, lasers and guns; and Thunder Dragon, a Pakistani-made anti-drone system that uses RF jamming and net guns.²⁶ China has demonstrated the capabilities of CUAS such as the LW-30 laser defence system, a vehicle-mounted hard kill system with 30 Kilowatt (KW) power developed by the China Space Sanjiang Group. The ZK-K20 tactical command system can control medium and long-range air defence weapons to intercept large combat drones as well as perform close-in counter-measures against medium, small or mini drones, including those travelling in swarms. The intercept system of the ZK- K20 includes a number of equipment options, including the HK-17AE short- range missile system.

Implications for India: It is evident that both these adversaries have significant capability in terms of UAS and CUAS. The larger UAS in these countries can be countered by the IAF through a well networked structure of air defence and weapon systems. Pakistan and China have also made covert use of UAS along the International Boundary (IB) and Line of Actual Control (LAC). Since 2018-19, Pakistan has been using drones to send in arms and ammunition, drugs and counterfeit currency across the IB and Line of Control (LoC). Pakistan's Inter-Services Intelligence (ISI) is reported to have established six drone centres across the border to coordinate anti-

25. Srinjoy Chowdhury and Rajeshwari Ganeshan, "Pakistan NRTC Installing Anti-Drone Systems in Karachi, Gwadar, Turbat" www.timesnownews.com/world/pakistan-nrtc-installing-anti-drone-systems-in-karachi-gwadar-turbat-and-sir-creek. Accessed on September 10, 2023.

26. Ibid.

China has deployed reconnaissance and cargo drones along the LAC with India ever since it deployed troops in Ladakh in 2020.

India activities through aerial means.²⁷ China has deployed reconnaissance and cargo drones along the LAC with India ever since it deployed troops in Ladakh in 2020. Reports of palm-sized UAS being deployed along the LAC in Arunachal Pradesh have led the Indian Army to look for counter-drone technologies.²⁸ Such UAS can be transferred to Anti-National Elements (ANEs) for operation in border areas as well as within Indian territory. They need to be countered by dedicated CUAS.

The Indian security agencies have started exploring indigenous CUAS solutions. The Border Security Force (BSF) has deployed hand-held RF jammers at the international border to disrupt and block drone flights. In July 2021, the BSF, in partnership with the Ministry of Electronics and Information Technology (MeitY) start-up hub, launched the BHUMI (BSF High-tech Undertaking for Maximising Innovation) challenge for exploring new technologies to provide solutions for border security.²⁹ A successful outcome of this initiative is the development of the indigenous counter-drone gun developed by Gurutvaa Systems, a Pune-based start-up. In a recent procurement, the Indian Army has inducted truck-mounted CUAS with an effective detection and jamming range of 10 km. Earlier, in January 2023, it had issued a procurement tender for 20 such systems. In May 2022, the Indian firm Gurutvaa Systems³⁰ delivered the first set of the indigenously

27. Colonel US Rathore, "Drone: The Winning Edge", *Indian Defence Review*, July 29, 2022, <http://www.indiandefencereview.com/news/drone-the-wining-edge/>. Accessed on September 10, 2023.

28. Editorial Staff, "IAF Signs Kamikaze Swarm Drone Contract with Indian Start-up", August 15, 2023, www.defencenews.in/2023/08/iaf-signs-kamikaze-swarm-drone-contract-with-indian-start-up/. Accessed on September 10, 2023.

29. MeitY IR, Press release-PIB Delhi, "Azadi ka Digital Mahotsav", Posted on December 02, 2021. Accessed on September 13, 2023.

30. "Indian Army Inducts 2 Truck Mounted CUAS", Internet Group Management Protocol (IGMP) Bureau, August 22, 2023, www.theigmp.org/indian-army-inducts-2-truck-mounted-counter-unmanned-aircraft-systems-c-uas/. Accessed on September 10, 2023.

developed Dronaam CUAS to the IAF within nine months of signing the contract.³¹

Opportunity for India: UAS have made air power available to all actors without the necessity of infrastructure, training and skill, and with cost at the lowest end of the UAS spectrum; reduced the risk of operation of air power when used with advanced technology, infrastructure and training as we progress towards the higher end of the same.

This has opened up an array of applications in the civilian as well as military domain. While their ability to undertake dull, dirty and dangerous missions provides decisive combat advantage, their increasing vulnerability to AD weapons and CUAS is also a point for consideration. Although drones are transforming warfare, they are not an invincible silver bullet and cannot win wars or battles on their own. Nevertheless, there is a definite case to revisit the concepts of air power and control of the air at both doctrinal and functional levels.

At the geopolitical level, the trends indicate that comparatively low levels of technology to manufacture and operate these systems enable nations to achieve combat advantage as well as geopolitical influence even when lacking access to high end technologies required for conventional air power. Turkey and Iran illustrate this point. These systems enable a weaker adversary to reduce the capability differential against a superior adversary to some extent. While UAS are far from being capable of replacing manned aircraft in all roles, they are effective instruments of warfare. The advantage that self-reliance in UAS and CUAS manufacturing can bring to a nation, therefore, cannot be overstated. This is where the biggest opportunity lies for India.

UAS have made air power available to all actors without the necessity of infrastructure, training and skill, and with cost at the lowest end of the UAS spectrum.

31. Amit Kalra, "Gurutvaa Systems Delivers 'Dronaam' C-UAS to Indian Air Force", May 19, 2022, www.janes.com/defence-news/news-detail/gurutvaa-systems-delivers-dronaam-c-uas-to-indian-air-force. Accessed on September 10, 2023.

UAS AND CUAS FOR EXECUTION OF AIR STRATEGY AS PER THE IAF DOCTRINE

Air power is like oxygen. When you have enough, you don't have to think about it. When you don't have enough, that's all you can think about.

– General Frank Gorenc, USAF³²

With UAS adding another dimension to the concepts of air or aerospace power, evaluation of the capability of the IAF in exploiting these systems towards the furtherance of the air strategy is necessary. The air strategy laid down in the IAF Doctrine 2000-22 provides the framework for the same.

Peace-Time Employment of UAS: The IAF's peace-time strategy of aerospace power consists of four broad approaches viz sovereignty protection, deterrence, air diplomacy and nation-building (Fig1).³³ UAS have been used in the airspace, sea and ground for peace-time surveillance and sovereignty protection across the globe. The IAF and Indian Navy have been operating the traditional Searcher Mk II and Heron tactical Unmanned Aerial Vehicles (UAVs) for ISR missions for the last 12–13 years.³⁴ These platforms also provide the capability to conduct missions towards aid to civil power in disaster relief operations by persistent surveillance. The IAF's plan, under "Project Cheetah," will see Heron drones flying with the IAF, Indian Army, and Indian Navy upgraded with laser-guided bombs, air-to-ground and air-launched anti-tank guided missiles. The recent induction of these systems in Kashmir Valley demonstrates the IAF's capability and resolve. The IAF already operates the Israeli-made UAVs, including the Israel Aerospace Industries (IAI)-made Searchers and unarmed Herons for surveillance and intelligence gathering. These systems provide many hard and soft power options of aerial diplomacy. The Mehar Baba Competition of the IAF has

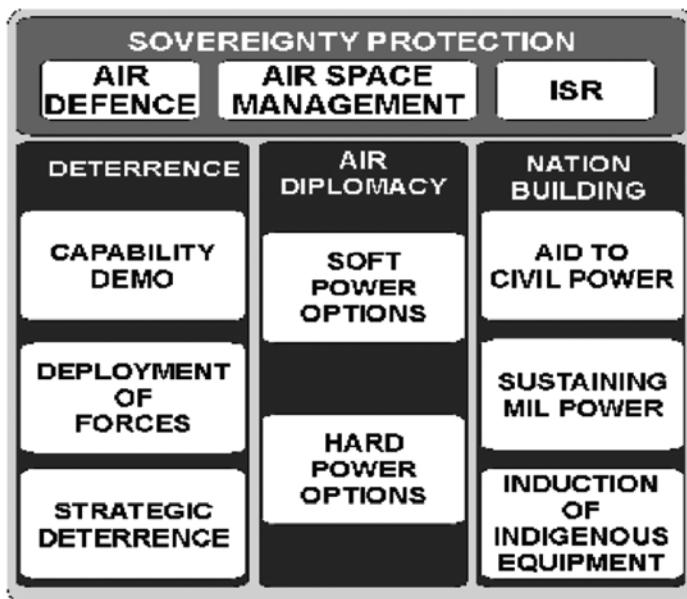
32.. "NATO Air Power," Joint Air Power Competence Centre, japcc.org. Accessed on September 12, 2023.

33. n.8, pp. 5-85.

34. Captain HPS Sodhi, "Naval Shipborne Unmanned Aerial System" Centre for Air Power Studies, February 25, 2015, www.CAPS_Infocus_HPS_3.pdf, capsindia.org. Accessed on September 10, 2023.

ushered in the drone swarm revolution in the country and paved the way for increased induction of indigenous systems.

Fig 1: Peace-time Air Strategy, IAF



The D4 (Drone Detect, Deter and Destroy) CUAS developed by DRDO have been deployed by the IAF during Republic Day, Independence Day and in the recent G20 Summit for Vital Area (VA) protection against drones.³⁵ A multi-system security apparatus was also established by the IAF to secure the airspace over the national capital for the G20 Summit on September 9-10, 2023, using counter drone systems, air defence missiles and airborne surveillance platforms. Such CUAS provide certain AD capability against enemy/ ANE UAS.

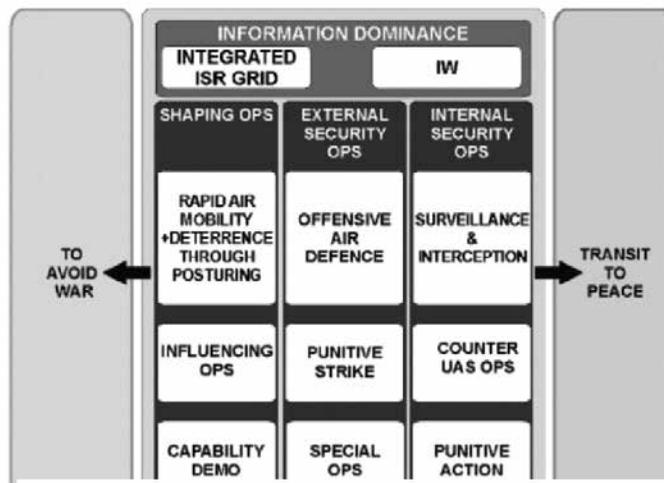
A major capability gap, however, exists in the conduct of UAS operations in sustaining military power. With numerous prolonged deployments in high altitude, mountainous and remote areas, induction of logistics UAS would

35. Ajay Banerjee, "G-20: Jets, Drones, Missiles to Secure Delhi Airspace During Summit," *The Tribune*, August 31, 2023, www.tribuneindia.com/news/india/g-20-jets-drones-missiles-to-secure-delhi-airspace-during-summit-540138. Accessed on September 10, 2023.

provide quick, cost-effective solutions, especially for supplying low weight critical items such as spare parts of sensitive equipment, medical supplies and rations to deployed troops.

Employment of UAS in the No War No Peace (NWNP) Environment: During NWNP, the IAF aims to use its aerospace power strategies to deter, deny, coerce or punish the adversary.

Fig 2: No War No Peace Air Strategy, IAF



The IAF executes its NWNP strategy through information dominance, shaping operations, external security operations and internal security operations (Fig 2).³⁶

The IAF has seen limited use of UAS in NWNP in both external and internal security situations. The roles have been restricted to non-kinetic means like ISR. Hence, there is a need for impetus on exploiting the versatility of UAS, both doctrinally and functionally, and to define situation specific roles and missions. External and internal security operations would be greatly enhanced by using armed UAS without proportionate risk. ISR and communication support in special operations to support insertion and extraction of Special Forces (SFs) would be invaluable. India is one of the

36. Sodhi, n.34, pp. 5-85.

few countries that has the UAS technology and capability but has not used it in an offensive mission. The biggest contribution by UAS can be in undertaking high risk missions at a significantly lower cost. Armed UAS or loitering munitions can be employed effectively for punitive strikes in internal as well as external security operations. CUAS would be of the essence in providing air defence, as ANEs and enemy nations could be expected to enhance use of UAS due to their lack of attributability.

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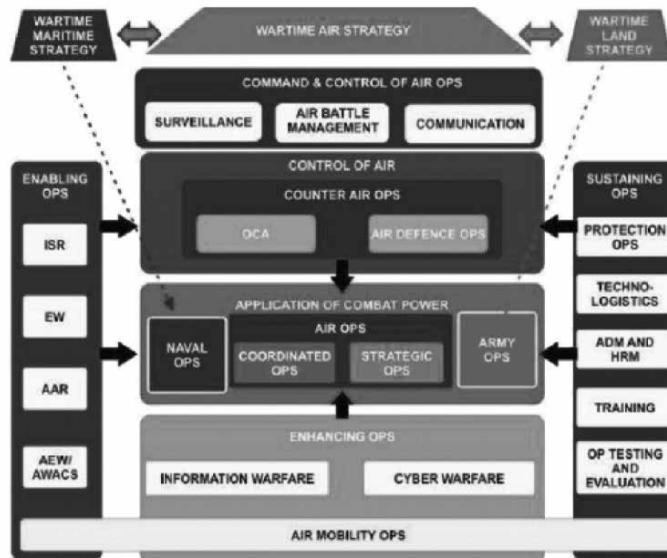
The planned inductions and acquisitions of armed UAS by the IAF indicate an effort towards capability building in this direction. Induction of the Cheetah UAS gives strike capability which can be exploited in internal and external security operations. Tata's indigenously developed ALS 50 loitering munitions have been inducted in the IAF;³⁷ which indicates a unique synergy in capability-building in the operational as well as industrial domain. The technological advancements in the field of UAS, with low cost of procurement and operations, provide an excellent opportunity to the IAF.¹ The need is to include these systems which have trans-domain operational capability as a part of the operational philosophy and Concept of Operations (CONOPS) in an NWNP situation.

Employment of UAS in a Conventional War Scenario: The IAF is an instrument of military power whose *raison d'être* is war-fighting and winning. The missions and roles to be executed by the IAF in war-time are depicted in Fig 3.³⁸

37. "Tata's Indigenously Developed ALS 50 Loitering Munitions Take Flight With IAF", *Indian Aerospace and Defence Bulletin*, May 8, 2023, <https://www.iadb.in/2023/05/08/tatas-indigenously-developed-als-50-loitering-munitions-take-flight-with-iaf/>. Accessed on September 10, 2023.

38. n.8, pp. 5-85.

Fig 3: War-Time Air Strategy, IAF



Global trends have shown that the application of UAS in war-time roles and missions is increasing in quantum as well as effectiveness. UAS and CUAS, undoubtedly, provide certain economical and efficient options in this spectrum.

The IAF has been utilising UAS (Heron and Searcher Mk-II class) in the ISR roles and for carrying out target designation.³⁹ The increasing inventory of armed UAS and loitering munitions adds to the offensive capability for conducting a variety of missions under counter-air operations or applications of combat power. These can include strategic strikes, coordinated operations against surface forces as well as Suppression of Enemy Air Defence/ Destruction of Enemy Air Defence (SEAD/DEAD) missions. The IAF fleet of the Israel Aerospace Industries (IAI)-produced Harpy UAS, which carry a high-explosive warhead and self-destruct to take out targets such as radar stations, aptly illustrates this capability.⁴⁰ These armed systems, however,

39. Ibid.

40. Anna Ahronheim, "India Buys 4 Heron MK II Drones for Surveillance in Ladakh", *The Jerusalem Post*, September 29, 2021, www.jpost.com/international/india-buys-4-heron-mk-ii-drones-for-

operate within the envelope of conventional Ground-Based Air Defence Weapon Systems (GBADWS) and may become vulnerable. Therefore, there is a requirement to induct or develop a true HALE class of UAS such as the Global Hawk that can provide deep strike capability without becoming vulnerable, by flying outside the GBADWS envelope.

Countering the Pakistani and Chinese CUAS would require novel strategies, including saturation of defences. Drone swarms and MUM-T would be an effective solution. The IAF is paving the way ahead for the use of UAS in kinetic military operations. On August 14, 2023, the IAF announced a Rs 300 crore contract with an Indian defence start-up for 200 swarm drones.⁴¹ CUAS would also form a crucial part of air defence and protection operations, especially towards countering Pakistani and Chinese UAS. Systems that focus on jamming satellite navigation systems would provide the additional advantage of affecting the accuracy of certain Precision Guided Munitions (PGMs) which rely solely on satellite navigation for guidance.

Lessons for IAF Air Strategy: UAS and CUAS enhance the options available to an air commander in war-time which would otherwise be unavailable due to the risk or cost. A potent inventory of these systems would augment the manned aircraft and GBADWS during peace, NWNP and war. Certain lessons that are relevant to IAF are given below.

The proven operational utility of UAS highlights the need to recognise them as an element of air power. The capability of UAS to achieve control of the air, though localised in time and space, is well demonstrated. By effective use of UAS, a favourable air situation can be achieved and can be timely exploited for furtherance of coordinated air operations. Conversely, in AD missions, keeping enemy manned aircraft away would not ensure the desired control of the air and effective CUAS would need to be in place.

The high rate of loss of Ukrainian UAS in the Russia-Ukraine War indicates that combat employment of UAS would need to rely on numbers, which can be sustained only by domestic capability. Assisting indigenous development

surveillance-in-ladakh-680589. Accessed on September 10, 2023.

41. "IAF Signs Kamikaze Swarm Drone Contract with Indian Start-up", *Defence News*, August 15, 2023, www.defencenews.in/2023/08/iaf-signs-kamikaze-swarm-drone-contract-with-indian-start-up/. Accessed on September 10, 2023.

UAS can be used to sustain air and ground operations by providing logistic supplies of critical equipment/ spares to units deployed in hilly and inhospitable terrains.

of UAS/CUAS directly by contributing in Research and Development (R&D) and indirectly by raising the demand for these systems, would benefit the IAF in the execution of the air strategy as well as in achieving national aims. The IAF, working synergistically with the industries, would be essential in this regard.

UAS can be used to sustain air and ground operations by providing logistic supplies of critical equipment/ spares to units deployed in hilly and inhospitable terrains. With India's geography, the use of logistics UAS in remote areas could provide a game-changing advantage.

Use of drone swarms in offensive operations such as strikes, airfield attacks and Airborne Warning and Control System (AWACS) busting missions could be explored. Similarly, in defensive operations, drone swarms, either with or without munitions, can act as fences or barrages around a Vital Area (VA) and Vital Point (VP). Drone swarms can play a great role in military logistics.

The manned-unmanned aircraft teaming concept is being developed globally.⁴² The Bengaluru-based start-up New Space Research and Tech is working with Hindustan Aeronautics Limited (HAL) to develop a futuristic air-launched swarm drone system as part of the Manned-Unmanned Teaming (MUM-T) project called the Combat Air Teaming System (CATS).⁴³ Induction and operationalisation of such systems shall add decisive edge to the IAF.

The importance of CUAS in ensuring AD cannot be overstated; however, the impact of CUAS on friendly aircraft and UAS as well as issues of collateral

42. Air Marshal Anil Chopra (Retd), "Drone Swarms are Both Asset and Threat: Is India Ready?" *First Post*, <https://www.firstpost.com/opinion/drone-swarms-are-both-asset-and-threat-is-india-ready-13011392.html>. Accessed on September 10, 2023.

43. Air Marshal Anil Chopra (Retd), "Drone Incursions on the Rise: New Form of Cross-Border Terrorism", *Indian Defence Review*, December 8, 2022, <http://www.indiandefencereview.com/drone-incursions-on-rise-new-form-of-cross-border-terrorism/>. Accessed on September 10, 2023.

damage, especially in the case of kinetic weapons, need to be resolved for effective employment.

REGULATORY FRAMEWORK AND ITS IMPLICATIONS

You need to put drones under control; you need to lay out certain rules of engagement in order to prevent or minimize collateral casualties. It is extremely important.

– President Vladimir Putin⁴⁴

The Indian government has embarked on the journey of making India the global hub of drones manufacturing by 2030, with the setting up of a Drone Directorate under the Directorate General of Civil Aviation (DGCA) and several other reforms. The Drones Rules, 2021, notified on August 25, 2021, provide the necessary regulatory framework for the commercial use of drones. The drone airspace map, published on September 24, 2021, has opened nearly 70 percent of the Indian airspace as a green zone for drones flying up to 400 ft.

The Production-Linked Incentive (PLI) scheme notified on September 30, 2021, to promote the growth of drone manufacturing by private companies provides an incentive of Rs 120 crore, spread over three financial years. The drone certification scheme notified on January 26, 2022, has made it easier to obtain the type certificate by drone manufacturers. The drone import policy, notified on February 9, 2022, bans the import of foreign drones and frees up the import of drone components. The Drone (Amendment) Rules, 2022, notified on February 11, 2022, abolished the requirement for a drone pilot licence.

The Drones Rules, 2021, notified on August 25, 2021, provide the necessary regulatory framework for the commercial use of drones. The drone airspace map, published on September 24, 2021, has opened nearly 70 percent of the Indian airspace as a green zone for drones flying up to 400 ft.

44. Brainy Quote, "Vladimir Putin Quotes", https://www.brainyquote.com/quotes/vladimir_putin_601126. Accessed on September 9, 2023.

The Ministry of Civil Aviation (MoCA) has proactively engaged with various union ministries and state/union territory governments across the country to promote drone applications by utilising the services of drone service providers for vaccine delivery, inspection of oil pipelines and power transmission lines, anti-locust operations, agricultural spraying, survey of mines and land mapping under the Survey of Villages and Mapping with Improvised Technology in Village Areas (SWAMITVA) scheme for issuance of digital property cards. Drone training schools have been set up in various states which have the potential of being a game-changer in the promotion and development of drone applications. With these measures in place, the growth expected in the industry in India is phenomenal. The annual sales turnover of the Indian drone manufacturing industry may grow from approximately INR 60 crore in 2020-21 to approximately INR 900 crore by 2024-25.⁴⁵ With its traditional strengths in innovation, information technology and burgeoning domestic demand, India has the potential of becoming a global drone hub.⁴⁶ There are, however, certain challenges.

Fig 4



In 2021, MoCA published an interactive drone airspace map that marked yellow and red zones across India. In order to fly drones in the defined

45. Press Information Bureau, pib.gov.in, <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1881767#>. Accessed on September 13, 2023.

46. Ministry of Civil Aviation, Press Release, "A Series of Reform Measures Undertaken to Promote India's Upcoming Drone Industry", December 8, 2022, <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1881767>. Accessed on September 10, 2023.

yellow zones, one must first obtain the necessary authorisation from the relevant air traffic control authority, IAF, Airport Authority of India (AAI), Hindustan Aeronautics Limited (HAL), Indian Navy, etc., as the case may be. The red area is the 'No Drone Zone' where drone operations require authorisation from the Centre. The green zone allows drones to fly up to 400 ft without a permit. The challenge remains in ensuring adherence to these limits by operators.⁴⁷

Civil Aviation Regulation (CAR) 1.0 stipulates that all UAS, excluding those in the nano category, must be registered on Digisky to get a Unique Identification Number (UIN). It permits commercial drones to fly within Visual Line of Sight (VLoS), only during daylight hours, and at a maximum altitude of 400 ft. Flying in the regulated airspace requires obtaining an Air Defence Clearance (ADC) or Flight Information Centre (FIC) number from ADC/FIC and a slew of equipment. The potential of UAS enabled by these provisions can be exploited without resulting in hazards only through spreading awareness, extensive training, a sufficient number of committed hardware and software trained personnel, strong cyber security and a solid ground control infrastructure.⁴⁸

To safeguard the constantly evolving and complicated airspace from rogue drones, a bigger and better push is needed for a commensurate development of CUAS. A few companies have developed CUAS devices capable of both hard and soft kills. Some of them have even concluded contracts with the Indian Army and IAF. However, their effectiveness and integration with existing Command and Control (C2) centres and the sensor-to-shooter cycles need to be evolved.⁴⁹

The Unified Threat Management (UTM) Policy Framework-2021, articulates that its stakeholders are responsible for the whole process of making policy and operations for drones. The central government, DGCA, Bureau of Civil Aviation Security (BCAS), airspace management agencies,

47. Swaim Prakash Singh, "Concerns for Drone Proliferation in India and Challenges to Airspace Management", *Air Power Journal*, vol. 16, no. 4, October-December 2022, pp. 203-219.

48. Ibid.

49. Ibid.

Air Traffic Control (ATC) Authority, and Air Defence Authority (ADA) are stakeholders in the UTM. This policy asserts that Real-time Identification and Tracking (RIT) of the UAS allows other airspace owners and people on the ground to share the identity of the UAS and its location; however, it also mentions the present technological challenges and recommends that studies need to be conducted or alternatives proposed for RIT due to its shortcomings, in case it is made operational and mandatory; however, it is an inescapable requirement for the AD organisation.⁵⁰ Identifying and monitoring an unmanned aircraft flying in the Indian airspace, while supporting high-density manned aircraft operations is a critical necessity. While de-regulation has greatly aided suppliers and operators, executing drone operations in the skies remains a significant challenge for AD organisations across India.

The International Civil Aviation Organisation (ICAO) mandates manned aircraft to maintain a minimum height of 500 ft above ground level except when authorised, and during take-off and landing. Nonetheless, many manned airspace users legally fly below 500 ft. The greatest hazard posed by unannounced helicopter flights in this Very Low Level (VLL) band occurs during election time in India. The development of a buffer zone between 500 ft and the area of VLL UAS flights is one way to increase the safety of manned aircraft flying slightly above 500 ft (similar to the transition altitude).⁵¹

The Air Defence Identification Agency (ADIA) of the IAF already has a large number of light planes to manage at any given point of time. The creation of an airspace authority placed at dispersed locations within the jurisdiction of ADIA and termed 'Drone Air Space Management Cell' (DASMC) may be considered.⁵² The DASMC should be the custodian of the Digisky platform and fully integrated with the IAF-IACCS (Integrated Air Command and Control System) for defending the national skies. All CUAS sensors should be on throughout yellow and red zones, and need to be connected to this network at all times. To equip the DASMC, the government and security

50. Ibid.

51. Ibid.

52. Ibid.

establishment will have to work out a holistic requirement of sensors and CUAS, along with the induction of trained manpower. The numbers of such DASMCs would be quite high, but with an approach of foolproof airspace management, this concept is both practicable and implementable.

There have been long strides in the governmental as well as the private sector towards UAS and CUAS manufacturing. The emerging trends towards self-reliance indicate fulfilment of this promise. In July 2022, DRDO achieved a major milestone by successfully test firing aUCAV meant for the IAF. The Indian armed forces meanwhile await the larger UAVs like DRDO's TAPAS BH-201 and Ghatak class combat UAVs. The HAL's Air Launched Flexible Asset (ALFA-S) air-launched swarming drones will be part of the proposed Combat Air Teaming System (CATS). The US Air Force's (USAF's) Air Force Research Laboratory is also collaborating with HAL for the ALFA-S. Among the private players, the top listed drone companies in India are Infoedge India, Zomato Ltd, Paras Defence and Space Technologies, Zen Technologies Limited, Rattan India Enterprises and DCM Sriram Industries. There were also about 134 drone start-ups in India as of early 2022.⁵³

The Indian government and IAF have been encouraging Indian drone start-ups. The IAF's Mehar Baba Competitions I & II have helped identify drone swarm start-ups. The IAF has taken a multi-pronged approach by signing multiple contracts for the purchase of UAS and CUAS with DRDO, the Public Sector Undertakings (PSUs), private players and start-ups.

On August 14, 2023, the IAF announced a Rs 300 crore contract with an Indian defence start-up for 200 swarm drones. This was the IAF's first contract for swarm drones placed on an Indian firm. The 'Swarm-Unmanned Munition Systems' (S-UMS) are catapult-launched jet-powered drones capable of precision strikes on heavily protected enemy targets. This is the single largest order ever awarded by the Government of India (GoI) to any start-up for unmanned systems. Each drone has a range of over 150 km and is designed to carry out long range strikes in concert with other

53. Chopra, n.42.

Much work is being done in the field of UAS in terms of rules, regulations and industry participation. The IAF can be a greater participant in the national effort which shall increase domestic capability as well as the IAF's operational capability.

drones, using satellite navigation signals to fly to pre-programmed targets.⁵⁴ The second edition of the 'Mehar Baba' Swarm Drone Competition was started by the IAF for Indian start-ups to develop a swarm drone-based system to detect foreign objects on aircraft operating surfaces.⁵⁵ A parallel 'counter-drone industry' must be created with the drone industry in order for this sector to be truly successful for the national cause.

MEASURES TO ENHANCE IAF EMPLOYMENT OF UAS AND CUAS

To exploit its rich experience in using these unmanned platforms, the IAF is partnering with the Drone Federation of India to co-host the 'Bharat Drone Shakti 2023'.

–Press Information Bureau, Government of India⁵⁶

The IAF can improve the effectiveness of missions under the air strategy by greater employment of UAS and CUAS. Many of the military strategic, operational and tactical measures have been discussed earlier in the paper. The effectiveness of the IAF's employment of these systems and conduct of other operations would be impacted by policy regulations and use of such systems by other stakeholders. Much work is being done in the field of UAS in terms of rules, regulations and industry participation. The IAF can be a greater participant in the national effort which shall increase domestic capability as well as the IAF's operational capability. Formulation of a counter-drone strategy involving all the stakeholders, providing a comprehensive understanding of the evolving risks posed by

54. n.41.

55. Mehar Baba Competition-II", www.indianairforce.nic.in/mehar-baba/. Accessed on September 10, 2023.

56. Ministry of Defence, Press Release-PIB Delhi, "Indian Air Force and Drone Federation of India to co-host Bharat Drone Shakti 2023", posted on September 6, 2023.

the malicious and illegal use of drones, as well as taking a 'full spectrum' approach to deter, detect and disrupt drone misuse are the needs of the hour. Certain measures to enhance the effectiveness of the IAF's employment of UAS and CUAS are given in the succeeding paragraphs.

Rising domestic technological prowess enables the IAF to seek customised solutions to operational problems rather than buying what is commercially available. Expansion of the scope of the Baba Mehar Competition or such initiatives would help in filling the capability gaps and enable the industry to grow concurrently.

Induction of HALE-armed UAS/ UCAVs that can operate outside the GBADWS and logistics UAS would fill a key capability gap and open up new avenues of operational capability.

A large number of engineering officers undergo M Tech with reputed institutions such as Indian Institutes of Technology (IITs). These officers could be tasked with specific projects to identify UAS/CUAS solutions to field problems and could be encouraged to work with centres of excellence in the domains of academia and industry. Institutional tie-ups could be made in this regard.

There is a need to reorganise the AD set-up, train and equip for CUAS operations and integrate with the defence forces and the police. A detailed study could be undertaken at the appropriate level.

The UAS threat is omni-directional, thus, there is a need for detection and interdiction along the entire border, which is an expensive proposition. A surveillance and engagement grid needs to be evolved to cater for high-threat areas initially, with options of sidestepping, if the situation demands. Therefore, asset allocation should be based on a short warning period, in proximity to high value targets and in anticipation of a faster pace of operations. A multi-agency approach is essential for the same.

There is a need to reorganise the AD set-up, train and equip for CUAS operations and integrate with the defence forces and the police.

Presently, CUAS technology is a niche area, and unlikely to be shared. Focussed Research and Development (R&D) needs to be carried out indigenously as per the *Atmanirbhar Bharat Abhiyan*, to enable our defence and civil industries to manufacture such equipment. This further needs to be supported by the government in terms of assured demand, material and monetary support, and with targeted time periods. The IAF may expand the Mehar Baba Competition to include CUAS as well.

Developing counter-drone systems that can capture or take the rogue drones to safe locations or escort them out of danger areas in order to protect civil airports, urban population and strategic assets could be explored in collaboration with the MoCA and Ministry of Home Affairs (MHA).

The IAF, Indian Army and HAL should examine the technical feasibility of integrating counter-drone systems on the Light Utility Helicopter (LUH), Light Combat Helicopter (LCH) and HTT-40 aircraft and initiate their development as counter-drone platforms.

The amount towards iDEX (Innovations for Defence Excellence) and Mehar Baba Competition may be increased to Rs 50 crore and Rs 200 crore respectively.

Development, miniaturisation and operationalisation of microwave counter-drone systems should be given high priority due to the swarm threat from adversaries.

The MoD and MHA should carry out joint assessments of the existing air defence system of the defence forces and corresponding elements in the police, para-military and other forces, gaps in technology, procedures and training, and prepare a roadmap to fill gaps and correct anomalies.

The MoD, MHA and MoCA should involve technically qualified personnel from defence, Central Armed Police Forces (CAPFs), MoCA and other security agencies in the research, design and development teams of indigenous projects undertaken by DRDO, Defence Public Sector Undertakings

(DPSUs), Department of Science and Technology (DST), private industry and academia, as required.

The emergence of UAS and CUAS in the civilian and military domains has offered numerous opportunities and challenges for the country. The IAF, being the principal user of the airspace and its guardian, is most affected by these developments. With India aiming to become a global drone manufacturing hub in the coming years, the IAF, working together with other stakeholders, could mitigate the challenges and exploit the opportunities.