Swarm Drones and Indian Academia

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> Drones and most likely drone swarms are something you're going to see on a future battlefield...I think we're already seeing some of it…
>
> —General John Murray, US Army Futures Command[1]

Air power is one of the most important elements of a military campaign and therefore, all countries strive to achieve Air Supremacy. The world has witnessed the influence of Air Power in wars, including Air Superiority of manned aircraft, in the last century. However, this paradigm of Air Superiority only through manned aircraft, and noticeably Fighter aircraft, may be challenged in this century through Unmanned Aerial Vehicles (UAVs). Future wars may be fought with a combination of both manned and unmanned aircraft. Days are not far-off when many countries would develop Unmanned Combat Aerial Vehicles that could be seen cruising in the skies moving intercontinentally and taking on precision targets. One of the reasons behind the exponential growth of the UAVs is their applicability for defence purposes. In civil sector too, Vertical Take Off and Landing (VTOL) UAVs have wide applications across sectors in areas like transportation, aerial recee, calamities, photography, hobbies, etc. The Urban Air Mobility (UAM), colloquially called as Unmanned Air Taxis, for transportation of people and cargo is seen as a new possibility in multimode transportation in future.

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In the military history, since World War I, UAVs have been used for dull, dirty and dangerous missions of surveillance and reconnaissance purposes. By the end of the twentieth century, in addition to intelligence gathering, the UAVs played a significant role in the suppression/destruction of enemy's air defence (SEAD/DEAD), that is, hard/soft strike on surface-to-air missile (SAM) sites. This was evident during Bekaa Valley Operation in the Israel–Syria War. Further, with the first on-board Hellfire missile fired from Predator UAV on 16 February 2001 by the United States (US), a new era of military use of armed UAVs for precision attacks against terrorists holed up in bunkers, buildings and moving vehicles, came into existence. Since 2001 predominantly, armed UAVs manned from the US shores, have been used in the global war on terror.

Noticeably, the lethality of armed UAVs/drones was clearly evident from the missile strikes in Afghanistan, launched from MQ-9 Reaper drones by the US in August 2021 against suspected individual of Islamic State of Khorasan (IS-K).[2] The increased use of drones brings out the perspective on future wars, where UAVs will dominate airspace as undisputable war machines.

Generally, the Unmanned Aerial Vehicle (UAV) is also called as Drone. It is an airborne platform without on-board human aircrew. The drone's flight can be automated or its course can be controlled remotely by a pilot. The UAVs, which have both commercial and military uses, are generally seen across the globe carrying out multifarious missions, such as command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR), logistics, traffic monitoring, agricultural survey and surgical strikes on targets.

Drones in civil and military use are classified into segments. The classification of UAVs is based on different characteristics, including weight and range. In India, the Military Drones are governed by policies framed under Technology Perspective and Capability Road Map 2013 which was amended in the year 2018 by HQ IDS.[3] The Ministry of Civil Aviation, vide the Drone Rules, 2021, had classified commercial drones based on their maximum all-up weight (with payload) as: (i) *nano drone*: less than or equal to 250 gram (g); (ii) *micro drone*: greater than 250 g and less than or equal to 2 kilogram (kg); (iii) *small drone*: greater than 2 kg and less than or equal to 25 kg; (iv) *medium drone*: greater than 25 kg and less than or equal to 150 kg; and (v) *large drone*: greater than 150 kg. Drones with maximum all-up weight of more than 500 kg fall

under the provisions of the Aircraft Rules, 1937. The Drone Rules, 2021 applies for commercial use of drones in Indian airspace and does not apply to drones used by Indian navy, military or air force.[4]

Micro/Small UAVs

Traditionally, India has been one of the largest importers of defence equipment. It has an inventory of medium and large drones, like Harop, Heron, Searcher and Harpy systems, which have been imported for military use. In future, India aspires to develop bigger and more capable medium-altitude long endurance (MALE) UAVs, high-altitude long endurance (HALE) UAVs and unmanned combat aerial vehicles (UCAVs). Studies show that India's large and medium UAVs programmes are in various phases of research and development (R&D) in the private industry and at Defence Research and Development Organisation (DRDO). However, India has a long way to go before it can join elite nations like the US, Israel and China.

While most defence forces are striving to develop armed UAVs that have global reach, that is, for multi-mission purposes, including high flying endurance and ability to carry large payloads, the micro/small UAVs have also captured a place in aerial warfare. Considering their low cost, tactical advantages and rising demand in military sectors, micro and small UAVs market has seen a positive growth trajectory. Indeed, optimisation of micro/small UAVs, and its equally important counter-drone mechanisms, are being explored by defence forces around the world.

India's indigenous micro/small UAVs development is booming in start-ups and Micro, Small and Medium Enterprises (MSME) sector. Small Vertical Take-Off and Landing (VTOL) class of UAVs are being produced by these companies, with a few firms seeking foreign original equipment manufacturers' (OEM) assistance in fields like Artificial Intelligence (AI), advanced avionics and warheads.

Micro/small drones are generally VTOL–multirotor type in India and have a wide application in commercial sector due to their cost-effective and efficient operations. They are the popular choice for aerial photography, video aerial inspection, leisure, agriculture, construction, security, filmmaking and surveillance. Further, these drones can be used by both professionals and hobbyists because of their small size and ready to fly out of the box capabilities.[5] The use of micro/small drones in healthcare to deliver medical supplies to home care patients is also

gaining traction. However, due to the low cost and easy availability in markets, these drones also impose security threats, particularly when in possession of non-state actors. The explosions caused by small UAVs carrying improvised explosive devices, in an attack on Jammu Air Force Station on 27 June 2021 that injured two air force personnel and damaged air force property, cannot be forgotten.[6]

Small UAVs and India's Initiatives

As mentioned earlier, India is one of the top importer of arms in the world. To minimise dependency on imports, it needs to gainfully utilise the huge potential of Indian industries to cater to the defence sector. For this, 'Make in India' initiative for promoting self-reliance in defence sector is being spearheaded by the Government of India (GoI). Easier government policies have been introduced to assist potential Indian vendors in indigenisation and technology development. With indigenisation and self-reliance being the key focus areas of the GoI, the Indian industries are being nurtured to indigenously design, develop and manufacture defence equipment at system, subsystem and component levels.

The Ministry of Defence (MoD) has also been promoting self-reliance (Aatmanirbhar Bharat) through regular awareness programmes by conducting Defence Expos, seminars and setting up of defence corridors at state levels. Defence industrial licenses are being issued to private industries, noticeably start-ups and MSMEs, for UAV production to boost private sector participation.

The Drone Federation of India Chief, Smit Shah, recently stated: 'India's drone market can grow to Rs 50,000 crore in 5 years'.[7] However, it is the market for micro/small UAVs for commercial use, primarily for aerial transportation (logistics) and surveillance purposes, in which the Indian companies have seen a boom. Over the past few years, the need for small drones has been on the rise, both for commercial and military use, due to economic viability, technology management and flexibility of use.

With the micro/small UAVs industry flourishing across the country, including a few instances of lethal use of the UAVs by non-state actors, the GoI felt that there is a strong need to regulate the use of drones in the Indian airspace. Accordingly, the Ministry of Civil Aviation published the Drone Rules, 2021, as per which the commercial applications of all drones are governed and it also highlights that while there are immense

opportunities for economic growth and employment generation in the drone sector, 'there is need to regulate the drone related activities in a manner such that they do not pose any risk to safety or security of people and assets'.[8]

Swarm Drones

While industries are focusing on R&D for micro/small UAVs from a business perspective, it is also seen that R&D on smart drones—Smart Warfighting Array of Reconfigurable Modules (SWARM/swarm)—in the category of micro/small UAVs (fixed wing and VTOL), is on the rise. The swarm drones are a micro/small group of drones, well-coordinated and distributed in formation, assigned to fly autonomously as a team to a particular area (capable of operating as individual drones too) and based on pre-programmed Artificial Intelligence (AI) with minimum human intervention. Each swarm has resource libraries programmed for various contingencies to self-decide to act as per the situation and re-arrange optimally as a group in case a few drones malfunction or are destroyed. In tactical areas, these swarm drones can be used for multiple purposes, such as reconnaissance or kamikaze attack, either collectively or individually. Numerous writings on applicability of these drones for tactical combat zones have emerged in the past two to three years, highlighting their use in future conflicts.[9]

Swarm drones are technology intensive, with AI swarming algorithms being the main source codes for dominance of these mini giants in the air. Prescriptive and predictive analysis of artificial systems that behave like neurological intelligence in human beings to take fair decisions from network of intelligence is the key element for these drones to fly as self-organised war machines. The AI platform behaves like on-board computer controlling the drones for all flight manoeuvres.

In recent years, the world has witnessed the lethality of swarm drones. On 9 January 2018, 13 swarm drones attacked Russian air base at Khmeimem and Tartus naval base in Syria.[10] Subsequently, those 13 drones were neutralised by Russian air defence with high-cost missiles and soft-kill cyber units. However, the attack was noted as the first swarm drone attack against a strong Russian air defence. Further, on 14 September 2019, Saudi Aramco oil production units at two important oil fields, namely, Abqaiq and Khurais, were attacked by swarm drones,[11] stalling oil production and causing huge economic loss to Saudi Arabia.

The use of swarm drones for low-intensity conflict and against vulnerable targets by non-state actors has jolted the defence forces across the world. Therefore, applicability of swarm drones and parallelly, counter-drone mechanisms are gaining momentum in the defence forces. Superior military powers, like the US, Russia and China, have matured in swarm drone technology and have made rapid advancements.

In India, during the Army Day celebrations on 15 January 2021, a live demonstration of quadcopter swarm drones was held.[12] A total of 75 swarm drones were airborne and few of them were utilised to destroy ground-based dummy targets in a kamikaze attack. Thus, the need for swarm drones by services for future warfare is evident.

Research Opportunities for Indian Academia on Swarm Drones

With prevailing GoI support and hand-holding measures in place for industries, along with growing demand for drones by defence forces; the indigenisation of drones, especially swarm drones will undoubtedly increase in the next few years.

Recently, the defence minister, at Defence India Start-up Challenge–5 (DISC-5),[13] unveiled 35 problem statements—13 from the services and 22 from Defence Public Sector Undertakings (DPSUs)—to achieve self-reliance and foster innovation and technology development by youth and academia. These covered various areas such as situational awareness, augmented reality, AI, aircraft-trainer, non-lethal devices, 5G network, underwater domain awareness, swarm drones and data capturing. It is evident that swarm drones are one of greatest challenges for the Indian industries in the years to come.

Unlike commercial micro and small drones, swarm drones are technology-centric, depending on advanced avionic AI platform. Though AI is a fast-emerging domain in medical, business, education, agriculture, entertainment, journalism and transportation sectors, it is at a preliminary stage in the defence sector in India. While industries are carrying out R&D on AI for defence applications, it is felt that Indian academia has a strong potential to contribute in AI-related research areas.

Centres of Excellence in AI for Drones

The academic institutions have imbibed the future challenges of evolving technologies like Robotics, AI, Data Science, Nano Technology,

Aerospace, Block Chain, Cloud Computing, etc., in their curriculum. Application of these technologies in business, government, medicine, etc., as projects is being seen in leading premier academic institutions. Young budding scholars from these institutions are looking for job opportunities in commercial sectors and drone start-ups from academia have bright chances to get industry back-up and jobs.

Swarm Drones are AI-centric and with Centres of Excellence in AI and robotics, AI and machine learning being major research areas in academia nowadays, it is felt that academia will play a huge role in supporting R&D on Swarm Drone Technologies. Few IITs have already started research on VTOL-class of UAVs.[14]

With various initiatives of GoI, such as Make in India for defence, and allocation of funds for Innovations for Defence Excellence (iDEX), Technology Development and Defence India Start-up Challenge, it is opined that academia should pitch in strongly in creating centres of excellence in AI technology for Swarm drones at their institutes.

Taking advantage of the favourable measures initiated by the GoI, the academic institutions should come forward to take up challenges of emerging swarm drone projects. It is the need of the hour to create incubation cells and evolve ecosystem by synergising and nurturing aspiring professors and students from specific domains, like aerospace, AI and machine learning, computer and communication engineering, to venture into design and development of swarm technologies for defence applications. The start-ups and MSMEs will greatly benefit from the technology back-up provided by academia. In this regard, even the defence officers of all the three services on postgraduate courses at leading academic institutions, can support academia as nodal project officers to unfold MoD's Make in India initiative.

It can be said that India's military sector is booming in both government and private sectors. UAV projects in DRDO (govt sector) are at various end stages of development and soon to be seen in defence forces. With initiatives of Make in India by GoI, the private industries are also encouraged and nurtured for defence manufacturing. Considering the future of UAV sector and specially Swarm Drones being one of the important niche sector in small UAVs defence segments around the world; R&D by Industry (government and private sectors) with technology back-up from academia will evolve a strong ecosystem for speedy, quality design and development of Swarm Drones.

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