SWARMING: USAGE IN CONTEMPORARY ARMIES VIS-À-VIS EFFECTS OF INDIAN SWARMING TECHNOLOGY ON PAKISTAN ARMY IN ANY FUTURE CONFLICT

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Abstract

With the advancement in technology, drones are extensively being used by many countries around the world during recent years for military operations which include combat operations, reconnaissance and surveillance missions, Kamikaze and intelligence gathering etcetera. Nevertheless, due to ongoing global arms race, efforts were made to bring autonomy in the drones subject to Artificial Intelligence (AI), which resulted in the creation of drone swarm technology, the machine working with autonomy. Many countries are endeavouring to bring autonomy and AI simultaneously with minimal financial implications in the elements of a swarm. Therefore, emerging trends of battlefield necessitates that Armed Forces should be equipped with latest equipment according to evolving threat. Thus, there is a requirement to analyse Drone Swarm Technology, its use in contemporary armies and implications for future conflicts, particularly in the Context of Indo-Pak duels.

Keywords

Drone Swarm Technology, Kamikaze, Unmanned Aerial Vehicles (UAVs), Electronic Warfare (EW), Nagorno-Karabakh Conflict, Notion of Victory (NOV), Air Defence (AD), Contemporary Armies.

Introduction

Expansion of tactical use of drones has been noted in the past century. United States (US) and United Kingdom (UK) introduced the drones during World War I (WWI), however, drones were never deployed during the War.[1] In World War II (WWII), the Nazis invented the V-1 (Vengeance Weapon One) to serve as a missile having simple mechanism but noisy pulsejet that earned it the nicknames of "buzz bomb" and "doodle bug".

More than 20,000 V-1 missiles were launched at British and continental targets, mostly London and Antwerp, from June 1944 to March 1945.[2] The drones were employed by US for surveillance missions during the Vietnam War and also for counter-insurgency surveillance and strike operations in Iraq and Afghanistan. In recent years, technological advancements led to the rise of unmanned aerial vehicles (UAVs), commonly known as drones. These versatile machines have revolutionised various industries, ranging from aerial photography to package delivery.[3] One remarkable development in drone technology is the concept of a drone swarm.[4]

Definitions: Swarm or Swarming

To comprehend the concept of swarming technology, different technological researchers have defined swarming with different perspectives, nonetheless, with matching backend logic.

- A US veteran technology journalist Phil Goldstein terms swarm Intelligence "as a field of Artificial Intelligence (AI) that focuses on the use of AI software to enable units i.e. drones, satellites or space crafts etcetera to act in coordinated way using de-centralised control, automation and self-organisation".[5]

- Gimber Jack defines in UK Journal the swarm technology "as enabler of a large number of drones to become highly interconnected, with the ability to efficiently plan and allocate mission objectives, make coordinated tactical decisions and collaboratively react to a dynamic environment with minimal supervision whilst making recommendations to human operators."[6]

- Indian Lieutenant General Balli Pawar (Retired) defines SWARM "as an acronym for 'Smart War-Fighting Array of Reconfigured Modules". This terminology signifies that drones will be smart, autonomously make decisions and will have potential to alter the shape of conflict. The writer terms it like a hive of bees, which is engineered towards an objective in which each bee will be capable of acting on its own to achieve the assigned target.[7]

- Joint Air Power Competence Centre (JAPCC), affiliated with NATO defines it as an enabler technology, highly interconnected, with the ability to efficiently plan and allocate mission objectives concurrently, make coordinated tactical decisions with minimum supervision by human and making suggestions to human operators.[8]

Concept of Swarming

Derived from the concept of flock of birds and swarms, it has no definite shape, however, this technology is structured in such a way that machines coordinate among each other autonomously through AI algorithms and are capable of striking the objective from unknown direction and distances.[9] Its effectiveness can be achieved only if it operates in large numbers, smart in size and can engage from far-off distances. Hence, based on interconnected small units, which operate autonomously in a directed way. The swarms will prove to be more effective and human friendly in various tasks and can also be used in military operations to threaten the enemy from different directions and in an irregular manner. Brigadier Rajan Ravindran asserts "The swarm would aim at psychological dislocation of the enemy more than his physical destruction".[10]

Historical Perspective

The historical context of drone swarming presents an intriguing exploration of how technology has evolved and affected diverse facets of society. Although drone swarming may appear as a contemporary innovation, its inception can be linked to early military and scientific trials. The genesis of drone swarming, traces its beginnings to military reconnaissance endeavours during WWI and WWII. Initial trials encompassed the employment of radio-controlled aircraft for tasks such as surveillance and target recognition. These basic drone prototypes served as precursors to more intricate advancements that unfolded over subsequent decades.

During WWI and II, the technology of drone swarming, in comparison to recent times, was in its early stages. Nevertheless, basic versions of Unmanned Aerial Vehicles (UAVs) and initial trials in coordinated flight established the foundation for subsequent advancements. In its classic sense, it might not have been swarming, however, it bore close similitude to whatever technology is being used for the purpose of swarming in ongoing conflicts around the world.

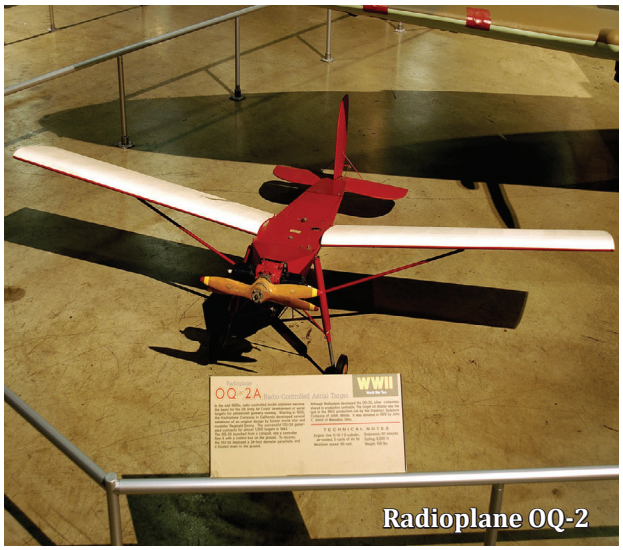
- ### Use of Swarm Technology in WWI

  In WWI, the concept of drone swarming was in its nascent stages. The most notable example was the development of the Kettering Bug, an early UAV designed by Charles Kettering in the United States. The Kettering Bug was essentially a flying bomb, controlled by preset mechanical mechanisms. It was used for reconnaissance and aerial bombing missions, with limited success. The Kettering Bug marked one of the earliest attempts at using drones for military purposes.

- ### Use of Swarm Technology in WWII

  In "Operation Aphrodite," allied forces launched Boeing B-17 and B-24 Liberator bombers equipped with explosives and radio guidance systems. These unmanned aircraft were deployed for perilous bombing missions aimed at heavily fortified targets within Nazi-occupied Europe. Pilots would initially man the aircraft before ejecting themselves, allowing remote control to take over.

While this idea did not achieve complete success, it served as a precursor for the development of subsequent drone technology. During WW-II remote-controlled aircraft called Radioplane OQ-2 was the first mass produced UAV in US and was a breakthrough in manufacture and supply of drones for the military which were used both by US Army and US Navy in WWII.[11] In Artillery, UAVs are specially used for forward observations to go deep in battle space for acquiring targets, relaying those targets and calling controlled fires.



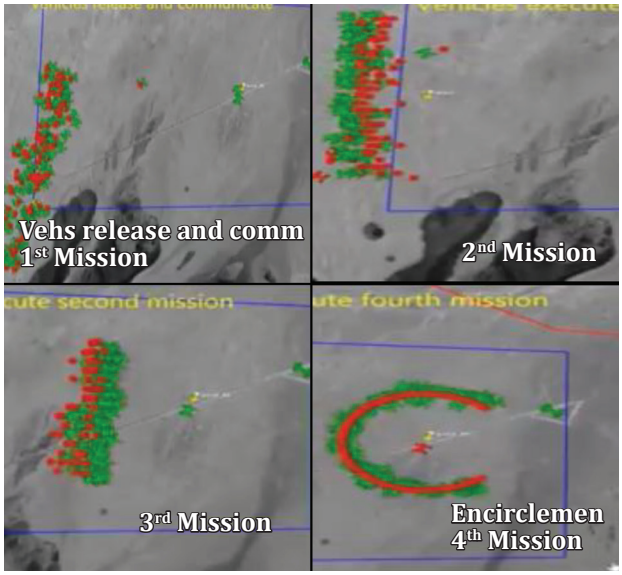
Radioplane OQ-2

Drone Swarming in Contemporary Armies

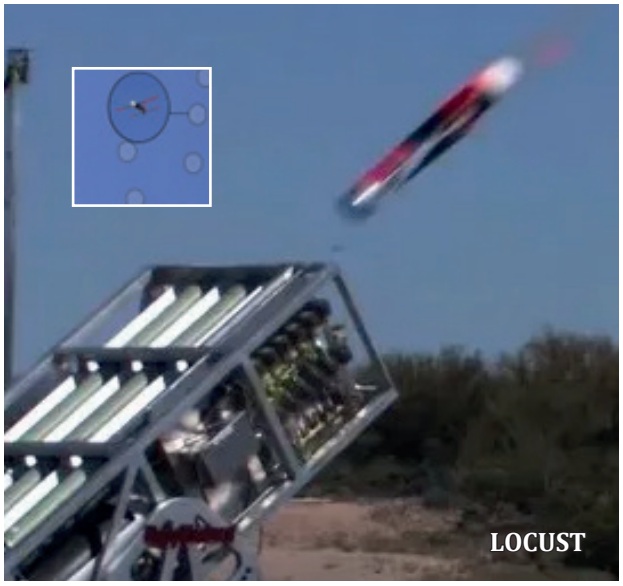
- **USA**

Drone Swarm Technology was first introduced by US by hosting a demonstration of Perdix swarm in 2017. In this demonstration, a triad of F/A-18 Super Hornet fighters released 103 Perdix drones in air. These drones were assigned to perform four missions in which first three missions were to form up at pre-defined points and then encircle the target in the fourth mission. The demonstration went as planned. This demonstration showed Perdix's swarms autonomous decision making by flying into a formation and remain inter connected. X-61A Gremlin air launched drones were also presented by US Defence Advanced Research Projects Agency (DARPA) in which C-130 (a cargo aircraft) acted as a mother ship for releasing and reverting the drones. The Low-Cost UAV Swarming Technology (LOCUST) program by US Navy and Marine Corps also proved to be an innovation, which fired small UAVs from a tube-based launcher to conduct varied class of missions. However, none of these technologies have been used so far in any conflict.


PREDIX SWARM DRONE




X-61A GREMLIN


LOCUST

- **China**

The Chinese are investing lots of efforts to match the standards of US in replicating the swarm drone technology which will be capable of taking autonomous decisions with built in AI. Recently, test has been conducted by China Academy of Electronics and Information Technology (CAEIT) in which 48 x tube launched drone swarm of CH-901 UAVs were fired. CAEIT has also demonstrated a 200 unit drone military swarm in 2017. Chinese companies have also demonstrated impressive swarms of 1,000 plus drones using quad-copter-type drones for large public displays, which however are ground controlled and do not have distributed intelligence conducted during exercises in Taiwan Strait.


CH-901 UAVs

- **Russia**

Russians are way ahead in drone swarm technology. Ministry of Defence's (MoD) Zhukovsky and Gagarin Air Academy's Scientific Research Center is currently working on the Staya-93 proposal "flock"-concentrating on the connection and communication between the leader and follower


STAYA-93

drones. Another recent swarm concept by the Kronshtadt Design Bureau called Molniya involves launching multiple jet-powered stealth drones from manned and uncrewed platforms to conduct aerial and ground strikes and to provide Early Warning (EW) and reconnaissance capabilities. Russian Military has also produced and experimented Okhotnik S-70 heavy combat UAV and Altius drones. The Russian Military of Defence


OKHOTNIK S-70

officials and academics are carrying our research and deveopment (R&D) in this sector.[12]

- **India**

  India is also carrying out R&D on swarm drone since 2019 to fulfil its hegemonic designs in the region. However, claims it to be working for in depth humanitarian assistance and disaster relief (HADR) operations. The Indian Army showed off an offensive capability with a swarm of 7 autonomous drones with distributed intelligence destroying a variety of targets with kamikaze attacks during India's Army Day parade on January 15, 2021. The Hindustan Aeronautics Limited (HAL) in India has unveiled the Air Launched Flexible Asset (ALFA-S) air launched swarming drone system as part of it next generation Combat Air Teaming System (CATS). This is a unique program which utilises a network of air launched remote carriers and swarming units to penetrate contested airspace. It is likely to be a 1-2 meters long canister based drone capable of being launched from aircrafts/ helicopters.

- **Turkey**

  Byrakter TB-2 has been vastly used in Syrian civil war, fighting with the Kurdistani belligerents and Nagorno-Karabakh conflict. These drones took out tanks and artillery which held strategic high grounds for Azerbaijan, a feat, previously impossible for Azerbaijan forces. In 2022, Byrakter TB-2 proved to be the saviour of Ukraine. However, a year later in 2023, nearly all of them were shot down by Russian Armed Forces. Hence, Ukraine is using Byrakters TB-2 for reconnaissance,

  intelligence and surveillance purposes rather than for attacking.[13] Turkey's 50 Pounds Kargu is designed to operate in herd of 20 others. Turkey has planned to equip 500 Kargu drones, with three types of warheads. Alpagu ammunition operated by a single soldier is also being made by Turkey with less cross section and can fly low to medium altitude.

- **Israel**

  Israel Defence Forces (IDF) claim that it has deployed AI drone swarm in Gaza attack especially in Operation Pillar of Defence by using

RHEINMETTAL TRUCK MOUNTED COUNTER DRONE SYSTEM

  it to pin point Hamas locations and to find the rocket launchers,[14] for which data was collected by satellites and years of ground intelligence. Moreover, IDF has also created Rheinmettal truck mounted counter drone system.

STATIC DRONE SWARMS

DRONES DESTROYED

Principles of Swarming

Successful swarming is based on some important principles, without which this technology cannot achieve the desired effect. Basing on the research and after carrying out logical analysis of the subject, it has been derived that swarming technology runs on the under mentioned principles:-

- **Elusiveness**

  This principle denotes that swarm drones due to small size and high mobility do not allow to be grasped or pinned down easily. Resultantly, providing a window of opportunity to perform tasks without being observed.

- **Stand Off Capability**

  In this principle, the swarms can inflict more damage on the enemy from far-off places without any damage.[15]

- **Autonomous and Decentralised Control**

  Each drone in the swarm operates independently making its own decisions based on local information and the overall objective.

- **Communication and Coordination**

  Drones in the swarm communicate with each other regarding their position, status and environment allowing them to coordinate their movements and actions effectively.

- **Adaptive Behaviour**

  Swarming drones are capable of adapting to changing conditions and dynamic environments. They can quickly respond to new information, adjust their flight paths and modify their behaviour to achieve the desired outcome.

- **Redundancy and Robustness**

  Swarming drones often have redundancy built into their systems. If one drone malfunctions or is disabled, the swarm can redistribute tasks and continue the mission without significant disruption.

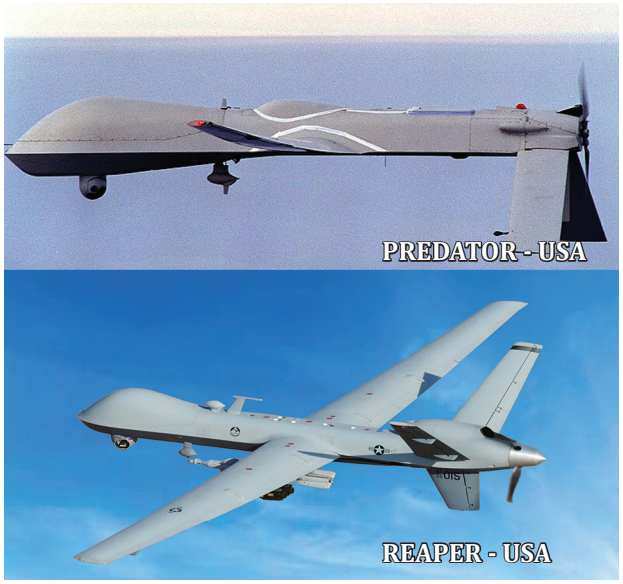
Drone Swarming in Recent Conflicts

21st century witnessed swift progression in drone swarming technology, propelled by its application in both military and civilian domains. The military sector began recognising the capabilities of drone swarms, particularly in areas like surveillance, reconnaissance and even offensive maneuver. Consequently, this recognition spurred greater investments and extensive research in the field.

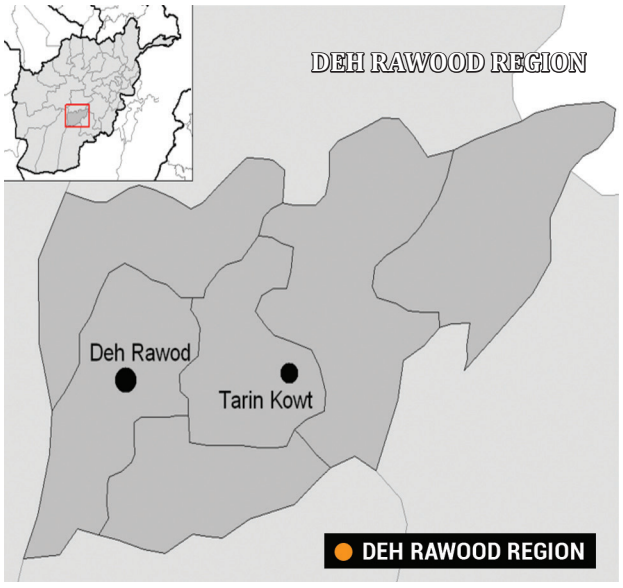
- **US Counter Terrorism Campaigns in Afghanistan**

  A month after 9/11 in 2001, US executed first drone strike in Afghanistan in an operation codenamed

Operation Enduring Freedom, to strike Mullah Umer, then supreme leader of the Tehreek-e-Taliban Afghanistan (TTA), but failed. This operation used Central Intelligence Agency (CIA) agents for intelligence gathering and directing to the target remotelessly. 'The Predator' drone was used in this



operation.[16] On October 28, 2007, the Air Force times reported that Reaper MQ-9 has achieved its first 'kill' successfully firing a Hellfire missile against the Afghan insurgents in Deh Rawood region of the mountainous Oruzgan Province.[17]

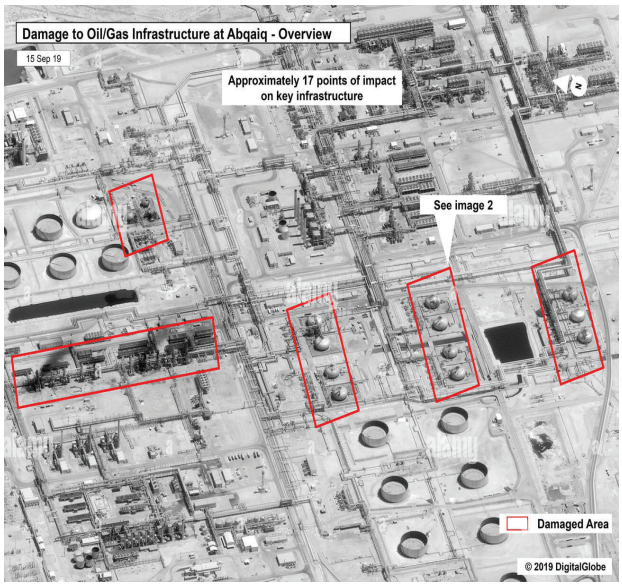


- **Syrian Civil War**

In early January 2018, Russian operators manning the AD system at Russia's Khmeimim airbase observed 13 incoming drones at low level in Western Syria. The Russian operators engaged these with EW & Short-Range Air Defence Systems (SHORAD). Though Russians shot down seven drones and jammed remaining six. Nevertheless, it became clear to the Russians that a new genre of a collaborative swarm drone attack is underway.

- **Houthi-Saudi Arabian Conflict/ Yemen Civil War**

During Yemen Civil War in 2019, Saudi Aramco oil processing facilities at Abqaiq and Khurais were attacked by 25 swarm drones in two waves. Later



on, the analysis of satellite images (of the Abqaiq facility) showed 19 individual strikes. It is pertinent to mention that the Saudi Air Defence (AD), including MIM-104 Patriot (US) and Crotale NGs

(UK) failed to detect these swarm of drones and cruise missiles.[18] This demonstrated that a group of drones and cruise missiles used collectively can remain undetected from a conventional AD system.

- **Use of Swarm Technology in Gaza**

  Israel Defence Force (IDF) claims to have used the drone swarm technology for the first time during the May 2021 conflict setting a significant new benchmark in drone technology. Manufactured by Elbit Systems, this technology was used in coordination with mortars and ground-based missiles to strike dozens of targets miles away from the border. The drones helped spotting the hideouts and relaying back the information for further operations.[19]

- **Nagorno-Karabakh Conflict**

  Nagorno-Karabakh conflict-2020 is one of the classical case studies for use of superior technology in minor conflicts to achieve the notion of victory. Azerbaijan achieved a great deal in enhancement of her drone fleet by procurement of drones from its allies i.e, Turkey and Israel. Azerbaijan armed forces liberally and effectively used Turkish made Bayrektar TB2 and Israeli made Harop drones to knock down Armenian tanks, Armored Personnel Carriers, Infantry Fighting Vehicles, Artillery Gun positions and AD weapon positions including S-300 Anti Ballistics Missile system.

- **Russia-Ukraine War**

  Optimum use of drone technology has been observed in Russia-Ukraine War. Since the war began, approximately 75,538 Ukrainian and around 218,800 Russia's Military casualties occurred.[20] Moreover, 3380 Russian and 2051 Ukrainian tanks have been destroyed, damaged, abandoned or captured as of February 23, 2023.[21,22] BBC verified that 190 drone attacks have been executed by Ukraine on Russia and Crimea whereas Russian drone strikes are approximately above 100.[23] On August 30, 2023, despite Russia's strong AD System, Ukraine struck Russia's Pskov airport (destroying four Il-76 Heavy transport

air crafts) near Estonia, Latvia borders and four military basis, which is considered as the biggest drone attack since inception of war.[24] Likewise

in September 2023, Russia carried out multiple drone attacks on Ukrainian grain infrastructure on ports along the Danube River destroying more than 270,000 tons of grain.[25] Cedric states that Ukraine is losing an estimated 10,000 drones per month.[26]

History shows that an intense transformation in warfare is afoot, based on advances in interconnected technologies related to AI, autonomy and connectivity of machines. In modern era, besides remote sensing satellites and air borne radar, UAVs have also transformed the means of situational awareness.

Swarming: Impact on Future Conflicts

Swarming technology can be termed as a game-changer for future conflicts. In Military Operations, it can assist with an enhanced situational awareness, increased operational efficiency, limited human resource wastage and improved mission success rates. This technology can also be used for precise target engagements, reconnaissance/ surveillance of the distant areas and even for the coordinated attacks. The ability of swarm drones to communicate, coordinate and collaborate amidst themselves allows them to overwhelm adversaries thus creating an autonomous and resilient force.

In the development of swarm technology, US, China and Russia are leading countries and are in advance stages of developing this technology. The US Perdix mission and LOCUST program, China's CH-901, Russia's Staya-93 proposal, Molniya concept, the Okhotnik S-70 and Altius drones are the latest developments underway. The use of swarm drone technology in hybrid warfare and by militants organisations cannot be ignored. The Houthi swarm drone attack is a case in point.[27]

Drone swarm technology will have a great impact in future conflicts. Presently, the battlefield transparency has increased manifolds with the increased number of satellites in which our adversary has excelled by sending various satellites in space. The coverage of the area was previously dependent on timing. However, when drone swarm technology will be interconnected with the satellite facility, India will have a continuous watch. Keeping this in view, impact of drone swarming techniques by our adversary (India) in different terrains, along with technical and logical limitations are worked out so as to enable us to counter the challenge, if India acquires this capability.

Desert

- **Impact**
  - **Surveillance and Reconnaissance.** Drone swarms can cover vast desert areas, providing real-time surveillance and reconnaissance data to the enemy for further military operations, without being observed.
  - **Target Identification.** Swarms can quickly identify and track potential threats, helping to enhance situational awareness and response times.
- **Limitations**
  - **Extreme Conditions.** Harsh desert environments can challenge drone components, leading to increased wear and tear.
  - **Communication.** Maintaining communication among drones in vast desert expanses can be challenging, affecting swarm coordination.
  - **Power Constraints.** Limited power sources in deserts may restrict swarm endurance and operational range.

Plains

- **Impact**
  - **Search and Rescue.** Drone swarms can cover large open areas quickly, aiding in search and rescue missions.
  - **Communication Relay.** Drones can establish communication networks in areas with limited infrastructure enhancing military communication.
  - **Sensor Deployment.** Swarms can deploy sensors to monitor movement and activities across expansive plains.
- **Limitations**
  - **Wind Factors.** Strong winds can affect drone stability and coordination, particularly in open plains.
  - **Obstacle Detection.** Identifying obstacles like buildings or structures can be challenging, requiring advanced obstacle avoidance capabilities.
  - **Collisions.** Maintaining safe distances between drones to avoid collisions becomes crucial in open areas.

Mountains

- **Impact**
  - **Surveillance in Challenging Areas.** Drone swarms can reach difficult-to-access mountainous regions for surveillance and monitoring.
  - **Mapping and Reconnaissance.** Drones can create detailed maps and gather data on challenging topographies.
  - **Tactical Support.** Swarms can provide tactical support by relaying information and aiding communication in remote mountainous zones.
- **Limitations**
  - **Altitude Challenges.** Thin air at high altitudes affects drone performance and endurance, limiting operational ceiling.
  - **Communication Loss.** Mountains can disrupt communication signals, necessitating resilient communication systems.
  - **Security.** Protecting swarm communication and data from cyber threats is a critical consideration.

Indian Projected Usage of Drone Swarm against Pakistan in Future Conflict

Leveraging swarm drone technology against Pakistan would require a strategic approach tailored to specific scenarios and objectives. Here are practical ways in which India could use swarm drone technology in a military context:-

- **Border Surveillance and Reconnaissance**
  Deploying swarm drones along the India-Pakistan

border can enhance surveillance capabilities. These drones can continuously monitor the border, detecting any suspicious activities or movements.

- **Target Identification and Tracking**
  Swarm drones can be used to identify and track military targets within Pakistan's territory. By employing a network of drones with advanced imaging technology, India can gather critical intelligence on Pakistan forces, including their positions, movements and troop deployments.

- **Communication Relay**
  In remote or inaccessible regions, swarm drones can serve as communication relays. They can extend the range of communication networks by acting as signal repeaters, ensuring that troops in the field maintain reliable connectivity with command centers.

- **Electronic Warfare (EW)**
  Swarm drones can be integrated into electronic warfare operations. They can be used to disrupt and jam Pakistan communication systems, radar and electronic sensors, thereby degrading Pakistan's ability to detect and track Indian military assets.

- **Offensive Operations**
  India can employ swarm drones in offensive missions, coordinating attacks on specific targets or military installations within Pakistan. These drones can carry various payloads, including explosives, to strike critical assets.

- **Naval Surveillance**
  In addition to land-based operations, swarm drones can be deployed for naval surveillance in the Arabian Sea. They can monitor shipping lanes, detect potential threats and gather intelligence on Pakistani naval activities.

- **Air Defence**
  Swarm drones can be used to supplement India's air defence capabilities. They can intercept and neutralise incoming hostile drones or missiles, protecting critical assets and population centers.

Impact of Indian Drone Swarm Technology on Pakistan

Although Indian armed forces will still take years to become a substantial threat, yet impact of drone swarm technology on Pakistan are mentioned as under:-

- **Enhanced Strain on Economy**
  Procurement of latest drone swarm technology will strain the economy. Moreover, lack of specialised manpower and weak Information Technology (IT) base will enhance our reliance on foreign countries.

- **Imbalance in Strategic Stability**
  As Indian Army intends to incorporate AI in various domains to include airborne platforms,

naval fleets, cyber space, outer space, drone swarm technolgy and strategic missile systems, this will alter the already fragile strategic balance hence, will kick start a new arms race in the region.

- **Enhance Support for Hostile Proxies**
  With access to AI means vis-à-vis drone swarm technology, it will be easy for India to actively support proxy operations in Pakistan.

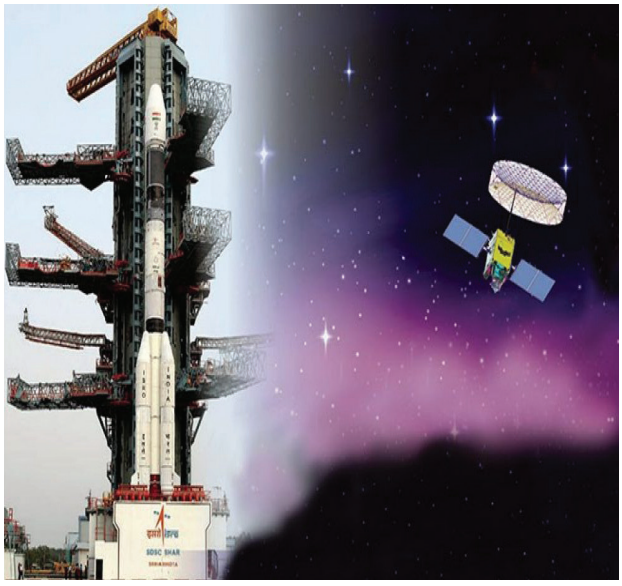
- **Improved Information Operations (IOs)**
  Dragged by its hegemonic designs, India will aggressively pursue its IO campaign against Pakistan. This will enable India to organise a more targeted campaign against Pakistan to create resentment and disenchantment.

- **Ability to Locate Pakistan's Strategic Assets**
  India's satellite network potency linked with drone swarms will increase its capability manifolds. This will give India the ability to easily locate our strategic assets thereby creating a security challenge for Pakistan.

Way Forward: Countering Indian Drone Swarm Technology

To counter the threats by our adversary, following are recommended:-

- **Establishment of Centers of Excellence for AI**
  It is need of the hour to improve in the air domain in both Air Defence and Air Attack. In 2020, Pakistan Air Force (PAF) has already inaugurated 'Centre of Excellence for AI & Computing', which should remain focused on countering enemy threat by establishing long term goals and integrate AI with drone swarm technology.



- **Retaining Balance through Concurrent Development**
  Pakistan should evade Indian coercion through incorporation of swarm drone technology, improvement in Electronic Warfare (EW) followed by improvement in AI means. This should be done by reforming Heavy Industries Taxila (HIT), Pakistan Ordinance Factory (POF), Pakistan Aeronautical Complex (PAC) and National Radio and Telecommunication and Corporation (NRTC) on modern lines.

- **Collaboration with Allies**
  Pakistan should initiate and promote joint ventures with private conglomerates enhancing collaburation with China and Gulf states.

- **Incentivising the Private Sector**
  Focus on broad based research by incentivising the private sector like interest free loans, tax exemptions and duty free import followed by task oriented programmes.

- **Anti-Drone Technology**
  Pakistan should invest in and deploy effective anti-drone technology to detect, track and neutralise

swarm drones. This includes radar systems, having the capability to counter EW, radio frequency (RF) detectors and jamming equipment specifically designed to disrupt drone communications and navigation systems. Moreover, enhancing existing AD systems to target and intercept swarm drones. Jamming communication frequencies and GPS signals can render swarm drones ineffective. Additionally, Pakistan could use electronic countermeasures (ECM) to deceive drone navigation systems.

- **Cyber Security Measures**
  Implement robust cybersecurity measures to protect communication networks and prevent unauthorised access to drone systems. Cyberattacks on the swarm drone control infrastructure can disrupt operations.

Conclusion

Swarming drones will definitely play a crucial role in the future conflicts and are dire need of the future warfare. Hence, there is a requirement to make special improvements in AD systems and EW measures simultaneously. As this technology gains prominence, it will introduce an innovative approach to exerting force on adversaries, with an increasing number of state and non-state actors embracing its potential. Swarming drones bring forth a three-fold impact on the battlefield. Firstly, they can create a "shock and awe" effect, instilling fear and uncertainty in adversaries, thereby altering the psychological dynamics of conflict. Secondly, they excel at inducing psychological dislocation among enemy forces, disrupting their morale and creating chaos on the battlefield. Lastly, swarming drones have the potential to paralyse enemy decision-making processes, rendering them less effective in responding to dynamic and evolving threats. Consequently, proliferation of drone swarming technology is inevitable in the coming decade across the world. But the clear fact is that aim of drone swarming would be less of a physical destruction but more of a psychological defeat.

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