UAVs and Air Power
Role of UAVs in Future Warfare

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Unmanned Aerial Vehicles (UAVs) provide the ability to locate and track enemy deployments, gather electronic intelligence, designate and/or destroy targets and simultaneously evaluate the extent of target destruction that has taken place. UAVs can therefore undertake the entire detection to destruction loop significantly faster and more effectively, thereby bringing in considerable operational effect.

From micro and mini drones operated by Pakistan-based elements to air drop arms and ammunition in India to small, medium and large UAVs used in Afghanistan, Iraq, Nagorno–Karabakh and in the ongoing Russia–Ukraine war and Israeli–Hamas conflict, drones are being employed by both state and non-state actors. The use of UAVs was critical in the success of Azerbaijan forces at Nagorno–Karabakh and highlighted how armed drones are changing the way warfare is conducted. From High-Altitude Long Endurance (HALE) UAVs to cost-effective Switchblade loitering munitions, UAVs have come a long way to make the battle tank become vulnerable in the contemporary battlefield.

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The emerging drones would have interactive ability and would transmit and exchange air and ground situation pictures between each other as well as with manned fighters. They are cost-effective as they can undertake persistent monitoring of contested spaces relatively inexpensively. These loitering drones act as a cost-effective nemesis to exposed target systems. The conduct of air warfare is therefore changing like never before with the emergence of more potent UAVs.

The future scenarios could include small drones swarming hostile air spaces for undertaking surveillance activities and identifying critical targets whilst saturating the enemy's air defence systems with low signature aerial elements. The value of drones could lie in simultaneously causing damage to numerous geographically dispersed high-value targets, thereby causing systemic functional paralysis and large operational effect. There is therefore a need to recognise the high potency of such an aerial platform and evolve an integrated philosophy for drone procurements, maintenance and training.

Keywords: *Unmanned Aerial Vehicles (UAVs), Air Power, Warfare*

Introduction

Unmanned Aerial Vehicles (UAVs) are pilotless aerial objects that could be termed as flying robots which can be remotely controlled or can fly autonomously. UAVs (also known as drones and remotely piloted vehicles) have numerous civilian and military applications that extend human capacities, enhance surveillance ability, aid in providing search and rescue, assist in monitoring people and crops, help in identifying transmission of infectious diseases, supply essential resources and medicines in remote locations and are important tools of warfare as well.

From mini drones operated by Pakistan-based elements to drop arms, drugs and ammunition in India to small, medium and large-sized UAVs that were used in Afghanistan, Iraq, Nagorno–Karabakh and in the ongoing Russia–Ukraine and Israeli–Hamas conflicts, these unmanned elements have emerged as a critical tool of warfare and are employed by both state and non-state actors to create a significantly large operational effect.

The use of UAVs proved critical in the success of Azerbaijan forces at Nagorno–Karabakh, highlighting how armed drones have changed the way warfare is being conducted today. From High-Altitude Long Endurance (HALE) UAVs to cost-effective Switchblade loitering munitions, UAVs have come a long way to expose the limitations of main battle tanks and manoeuvre elements in the contemporary battlefield.

This article covers the evolution of the UAV, its role in peacetime and during conflicts, its strengths and limitations, its relationship with air power including the envisioned role of fighter aircraft in future, emerging concepts of utilising the UAV and the way forward.

Evolution of UAVs as a Game Changer and Its Roles of Employment

Evolution of UAVs

The concept of drones dates to 1849, when Austria attacked Venice using balloons filled with explosives. Each balloon carried between 11 kg and 14 kg of armament.[1] In 1907, Jacques and Louis Breguet designed a gyroplane, which was the forerunner to quadcopter technology. In 1916, the first pilotless aircraft was designed by Archibald Low, the *Ruston Proctor Aerial Target*; it used a radio guidance system and technology that was later adapted by the Germans for their V1 rocket programme.[2]

After World War I, inventions including the Hewitt-Sperry Automatic Airplane and the Kettering Bug took forward concepts related to unmanned elements. In 1935, Reginald Denny developed a remotely piloted vehicle; subsequently, the UAV technology further improved during World War II when both Allied and German forces used drones to train aircraft gunners and aid missions.[3] During the Cold War, flying models became popular with advances in transistor technology that brought in miniaturisation of radio components.

The US used more than 3,500 drones in the Vietnam War from 1965 to 1972,[4] mostly for reconnaissance purposes. In 1982, at Bekka Valley, Israel was the first country to use drones in coordination with manned aircraft to reconnoitre enemy positions, jam communications, act as decoys and assist in neutralising the Syrian Air Defences (ADs).[5] Later, Israel developed Harpy, a kamikaze drone that attacked radars. The major developments in drones took place in the US, Israel, China and France. Drones also made a prominent contribution in the conventional roles of air power in the 1991 Gulf War, which included gathering intelligence to attacking vital targets.

By the beginning of the 21st century, Predator drones with thermal cameras were able to detect human signature from 10,000 ft.[6] A single Predator flew 164 operational missions over Afghanistan between September 2001 and January 2003.[7] US used these high-altitude drones extensively to locate and neutralise terror elements.

Civilian applications of the UAVs commenced in earnest in the 21st century and drones were used for Search and Rescue (SAR) missions during natural disasters and for monitoring affected areas. It then revolutionised the consumer drone industry. In 2010, the French manufacturer Parrot developed the consumer quadcopter that could be operated by an app on the smartphone. Subsequently, many delivery companies such as FedEx, Uber and Amazon documented the benefits of drone transportation. During the COVID-19 outbreak, their true worth was recognised when drones were used to monitor and undertake surveillance operations as well as provide medicines to remote locations. Meanwhile, their wartime applications assumed even deadlier roles with the integration of precision weaponry, turning them into Unmanned Combat Aerial Vehicles (UCAVs).

Though the Chinese drone industry was established in the 1960s, it is in this period that China started the active development of drones for civil and military use. In 2012, the Chinese drone company, DJI launched its drone called S800. This is the time when China marked the beginning of its success story in the commercial drone industry and became the second-largest drone market in the world.

Use of Drones by Non-State Actors

In the last 15 years, non-state actors have increasingly started utilising drones as a weapon of choice for observing areas, creating terror psychosis, using them for propaganda and for undertaking attacks on specific targets. In June 2021, Jammu air base was attacked by two drones during night-time, causing damage to the roof of a building and creating a small crater in an open area.[8] This brought an escalation in the scale of conflict, bringing it to a no peace, no war situation; the operations yet had a high degree of deniability.

The successful use of mini drones with a few kilograms of explosives makes it very difficult to detect, identify and neutralise such threats in time. The defence against such threats requires an integrated response from the three combat services and the Central Armed Police Forces (CAPF) due to the extensive area that needs to be covered. This also implies that there is a requirement to deploy several detection systems in the likely ingress routes of such drones and provide effective terminal counter-drone measures at key vital points such as air bases, cantonments and forward posts.

Shift in the Conduct of Warfare by Using Cheap Loitering Drones

Initially, the Bayraktar TB2 drones were effectively used by Turkey to attack vehicles and weapon systems in Libya and Syria. Subsequently, they were extensively used in the Nagorno–Karabakh conflict and became critical in the success of Azerbaijan forces. The conflict highlighted how the relatively cheap drones were changing the way warfare was conducted and how Azerbaijan forces used drones to identify battlefield targets and later used kamikaze drones to destroy them.

A wartime analyst has listed the Armenian losses at 185 T-72 tanks, 90 armoured fighting vehicles, 182 artillery pieces, 73 multiple rocket launchers, 26 surface-to-air missile systems, including a Tor system, five S-300s, 14 radars or jammers, one Su-25 war plane, four drones and 451 military vehicles.[9] Small and inexpensive drones have therefore demonstrated that they can create an out-of-proportion effect in the conduct of surface warfare. This conflict also highlighted the vulnerability of costly high-technology equipment, tanks and surface-to-air weapon systems against drone attacks.

Kamikaze drones using quadcopter/multi-copter technology have now made their presence felt both in conflicts between states (Russia–Ukraine War) and against non-state actors. A shift in the conduct of warfare has therefore started with the use of cheaper loitering drones instead of more costly aerial elements.

Use of Swarms in Operational Conditions

Advancements in emerging technologies such as Artificial Intelligence (AI), blockchain, robotics, sensors, communication systems and navigation technologies significantly enhanced the lethality and accuracy of drones. These technologies allow them to be flown either individually or to operate collectively in swarms with the capacity to collaborate and cooperate intelligently.

Israeli Defense Forces created history in May 2021 when they first used drone swarms in the 'Guardian of the Walls' campaign to attack the source of rockets fired from the Gaza strip. They used many multi-copter drones in over 30 operations to locate, identify and strike militants several kilometres inside hostile territory.[10] The use of swarms saturated the air spaces and enhanced mission effectiveness. With the low Radar Cross Section (RCS) of mini-UAVs, their survivability got enhanced, especially when they are operated in large numbers. A new concept of warfare has therefore started.

Use of Drones in the Russia–Ukraine and Israeli–Hamas Military Operations

After the potency of drones gained widespread recognition in the Nagorno–Karabakh conflict, they are extensively being used in the ongoing Russia–Ukraine and Israeli–Hamas conflicts. Ukraine initially purchased 12 medium-altitude, tactical Bayraktar TB2 drones from Turkey in 2019. By February 2022, they had 20 such drones. These UAVs have a range of more than 150 kilometres, an endurance of 27 hours[11] and can carry laser-guided munitions.

Ukraine used them to attack the exposed armour elements, logistics storage dumps and air defence weapons. They were also used to reclaim Snake Island. In naval engagements, UAVs monitored Russian ships, decoyed the launch of missiles, relayed radio transmissions, placed sonar buoys and undertook anti-submarine operations.[12]

Although TB2s were used successfully in February/March 2022, by the summer, they had become less effective. Initially, Russians were slow to set up proper air defences (ADs), but once they did, the Ukrainian UAVs were attacked with increasing frequency. In addition to being shot down, electronic warfare was used to jam and disrupt the communication links. This caused the Ukrainians to scale down the use of TB2 drones.[13] The primary reason of their vulnerability was their slow speed and their operating at medium altitudes which made them vulnerable to the Russian AD systems. Hence, many were shot down.[14] This implies that the use of counter-drone systems is an effective way to limit the use of this potent aerial weapon.

Further, the US provided Ukraine with 700 Phoenix Ghost drones and hundreds of kamikaze Switchblade loitering munitions, which could circle over the battlefield and attack designated targets.[15] The Switchblade 600 is designed to attack tanks and armoured elements and includes an explosive charge like that of a Javelin anti-tank missile. It has a range of 24 miles and endurance of 40 minutes.[16] These UAVs provide 'operators with real time video downlinks for a centralised view of the area of operations' and have 'wave-off capability' to adjust to emerging targets.[17]

There was also the widespread use of small commercial drones by the Ukrainians to gather intelligence and document war crimes in the affected areas. This contributed to increasing the situational awareness of Ukrainian forces, identifying Russian targets and monitoring troop movements.[18] Ukraine also claimed to have shot down several Shahed-136 drones.

From September 2022, Russia used Iranian Shahed-136 drones with mixed results. The drone_has explosives placed at its nose portion and is designed to loiter over an area until a target is designated. These drones were used to attack key military targets in Kharkiv, Kyiv, Odessa and Mykolaiv. Russia also deployed several commercial drones for intelligence gathering to attack tanks and armoured personnel carriers. Their vulnerability to deployed AD systems limited their effectiveness; a large number of Russian drones were claimed to have been shot down by the Ukrainian AD. For example, Russia launched 75 Shahed drones against Ukraine on 25 November 2023, and a significant number was claimed to have been shot down by Ukraine.[19]

The Russia–Ukraine War has clearly highlighted that *exposed and moving land and naval targets are becoming increasingly vulnerable to drone attacks and there is a need for counter-drone technology to be deployed appropriately during a conflict and in no war, no peace situations*. However, both aircraft like UAVs such as TB-2/Shahed-136 drones and loitering munitions such as Phoenix/Switchblade have their own limitations and situations in which they can be deployed.

In the Hamas attack on Israel on 7 October 2023, UAVs (called the Zouari) constituted the first wave of attacks to degrade Israeli observation towers, cameras and communications. Drones were also deployed to attack tanks, some naval vessels and energy infrastructure.[20] In Gaza, the Israel Defense Forces (IDF) uncovered a drone factory that Hamas was using to make such drones. However, the overall effect of the drones used by Hamas was limited.

For the first time, Hezbollah deployed kamikaze drones against Israel. It claimed that its fighters launched explosive-laden drones targeting an Israeli Army command position in the disputed Shebaa Farms area. Hezbollah had also employed armed drones to hit Islamic State positions, bunkers and fortifications in the western Qalamoun area of Syria. The use of explosive drones by Hamas and Hezbollah underscores the evolving nature of warfare and the increasing sophistication of non-state actors.[21] It is primarily because drones are small and cheap and can be easily assembled in urban areas.

On the other hand, the US had deployed its MQ-9 Reaper drone to aid in the search for about 240 people being held hostage in Gaza. The tunnel network, estimated to be around 200–300 kilometres in length, is a death trap for Israeli soldiers. In addition, they could be housing the hostages. It is for this reason that Israel used quadcopters such as Lanius to view inside the confined spaces of the tunnels. In the West Bank too, the IDF used drones for strikes and surveillance, especially against targets located in the Jenin camp.

The IDF has used a variety of drones including Hermes 450 or Zik, IAI Heron, Elbit Systems, Thor, and Rafael's Firefly loitering munition, known as

Maoz. Zik weighs about 550 kg and can fly for 17 hours at a time. Brigadier-General Omri Dor, commander of Palmachin airbase, in November 2022, indicated that drones accounted for almost 80 per cent of IDF's operational flight hours.[22] Thus, implying that *drones are replacing many of the traditional roles of more expensive manned aircraft*.

Due to the small size of the drone, their low altitude of operations and smaller Radar Cross Section (RCS), kamikaze drones are being employed to penetrate defended targets; however, their effect gets limited when counter-drone technologies are used. The drones are still being effectively used against mobile elements that operate outside the protected AD environment or against target systems located in urban areas.

The evaluation of the ongoing conflicts indicates that currently warfare is becoming more autonomous at the tactical level, is of much longer duration and is using unconventional techniques and cheaper combat elements to neutralise high value, highly potent and expensive weapon systems that belong to much stronger armed forces. The use of cheaper elements can neutralise force asymmetry to a reasonable extent.

Role of UAVs

UAVs could be classified as per their altitude of operations such as High-Altitude Long Endurance (HALE), Medium-Altitude Long Endurance (MALE) and Low-Altitude Low Endurance (LALE) UAVs. Strategic UAVs generally are HALE UAVs and are typically used for surveillance operations over large areas. They may have an endurance of over 40 hours and can fly at altitudes of over 30,000 ft. The future HALE UAVs could fly from 60 hours to 64 days depending on the type of batteries used, for example, solar powered batteries. It is this long endurance capability that gives UAVs significant advantage with regard to manned fighters as the fighters would have to land back due to human limitations even when air-to-air refuelling is available.

Two popular strategic UAVs are Global Hawk and Sentinel. The MALE UAVs such as Heron, Wing Loong I/II and Reaper fly between 10,000 and 30,000 ft and have an endurance between 24 hrs and 48 hrs. UAVs flying below 10,000 ft could be termed as Low-Altitude Low Endurance UAVs. Some of the roles in which these UAVs could be employed could be the same irrespective of their altitude of operations. LALE UAVs could be further subdivided as micro/mini/small drones. At the same time, usually LALE UAVs would be more effectively used in short endurance loitering and attack roles.

At the operational and tactical level, the employment of UAVs provides the ability to locate and track enemy troops and weapon systems, gather electronic intelligence, designate and/or destroy targets and simultaneously evaluate the extent of target destruction that has taken place. UAVs could therefore help undertake the entire detection to destruction loop significantly better and more quickly.

The key applications of the medium- and high-altitude UAVs could even substitute or supplement the functions of recce satellites. They can maintain continuous surveillance over Vital Areas (VAs)/Vital Points (VPs) for extended duration of time and provide a larger portion of the useable imagery in a much shorter time frame.[23] They also have the added advantage of operating at a much lower cost than manned aircraft.

Integration of Satellites with UAVs

Whilst satellites give imagery with a larger swathe, UAVs provide imagery with better spatial resolution (less than 10 cm), but over a much smaller swathe. For example, Earth Scanner-2 satellite gives 50 cm resolution with a swathe of 150 km whilst collecting 2 million square km of imagery per day. On the other hand, UAVs provide 4–8 cm resolution imagery though with a much lower swathe, thus providing much lesser quantum of imagery.

Satellites have the inherent advantage of covering large areas in a shorter time span, but cannot maintain orbit over a location and are constrained by re-visit times, whilst UAVs can maintain orbit over a location continuously.

UAVs usually require an operator to control it effectively, and the winds and weather can affect it significantly. On the other hand, satellites overcome terrain and obstacle limitations as well as sovereignty issues. Hence, both platforms have their unique advantages and disadvantages but the synergised integration of both could lead to significant complimentary and potential synergies.

In India, the synergies could be brought about at the operational level by coordinating with Defence Imagery Processing and Analysis Centre, located at Delhi and the Defence Satellite Control Centre, located at Bhopal through the Defence Space Agency.

It is important to assess the developments taking place in the neighbourhood in terms of manufacturing drones and in terms of concepts of their employment to appraise the emerging threat perception.

CHINA'S UNMANNED CAPABILITY

China has made significant strides in unmanned platforms that include Wing Loong UCAVs, autonomous amphibious vehicles and helicopter drones such as Blowfish 2 in the last two decades. China also uses UAVs to train infantry personnel to undertake beyond visual range targeting.[24] They have developed a 500-km range V-750 unmanned helicopter that successfully test fired anti-tank missiles in June 2017.[25] In 2019, a private Chinese company, Ziyan UAV, demonstrated armed swarming drones.[26]

China has developed several loitering munitions. These include:

(a) CH817, an anti-personnel LM with a munition weighing two pounds.
(b) WS-43, with endurance of 30 minutes and a 20-kg warhead.
(c) CH901, with endurance of two hours, can operate in swarms and destroy light armoured vehicles.
(d) Dragon 60B, a new loitering munition that is designed to engage beyond line-of-sight ground targets with an explosive warhead.[27]

The different types of MALE/HALE Chinese UAVs are given below:

(a) Medium-Altitude Long Endurance drone fleet consists of BZK-005, GJ-1 (Predator equivalent) and GJ-2 (Reaper equivalent) drones. These are basically Wing Loong I and Wing Loong II variants[28] utilising laser-guided HJ-10 anti-tank missiles.
(b) CH-3 is a fixed wing UCAV and can carry Anti-Radiation Missiles (ARMs), inertial/GPS munitions and Air-to-Surface Missiles (ASMs).
(c) Airborne Early Warning (AEW) UAV, Divine Eagle, would become operational by 2035.
(d) GJ-11 (Sharp Sword), a stealth UCAV,[16] has a combat radius of 1,000 km and can carry 500 kg/100 kg guided bombs. It can be used for autonomous tasks, swarming and Manned–Unmanned Teaming (MUM-T) missions.

In 2021, People's Liberation Army Air Force (PLAAF) flew WJ-700 HALE drones in Tibet,[29] thereby highlighting China's proficiency in manufacturing and operating a wide range of unmanned elements from loitering LALE drones to HALE UAVs, which could affect India's area of operations.

Pakistan's Unmanned Capability

Pakistan operates a wide variety of UAVs including armed drones such as Burraq (12), Satuma Bravo (45), Galileo, Falco (25), CH-4 (04), AAI (RQ-7) (12) and Shahpar (05). It is currently focusing on the development and production of Medium-Altitude Long Endurance unmanned platforms and has identified Project Azm for the same.[30] Under this project, UCAV manufacturing will be carried out in Pakistan. The conceptual design phase is complete, and the prototype is undergoing three more cycles of tests with high fidelity tools.[31]

In May 2018, Pakistan Aeronautical Complex (PAC) signed a Memorandum of Understanding (MoU) with a Turkish company, Havelan, to collaborate with Pakistan on ground control stations, mission and weapon control computers and sensor integration. Pakistan and China have also been working on the production of Caihong-5 and Wing Loong UCAVs.[32] China has sold 48 advanced MALE Wing Loong-II UCAVs to Pakistan. This UCAV employs up to 480 kg of weapons with the ability to carry both bombs and air-to-surface missiles and has an endurance of around 20 hours. Indian armour in Pakistani territory therefore is likely to face stiff opposition from the Pakistani armed UAVs.

Shahpar is a tactical UAV designed, developed and manufactured by Global Industrial Defence Solution for the Pakistan Armed Forces. The UAV can be deployed for real-time reconnaissance and surveillance, target acquisition, generate situational awareness and also for disaster management related missions. The UAV can fly at 150 kmph (81 kts) and can operate for more than seven hours at 5,000 m.[33] Pakistan also uses quadcopters, such as DJI Mavic 2 Pro model, made by Chinese companies, which were shot down by the Indian security forces in 2022–23.

Pakistan therefore possesses short- and medium-range UAVs with varying ranges and endurances. The range bracket extends from 6 to 8 km till about 300 to 350 km. The endurance bracket is from a few minutes to about 8 to 14 hrs (Falco UAVs 14 hours).[34]

Analyses of Chinese and Pakistani UAV Challenge

Whilst the Chinese employment of drone and counter-drone technologies in Tibetan Autonomous Region (TAR) has increased significantly, its use of small kamikaze drones is limited due to high altitudes of operation. The MALE and HALE drones yet are being employed at TAR; however, they are likely to be vulnerable to the AD systems deployed in Ladakh and Arunachal

Pradesh. At the same time, a comprehensive study is required for both the northern and western borders to ascertain the optimum positioning of the long-, mid-, and short-range AD and counter-drone systems to mitigate the integrated threat from hostile drones and stealth fighters (J-20).

Pakistan has significantly improved its armed drone capability and this would be extensively utilised during combat operations, but its employment of micro and mini drones in peacetime to support terror operations is the key threat. Pakistan-based terror elements with the active connivance of Pakistan's intelligence agency, ISI, extensively employ mini and small Chinese drones to transport arms, ammunition and drugs across the border both in Punjab and in the Jammu and Kashmir region to fuel terrorist activities.

Indian Armed Forces' UAV Capability

In comparison, the Indian Armed Forces possess around 200 plus Israeli origin MALE Searcher-I/II and Heron UAVs[35] and around 110 HAROP drones. Searcher is limited both in payload capacity (150 lbs) and its operational ceiling (20,000 ft), however, with its endurance of up to 18 hours and its ability to carry a wide variety of sensors, it has rendered yeoman's service along the western borders. Heron, with a takeoff weight of 1,150 kg, 250 kg payload, endurance of 40–52 hours and an operating ceiling of 32,000 ft has proved to be extremely useful for surveillance along the mountainous borders.[36]

Currently, both Pakistan and China have an edge in the development and employment of armed UAVs. There are very limited Indian UCAVs that can carry air to surface weapons and can loiter and attack vital targets besides radars. In February 2019, the Indian Air Force (IAF) planned to add another 54 Harop drones to its fleet.[37]

India has increased collaborations with foreign partners, particularly Israel and the United States (US) to procure UAVs and enable transfer of technologies. Ten Israeli Heron TP-armed drones are ready for delivery. These drones with a 1,000 kg payload are capable of detecting, tracking and attacking targets with air-to-ground missiles. Under the Make in India initiative, the production of these drones may shift to India.[38]

The US government's decision to export 31 Guardian drones (15 Sea Guardians for the India Navy and eight each for the Indian Army and the Indian Air Force) is likely to address the gaps in India's maritime surveillance to an extent and help free Boeing P-81s for Anti-Submarine Warfare (ASW) duties. This acquisition is considered critical given the increasing forays of

Chinese submarines in the Indian Ocean region.[39] As per a CDS study, the acquisition of 31 MQ-9B High-Altitude Long Endurance UAVs and 155 MALE UAVs is recommended.

The MQ-9Bs can loiter up to 50,000 ft, remain airborne for over 35 hours and carry four Hellfire missiles besides around 450 kg of bombs.[40] General Atomics is also likely to establish a Comprehensive Global Maintenance, Repair and Operations (MRO) facility in India.

In 2021, the Indian Army procured four Heron MK-IIs, which were inducted in 2022. There have been some emergency procurements carried out by the three services, which are likely to fructify by 2024. While the Army and the Navy have procured the Hermes-900 manufactured by Elbit Systems, the IAF has procured the Heron MK-II. There is also a major upgrade plan for evolving all the Heron UAVs to MK-II standard to incorporate weaponization and for the integration of SATCOM services, estimated to cost Rs 21,000 crores.[41]

At the same time, these numbers are considered inadequate to provide an effective deterrent capability and to cover the land and maritime borders. In addition, there is a need for India to develop stealth capability in UAVs.

India has a long way to go to reduce the gap between its existing UAV capability and the growing demands of its armed forces to cater to a two-front scenario. There is also a need to augment the strength of the UCAVs and procure additional armed mini/small loitering munitions. Further, the three services usually procure UAVs independently and have separate training infrastructure for similar UAVs, thereby dissipating valuable resources and increasing inter-services friction. There should be a single lead service, preferably the IAF, on entire drone-related issues and training.

In addition, indigenous research in drone technologies by the defence research entities has been slow. Hence, to enhance accountability and to attain the desired level of research outcomes, the research teams for different UAV projects need to be placed under the stewardship of the IAF for speedier implementation of the project as the qualitative requirements, design and development could then be handled as one team and not as three individual teams.

At the same time, the Indian government has initiated a new drone policy in 2022 that will help leverage India's strengths to make India a global drone hub[42] and help the private sector to extensively develop mini/ small drones. These developments indicate the emerging partnership between the public and the private sector. It is here that private multinational integration with the IAF may help accelerate the modernisation process in UAVs to counter the Chinese challenge. In addition, it is here that an evaluation of counter-drone technologies could assist in the evolution of an integrated strategy.

Counter-Drone Technologies and their Limitations

Counter-Drone Technologies

To counter mini/small loitering drones, it is vital to complete the detection, identification, tracking, interception and destruction loop. It is not easy to counter such drones with the help of conventional AD systems due to their very low altitude of operations, extremely low flying speeds and very small RCS. This would require special types of radars and detection systems. The different types of detection devices in use currently include special Radio Frequency (RF) analysers, electro-optical sensors, Infrared (IR) devices, acoustic sensors and different types of radars such as Elvira, which has a Frequency Modulated Continuous Wave (FMCW) micro doppler system that can differentiate between drones and birds.

Some of the counter-drone detection equipment can identify the particular model of drone or even its Media Access Control (MAC) address, which is a unique identifier assigned to a Network Interface Controller (NIC) for use as an address in communications within a network segment. This becomes necessary to geo-locate the operator who may be a non-state actor, thereby identifying the source of the non-state operations being undertaken.

Soft-kill measures are used to neutralise the effectiveness of a drone, to take over control or make the controller lose control over the drone by using GPS spoofing, GNSS jamming, RF Jamming and Electronic Warfare techniques involving jamming the signal between the operator and the drone. Hard-kill measures include drone guns, LASER systems, drone catchers, Sky Fence systems and combined or hybrid interception elements comprising multiple soft- and hard-kill options.

The future counter-drone systems include AD systems with longer ranges such as Iron Beam (7 km) and Iron Dome (70 km); the latter uses kinetic interceptors to provide protection against incoming rockets, mortars and small drones. The 100+ kilowatt Iron Beam weapon has already been live fired to test its destruction capability.

India has a strong integrated AD system, yet its ability to detect and neutralise mini/micro/small drones is quite limited. Further, the extent to which the entire northern and western borders that could be covered by such systems, which themselves have limited ranges, would require millions of these to be deployed, which is practically impossible. This implies that only selected areas and vital points can be covered where there would be a high probability of presence of such malicious elements.

This requires a comprehensive analysis of AD requirements to be carried out by all the three services under the CDS with the IAF being the lead agency since it has been entrusted with the responsibility of AD for the entire country.

There are several indigenous systems that are currently undergoing operational and validation trials and could be inducted into the armed forces soon. At the same time, no armed forces in the world can counter the proliferation of tens of thousands of rogue drones. It is here that intelligence in the field is vital to prevent attacks from micro/mini drones.

Indigenous Developments in Counter-Drone Technologies

The Defence Research and Development Organisation (DRDO) has developed a D-4 hybrid counter-drone system, which has both soft- and hard-kill options. The hybrid system incorporates a radar that has a detection range of 4 km, RF system 3 km, and EO/IR system 2 km. The RF jammers have a range of 3 km and hard-kill LASER range is 1 km. There are other counter-drone systems being developed such as BELs autonomous operating system that integrates a radar, EO/IR detectors and a hard-kill weapon.

There are many private firms as well that are developing such technologies. The IAF has given Rs 155 crore contract to Zen Technologies for providing Counter Unarmed Aircraft System (CUAS). The Navy too has given a contract to BEL to provide Anti Drone Systems that can detect and jam micro drones and which use a laser-based kill mechanism to destroy small drones. With the proliferation of micro/mini drones, the need for effective counter-drone technology has become vital.

Limitations in Tackling Drones

Counter-drone detection systems may use IR equipment to track heat signatures, RF analysers to detect signals from a drone's remote controller and acoustic techniques to recognise the unique sound of drone motors. In spite of this there are limitations to the use of such detection systems, primarily due to the very low altitude of drone operations, their lower operational speeds and the requirement of line of sight for detection (which may be a problem in urban areas and in hilly terrain). In addition, electro-optical systems get affected by weather, storms, low visibility or when they are in the presence of strong background light. Further, the drone could be mistaken as a bird and the GPS spoofing systems may also spoof other aircraft in the vicinity that are using GPS for navigation.

RF sensors' detection capabilities can get degraded due to electromagnetic interference because of microwave or communication towers operating in the vicinity. As for acoustic sensors, they may not cover the entire range of frequencies of all drones that has been stored in their library, which is in turn housed in these sensors. Further, counter-drone systems, especially those that use Directed Energy Weapons or LASERS, need to be highly accurate as any miss could result in posing high threat to other air-borne elements.

The widespread use of mini/small drones by both state and non-state actors in peacetime, in no war, no peace situations and in conflict situations as cost-effective options is likely to increase. Hence, an integrated air and space defence system is considered necessary to tackle all aerial threats.

Integrated Air and Space Defence

The key limitation in providing defence against UAVs is the wide variety of UAVs that could be utilised by an adversary. These include high-altitude, medium-altitude and low-altitude unmanned elements that require different detection and interception techniques due to their altitude of operations, size and unique characteristics. Though Standard Operating Procedures (SOPs) and policies exist for providing AD as well as in segmentation of altitudes for air space management, yet the altitudes and SOPs need review with evolving circumstances.

Keeping in mind that HALE UAVs operate above 30,000 ft, MALE between 10,000 ft and 30,000 ft and LALE below 10,000 ft, and also all the three services use different types of UAVs, an integrated air and space defence philosophy would need to be evolved where drones flying below or at 2,000 ft could be autonomously tackled by the agencies guarding vital areas and vital points, and above 2,000 ft should be tackled by the IAF as part of its Integrated Air Defence network for the whole country. This is likely to prevent fratricide and make optimum employment of available resources. However, this decision could be reached after an analytical study has been carried out on providing integrated air and space defence from peacetime to wartime scenarios. One aspect that would need deliberation would be multi-domain integration.

Air Warfare in Multi-Domain Operations (MDO) and UAV Integration

Future conventional wars fought in integrated battle spaces with the MDO strategy would move beyond the 'air-land battle' concept to attain multi-domain dominance. This fighting construct integrates different systems belonging to the three services as well as utilises surface, air, space or under water elements, including the electromagnetic spectrum and cyber, to create a strong interconnected system of systems network.

From being platform-centric, the operational philosophy would gravitate towards fusing platforms over interconnected networks. The effectiveness of air warfare would depend on *how well the manned and unmanned elements could be seamlessly integrated to exploit their combined potential* to create significant operational effect. The MUM-T outcome could get force multiplied with the interconnectedness and transparency provided by the numerous UAVs flying in the battle space. Air forces would therefore need to develop coherence to operate across multiple domains by *employing manned and unmanned elements as one system to reduce fratricide and maximise potential of exploiting available windows of opportunities, whilst effectively tackling threats utilising the air and space domains and simultaneously providing maximum freedom for surface operations.*

UAVs and Air Power

UAVs are part of air power as these aerial elements are propelled with a piston or jet engine and use aerial environment for their operations. The aim of employing air power in future conflicts is likely to be to isolate the opponent's Command and Control structures, augment psychological warfare, paralyse his communication networks and simultaneously strike deep inside his territory on vital centre of gravity targets with precision to attain comprehensive out-of-proportion outcomes. Such concepts favour employment of air power more than any other military force.

Several roles of air power are now effectively undertaken by UAVs. At the same time, deeper situated targets may still need modern fighters as using HALE/MALE UAVs deep inside hostile territory would make them vulnerable to the enroute AD systems due to their lower speeds and higher altitudes of operation. This was evidenced in the recent conflicts. A combination of optimally employing both these vital assets is therefore necessary.

Analyzing Russia–Ukraine war for employment of air power, despite Russia's overwhelmingly superior air force capability, the Russian Air Force was not truly effective over Ukraine. Initially, its air and missile strikes were distributed across the country and not targeted against critical nodes. Hence, it was unable to create concentration of effort. Secondly, Russia's Suppression of Enemy Air Defenses (SEAD) plan was inadequate. It was unable to destroy mobile Surface-to-Air Missiles (SAMs) and its targeting of Ukrainian military airfields was largely ineffective. It could not destroy enough number of combat aircraft on ground either. In addition, Ukraine possessed several MANPADS such as Stinger and the Russian aircraft flew in its lethal coverage.

Thirdly, Russian forces failed to integrate tactical or battlefield intelligence. Lastly, Russia initially appeared not to have an effective plan to counter Ukrainian drones and this took a toll on the Russian ground forces, which were in the open. The air campaign therefore appeared to have no overarching concept or unifying theme.[43]

Hence, the Russia–Ukraine War displayed improper use of the Russian air power in that the air campaigns were initially inadequately planned and later neither were they comprehensive enough nor did they use all their capacity, thereby losing their phenomenal potency and effect.

This conflict has also proven the Russian Air Force's inability to continuously generate a favourable air environment that permits unhindered surface operations. This inability resulted in Russia exposing its armoured and other vital combat elements to successful drone attacks. The second issue that got highlighted was that the initial Russian use of UAVs has not been documented, whilst the first use of Ukrainian TB2 drone was documented on 27 February 2022 against the Russian Buk AD system north of Kyiv.[44] The UAVs should therefore have been a part of an integral Russian surface plan right from the initial stages and counter-drone technologies should have been incorporated with the mobile surface elements once attacks began to take place from Ukrainian drones.

Future conflicts would require swift reaction and the capacity to control information would become even more decisive.[45] Earlier the role of collating information was performed by manned aircraft flying at high altitudes such as SR 71, U-2, Mig-25, E-8 and JSTARS. Emergence of drones has provided the ability to locate and track enemy deployments efficiently and complete the entire detection to destruction loop effectively.

As air defences become more potent against manned aircraft, and the manned aircraft become more costly, such as the B-2 stealth bombers costing around a billion dollar a piece, they have become out of reach for most nations. The cheap small drones then become a cost-effective alternative against stronger armed forces (example of Ukraine conflict and use of drones by non-state actors in different conflict situations). This implies that currently the unmanned elements are undertaking traditional roles that were once considered the sole domain of the manned aircraft. In future, kamikaze loitering drones are likely to become even more effective as Artificial Intelligence (AI) improves combat capability and reduces costs.

With the integration of various types of UAVs at different levels, air power could provide a cost-effective nemesis at different stages of a multi-domain campaign to detect, monitor, destroy vital targets, instill delays and create psychological impact where the intent of the adversary is clearly identified and effectively neutralised.

Emerging Concepts of Utilising UAVs

Emerging Role Shift from Manned to Unmanned Elements

Drones are extensively utilised today for undertaking sustained surveillance operations over areas of concern to detect and monitor enemy deployments, track troop movements, gather Electronic Intelligence (ELINT), designate targets of importance, locate and destroy targets of opportunity and undertake battle damage assessment.

Responsiveness is the key advantage of using drones; especially, once the situation changes, the engagement could be terminated or shifted to another target. Mini drones' small size, lower weight, and low RCS give it significant survivable benefits.[46] Currently, China is developing underwater drones that can fly from the water surface to target aircraft carriers and naval battle groups to implement its Anti-Access Area Denial Strategy.

UAVs in several situations therefore obviate the need to employ expensive manned fighters. This implies that a slow shift is taking place where more and more small, smart and highly potent UCAVs are being used instead of expensive manned combat fighters and manned surveillance aircraft. The unmanned systems are also developing the ability to interface intimately with their manned counterparts or other unmanned elements as AI develops increased interactive capability.

It therefore implies that many of the roles that were once considered to be the sole domain of a manned aircraft are now being effectively performed by UAVs. Another major advantage of using UAVs is that if it is shot down in hostile territory there is no concern that the pilot will be taken captive and used for propaganda purposes.

The use of drones in contested air spaces can therefore generate a degree of dominance and create an upward spiral of combat operations as they continuously operate within the Observe Orient Decide Act (OODA) loop of the adversary. Drones have therefore become a game changer in the true sense. Hence, there is a slow shift taking place in employing UAVs in many of the roles that were earlier performed solely by manned aircraft.

Utilisation of Swarms and Manned–Unmanned Teaming (MUM-T) Concepts

The wartime scenarios could include swarms of low signature drones flying over a wide area detecting and attacking key elements whilst saturating enemy's AD systems. The value of this concept lies in simultaneously causing significant damage to geographically dispersed high-value targets, thereby creating systemic functional paralysis whilst simultaneously saturating the hostile battle space.

The MUM-T concepts have been practiced by both the Russian and the US Air Force. Essentially, the concept integrates unmanned elements flying with manned aircraft. The architecture for MUM-T involves communicating wirelessly with UAVs, while these UAVs efficiently share data across all platforms and let manned platforms connect at different Levels of Interoperability (LOI), thereby enhancing situational awareness, decision making and mission effectiveness.[47] The concept denotes the homogenous employment of heterogenous aerial assets within individual combat units. The MUM-T concept leverages inherent benefits of both manned and unmanned platforms.[48]

In September 2019, Russia released details of their first flight of the sixth-generation stealth Su-70/Hunter-B UAV flying alongside Su-57 fifth-generation fighter in a wingman role for MUM-T missions. The Russian low observable UAV is likely to be developed by 2025 and will have the ability to transmit radar and imaging data to fighters that are flying in depth and use long-range air-launched weapons; in this concept, the manned fighter remains well outside the coverage of the enemy's AD systems and attacks the heavily defended targets after receiving inputs from unmanned platforms.

China too is undertaking the development of Tian Ying, a similar drone. The Americans are employing RQ-170 Sentinel and are developing X-47B and X-45C drones. The American Valkyrie and the broader Skyborg programmes are aimed at developing relevant hardware and software to integrate manned aircraft with unmanned drones with the aim of separating the sensor from the shooter and flying mixed formations of stealth UAVs with manned fighter aircraft[49] that are operating in depth carrying long-range air-to-surface weapons. This enhances the survivability of expensive manned fighters whilst improving their strike effectiveness. With the integration of AI, drones are likely to have enhanced interactive ability and would be able to transmit and exchange air and ground pictures between each other and with manned fighters.

The conduct of air warfare is therefore changing like never before and this progress is expected to bring significant effectiveness in surveillance, navigation and direct combat action by 2035.[50] The cheap loitering drones are acting as cost-effective nemesis to the exposed target systems. The questions being asked now are whether the days of procuring large numbers of expensive tanks and manned fighters over?

Are the Days of the Fighter Aircraft Over?

Today many strategic theorists are questioning the employment of expensive manned fighters and are asking whether Biggles' (war magazine hero) days are numbered. Whilst technology has moved from UAVs towards UCAVs and smart drones that can locate, identify and accurately attack targets, the US Air Force has released details indicating how tiny drones will soon swarm hostile airspaces for undertaking surveillance, targeting and destruction activities and that Boeing is creating a swarming system for larger drones.[51]

The future scenario could include several cheap low observable mini/ small drones to enter an adversary's air space to saturate its AD systems and simultaneously cause significant attrition on many geographically dispersed high-value targets. These drones would have the ability to undertake spaced multiple attacks to cause systemic paralysis.

Initially, the transition could come with a combination of manned and unmanned elements operating in integrated battle spaces and working in tandem and subsequently, majority platforms in conflict spots would be unmanned with embedded AI systems both in drone technology as well as in Command-and-Control architecture.

As AI technologies progress to deep and super learning, artificial neural networks could then be inter-connected in such a manner that the system becomes superior to the functioning of a human brain as it gathers, collates and processes large amounts of data obtained from a number of different drones and sensors (something that will happen when swarms of drones penetrate enemy air space) and these neural networks would have the ability to operate much faster than a human brain can ever process whilst simultaneously learning and upgrading itself by interpreting data patterns and the experience that it obtains.[52]

The advantage of using different types of drones is that they enhance security in peacetime in disputed areas by monitoring contested regions continuously, leading to a reassurance that potential adversaries are not attempting to alter the status quo.[53] In combat situations, multiple UCAVs are likely to be initially used for Suppression of Enemy Air Defence operations by pre-emptively attacking Command and Control Centres, radars and other AD elements whilst providing continuous surveillance and battle damage assessment; a task that a fighter aircraft is unable to undertake simultaneously in real time. Several drones could also simultaneously carry out high value time critical targeting on Centre of Gravity (CoG) targets, thereby providing dynamic air and surface domination at much lower cost.

In future, manned assets would mostly be used in situations where discrimination is required between targets, especially in a fast-changing battle situation, act as an aerial command post, attack rapidly moving targets in close vicinity of friendly elements, tackle targets that are located in depth or be a shooter in the sensor-shooter chain.

In the near future, MUM-T operations would gain prominence as a significant number of platforms in conflict areas would be unmanned. By 2035, unmanned platforms would constitute a significant proportion of the aerial combat elements in concert with manned aircraft. In a two-front scenario, possession of large numbers of different types of drones from HALE to LALE as well as effective and integrated counter-drone technologies, supplemented with long-range AD systems, could make a significant difference in neutralising force asymmetry.

Conclusion

The ability to obtain and control information can create disproportionate effects. Emergence of drones provides the ability to locate and track enemy deployments, gather electronic intelligence, designate and/or destroy targets and simultaneously evaluate the extent of target destruction that has taken place, implying undertaking the complete detection to targeting loop effectively.

As air defences become more potent and high-value manned aircraft become more costly, the relatively cheaper drones offer a cost-effective alternative, even against much superior enemy forces. Further, kamikaze loitering drones have become popular as they are much cheaper, easier to acquire and require less infrastructure to operate. With the incorporation of AI technology in drones, their combat capability has significantly enhanced whilst lowering the cost of operations. In future, AI integration will allow interactive engagements both within drones as well as between drones and manned aircraft.

This implies that slowly the unmanned elements are taking over several traditional roles of manned aircraft. There is already an increased employment of unmanned elements in different combat roles, as well as testing of the MUM-T concept and the concept of using swarms to saturate enemy battle spaces. This is going to become even more prominent by 2035, when there will be a significant number of unmanned elements operating in concert with manned aircraft that will dominate the battlefield. There is therefore an urgent need to identify the desired numbers of different types of UAVs required to cater to a two-front threat both in no war no peace situation as well as during combat operations, as well as to effectively counter the threat posed by the opponent's UAVs and design a proper air space management philosophy, where there is maximum freedom for surface forces' operations and at the same time it allows freedom to combine aerial manned and unmanned elements.

The Way Forward

To evolve India's comprehensive drone and counter-drone strategy, there is a need to undertake a comprehensive analysis of India's threat perception by the three services under a lead agency, the IAF. These analyses should cover different types of drone threats from state and non-state actors, from high to low levels and should simultaneously identify India's drone requirements that include HALE, MALE, LALE and mini/micro drones.

The focus of the analyses should be to identify whether our integrated air and space policy is effective and is catering to peacetime, no war, no peace situations and wartime scenarios effectively whilst providing optimal simultaneous centralisation and decentralisation effects and whether the current height/altitude and time segmentation needs further review and modification.

Secondly, to recommend the numbers of each type of drones that need to be procured for the three services and also the numbers of counter-drone systems required and where to base them to defend against drone attacks, keeping in mind the overall air, land and maritime requirements. At the same time, ensure that the overall AD of the nation as well as coordination for the same lies with the IAF, irrespective of the decentralisation provided for providing flexibility for progress of rapid surface operations.

Thirdly, there should be a common drone procurement strategy for the three services that incorporates commonalities in drone/counter-drone system acquisition, to bring down the cost of acquisition when large numbers are negotiated, have minimum different types of drones/counter-drone systems and devise common maintenance and operational philosophies and infrastructure requirements so as to optimise the use of resources and bring in efficiency and effectiveness in drone procurements, operations and in their maintenance policies and infrastructure.

Fourthly, there is also a need for greater integration within the different intelligence agencies; periodical meetings should be held to assess the threat perception with respect to the utilisation of drones by hostile elements in irregular warfare. There should be a communication link established between all the AD elements within each service and the area Air Defence Command and Command architecture, which is maintained by the IAF.

Fifthly, the IAF should be the lead agency in maintaining and training the drone force and its human capital. Sixthly, a three-layered air defence system should be established for threats originating from HALE and MALE UAVS, LALE UAVs and from micro/mini drones flying at extremely low height. This integration will decide at which level centralisation should take place and below which decentralisation should occur so that Jammu-like incidents do not take place.

Lastly, war fighting doctrines and procurement strategies too need to be evaluated to cater to the revolution brought about by the employment of different types of UAVs. Further, due to the slow shift taking place from manned to unmanned elements and MUM-T missions involving a combination of manned and unmanned platforms there is a need to bring about changes in the operational philosophies of integrated force employment in multi-domain integrated warfare.

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