Counter UAS Technologies for India
A Prognosis

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Unmanned systems pose grave threat to several countries and their interests due to a number of reasons: low barrier of entry into the procurement sector, commercial availability off the shelf (COTS), ubiquity, persistence and low radar cross section (RCS). Due to this, counter drone systems have been either deployed piecemeal or existing air defence systems have been used to fill the gap. The Indian Armed Forces have a very limited experience of dealing with either drones or counter-drone systems in an operational environment. The Jammu attack using improvised drones was a wake-up call. With the impetus to indigenisation given through 'Atmanirbhar Bharat', this is an opportune time for the Indian defence industry to rise up to the challenge. However, it is equally important that certain guiding philosophies, based on other countries' experiences, role of drones, threats posed and possible counter-measures be analysed so that a definite addition can be made in the drone literature in the Indian context. This article intends to do the same. By first briefly analysing the historical context under which the role of unmanned systems gained ground, followed by their unique characteristics and qualities, various counter-drone systems in vogue and case studies, the article attempts a prognosis on a practical counter-drone philosophy for the Indian Armed Forces, using a combination of academia and a practitioner's perspective.

Keywords: *Unmanned Aerial Systems (UAS), Counter UAS, C-UAS Philosophy, Drones, Atmanirbhar Bharat*

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Introduction

Since the advent of modern civilisation, war has always involved a clash of wills—between groups of men, kingdoms, and now nation-states—with each side attempting to subjugate the other through the threat or use of violence, for a fixed end game. Theorists have divided war very broadly into its components, namely, nature and character.[1] While the nature of war, that is, imposing violence on the other, remains unchanged, the character of war has continuously been in flux. A number of 'revolutions in military affairs (RMA)' have taken place since the days of bows and arrows and prehistoric tools, to the current era in which drones and cruise missiles dominate.[2] These RMAs, which describe a generational jump in technologies (crossbow, gunpowder, nuclear weapons, etc.), organisation (Napolean's *levee en masse*, total war), and doctrine (German blitzkrieg, carrier airpower), have influenced warfare exponentially, ceding major advantages to states or groups that have used them first against their adversaries.[3]

It has also been seen that the balance between man and machine in warfare has shifted, subtly if not imperceptibly, towards the latter. And the relationship between them is based if not on trust, then on dependence.[4] Trench warfare and daylight charges were replaced with mechanised warfare during World War II; and now, non-contact warfare involving cyber-attacks, unmanned systems, and cruise missiles are the staple fare of contemporary conflicts. In this move towards greater autonomy for weapon systems, the so-called "man-on-the-loop" where the operator is present is only a fail-safe in case of a major deviance of the system from the end goals, and unmanned systems play a huge part.[5] They have become so ubiquitous that some analysts believe that an "unmanned revolution in military affairs" is in the offing.[6]

However, as has been the case since the start of war, every use of technology on the battlefield provides an opportunity for the other side to come up either with a counter, or a better use of the same technology, thus dampening the prime mover advantage of the initial side.[7] Unmanned aerial systems (UAS), in their present form(s), have started figuring prominently in the military thinking of a number of countries, apart from being used in a number of civilian applications. Their proven efficacy in a number of contemporary conflicts such as the Azerbaijan–Armenia war,[8] the ongoing Russia–Ukraine conflict,[9] and other clashes, have made them critical components of the battle systems of a number of militaries. As a result, counter-UAS technologies

(C-UAS) have been innovated and demonstrated, which are based on the perceived weaknesses of the UAS. These are still in the nascent stage, and the challenges of employing them—as will be analysed in this article in detail—are formidable, both operationally and doctrinally.

It is the intent of this article to lay out first, the importance of the UAS in warfare with a small historical background. This will be followed by global perspectives as well as the Indian (tri-services and civilian) perspective on the philosophy of C-UAS. Finally, case studies on the use of C-UAS in warfare will be followed by how 'Atmanirbhar Bharat' can be used to spur innovation and manufacturing of C-UAS technologies in a holistic manner. In this article, drones, Remotely Piloted Vehicles (RPVs), and Unmanned Aerial Vehicles (UAVs) have been used interchangeably while the designations of mini, micro, tactical, medium and high altitude have been taken from the Drone Databook.[10]

Unmanned Aerial Systems (UAS): Historical Background

There is a long history of the use of UAS in warfare going back to the 19th century, with the use of incendiary balloons by Austrian forces against Venice in 1849.[11] Incidentally, this event also marks the first offensive use of air power in naval aviation.[12] However, the Austrian incident was a one-off event, and there was no sustained thought process behind developing unmanned systems for further use in the battlefield. During World War I, there were certain attempts at developing unmanned systems, such as British engineer A.M. Low's "Aerial Target" (1916),[13] while the inter-war years were used for designing and manufacturing close to 400 "de Havilland 82 Queen Bee" aerial targets (1935).[14] Both were used as practice targets for militaries, especially *ack-ack* gunners. In terms of offensive weapons, the Kettering Bug unmanned torpedo, the Hewitt-Sperry automatic airplane in 1917,[15] and efforts aimed at controlling Tupolev TB-1 bombers by the Soviets in the late 1930s,[16] tried to arm unmanned systems with rudimentary radio communications systems and explosives.

It has to be reiterated that these technology demonstrations were not aimed at replacing pre-existing conventional platforms or transforming battle procedures. They were meant to act as crude support systems to further the war effort and, in the case of German development and later operationalisation of the V-1 and V-2 rockets, take last-moment pot shots at British civilian population centres.[17] The US pursuit of unmanned systems in the aftermath of World War II lost steam, with the drawing of the Iron Curtain and the focus turned to ballistic missiles and nuclear warfighting.[18]

The loss of precious US aviator lives over Vietnam forced the Americans to think of UAVs or RPVs as critical combat support systems[19], although some scholars refute the categorisation of UAS in the American context as meant primarily for saving lives.[20] UAV development started in earnest in 1959, and efforts were intensified after the shooting down of a U-2 spy plane by the Soviets in 1960,[21] and after Gary Powers was paraded by Moscow to Washington's utter shame and embarrassment.[22] Ryan Model 147 "Lightning Bug", Ryan AQM-91 Firefly, and Lockheed's D-21 were used as part of US intelligence, surveillance, and reconnaissance (ISR) missions, psychological warfare, and signals intelligence (SIGINT) during the Vietnam War.[23] The year 1982 can be said to be the year of reckoning for UAVs, when they were used by the Israelis against Syrian air defence (AD) systems in the Bekaa Valley, taking out 19 Soviet-made AD systems and 87 aircraft in a matter of 46 hours, without the loss of a single aircraft.[24] Interestingly, Jasjit Singh, writing for *Strategic Analysis* in 1984, situated the use of UAVs in the move towards the mechanisation of the Indian Army,[25] a process which had started in 1969 with the induction of SKOT and TOPAZ APCs.[26] This had gained steam towards the mid-1980s, with General K. Sundarji, the then Army Chief, pushing for a major showdown with Pakistan, before the inevitable weaponisation of the nuclear power of both countries.[27] The UAVs were deemed to provide battlefield surveillance and reconnaissance, fire control and direction, real-time communication, and defence suppression using electronic warfare (EW) systems. The last of these roles was supposed to be carried out in conjunction with manned aircraft.[28] The offensive role of UAVs and as relays was also visualised, but only in a theoretical manner.[29]

With the start of its global war on terror (GWOT) in the wake of the 11 September attacks, the US innovated and, in retrospect, perpetuated the use of UAVs in an offensive role, that is, targeted the killings of suspected terrorists.[30] Initially limited to Afghanistan, this use of drones proliferated to the bad lands of the Afghanistan–Pakistan border, Pakistan itself, Libya, Syria, Iraq, and many other places, in which the sovereignty of the state was deemed to be sufficiently fluid. This led to legal and ethical implications where activists and academics accused initially the US and, later, the Western partners of the North Atlantic Treaty Organization (NATO), of indulging in remote-control warfare, with its attendant immunity and lack of battlefield conditions for the 'pilots', and excessive collateral damage for the victims.[31] The use of drones has also been implicated in the perpetuation of radicalisation and the recruitment of a number of terrorists from the victim countries, often using these deaths as effective propaganda.[32] These case studies also built up a perception that drones may, in the long run, replace manned aircraft since they tended to 'dominate' the 'battlefield'.[33] However, the non-existent AD systems of the victim states, and near air-supremacy was always assumed to be a given, something which has come to be challenged in the latest conflicts where counter-UAS systems and procedures have challenged the operation of drones in their airspace. Today, due to very low entry barriers to procuring UAV technology as well as options of varying payloads and improvisation have forced the US to dial down their "God-mode" view of conducting operations in other countries, to the extent that the top US Special Forces Command (SOCOM) General has admitted that even the American troops now need to look up for these threats.[34]

Importance of Drones, their Uses, and Technological Developments

Drones or UAVs have primarily been used for ISR, intelligence gathering, artillery fire correction, signals intelligence, bomb/ battle damage assessment (BDA), post-strike damage assessment (PSDA), EW, coastal surveillance, and remote sensing,[35] apart from civilian uses in e-commerce, agriculture, civil aviation, health care, and others.[36] In the military ecosystem, their importance stems from a number of perceived advantages: the taking on a number of roles initially ascribed to manned aircraft, obviating the shortage of manned platforms (either due to finances, technology, or manufacturing deficit) and, finally, reducing casualties of military personnel which is also a reflection of a society's maturation. UAVs also offset the prohibitive costs of 'big-ticket' conventional platforms, both in terms of cumulative budgetary requirements as well as per unit costs. The ubiquity, element of surprise, and persistence provided by UAVs is unmatched in a cost-benefit analysis, especially in the case of developing countries. In terms of their relative importance, as with the inception of aircraft during the early years of World War I, they are considered to be ancillary rather than the primary means of combat, meant to support manned combat operations. This idea, however, is slowly undergoing a change.

There are six major components of a UAV system or UAS, which are: the drone itself (single or multiple aircraft which are either expendable or recoverable); lethal or non-lethal payload; flight control system; information processing system; a communication system generally based on the global positioning system (GPS); and wheeled vehicle to carry launch and recovery platforms.[37] The last requirement may be done away with in case of hand-launched micro or nano systems. When designing C-UAS, all these form vulnerabilities which can be targeted.

The development of UAVs across the world—more than 100 countries and non-state actors have access to drone technology now—has been astonishing, to say the least.[38] This is part of an increasing trend where latest miniaturisation as well as digital and unmanned technologies have proliferated across the world through the internet, either in the form of do-it-yourself (DIY) manuals and videos, or private industries, many of them supported by their respective countries. In the case of UAVs, four states—the US, China, Israel, and Turkey—have cornered the maximum chunk of the UAV export market,[39] while indigenous industry has been successful in increasing the drone inventory in Pakistan.[40] The persistent drive towards miniaturisation in military electronics,[41] especially post 1945, with the induction of now etched solid-state circuitry, has helped diversify the field of UAV manufacturing in terms of sizes (mini, micro, nano), altitudes (High, Medium), and payloads (explosives, including missiles and laser-guided munitions, EW pods, and cyber warfare tools). Close to 26 countries currently operate armed drones or unmanned combat aerial vehicles (UCAVs), with six more, including India, likely to join in the near future.[42]

Challenges for India

A varied arsenal of UAVs with multiple payloads, design configurations, and combat capabilities on both India's Western and Northern fronts, apart from the derivative battlefield of Kashmir, poses a serious threat to Indian forces. While Pakistan's Burraq, Shahpar, and Uqab are indigenous UAVs, Burraq has already demonstrated combat effectiveness as a UCAV when it neutralised three terrorists in the Shawel Valley in September 2015, using Barq air-to-ground missiles (AGMs).[43] Integrated Dynamics, SATUMA, and Global Industrial Defence Solutions (GIDS) have taken the lead in Pakistan's development of UAVs of all shapes and sizes, especially in the mini and tactical UAV category.[44]

China has also developed close to 45 different types of UAVs,[45] and is now experimenting on the onboarding of artificial intelligence (AI) based systems, man–unmanned teaming (MUMT), brain–computer interface mechanism (BCIM), swarm drones, and lethal autonomous weapon systems (LAWS), all in the context of UAVs.[46] China has also experimented with UAV vs manned jets dogfights.[47] The more prominent of the Chinese UAVs are CH-3 (20 air vehicles exported to Pakistan), CH-4 (also exported to Pakistan), CH-5, CH-92, Beihang BZK-005, Wing Loong I and II,[48] GAIC Xianglong (three were spotted near Doklam during the standoff with India in 2017),[49] Ziyan Ranger (helicopter design—it was deployed near the Sino-Indian border in November 2020 and is currently in service with the Tibet Military District TMD)[50] and the WZ-8 (rocket powered high speed and high altitude drone which operates currently from the Malan airbase in China's Western Theatre Command opposite India).[51] Both Pakistan and China pose a serious challenge to India, and due to the disputed nature of borders against both, UAVs may be used during both conventional and grey-zone warfare.

UAVs have also been used by non-state actors against Indian interests, especially in Kashmir and along the International Boundary (IB). These non-state UAV threats have also manifested in two ways: non-kinetic, in which drones have been used to smuggle drugs, counterfeit currency, and small arms and ammunition across the IB; and kinetic, an example of which was demonstrated on 27 June 2021 when an improvised drone, fitted with crude explosives, was used to target the Jammu air force station.[52] These threats still remain resonant in the current scenario, especially due to the diffusible nature of technologies, and the derivative nature of the Kashmir 'battlefield' wherein most technologies have already showcased as being effective, and have been imported wholesale in the West Asia and North Africa (WANA) region.[53] In the past, militarily active non-state groups, such as Hamas and Hezbollah, and the Islamic State of Iraq and the Levant (ISIL), have used UAVs extensively in their campaigns. While Hamas and Hezbollah used the Iranian Shahed-129, Ababil, Mohajer and Yasir drones, ISIL was a consumer of Chinese UAVs, especially the DJI Phantom Quadcopters and Skywalker drones, the latter modified for dropping hand grenades on Syrian and Iraqi troop concentrations.[54]

The liberalised Drone Rules of 2021,[55] and subsequent amendments of 2022,[56] focus on training remotely piloted aircraft (RPA) pilots by the Ministry of Civil Aviation,[57] an encouragement to small industries for developing indigenous drones through various government initiatives such as the performance linked incentives (PLI) scheme,[58] and the Digital Sky programme.[59] All have created a big dichotomy when it comes to UAS and C-UAS. On the one hand, India seeks to position itself as a major player (producer and consumer) of drone technology in a number of fields. On the other hand, the nature of drone technology—diffusable, miniaturised, off-the-shelf, persistent, registration on voluntary basis, and invisible to conventional radars—poses a formidable threat to India, and creates a situation which may blur, and subsequently erase the line between war and peace in the near future.

Current State of C-UAS

C-UAS systems work on the principle of detection–identification–neutralisation.[60] Detection involves using one of the techniques of radar frequency (RF), electro-optical (EO), infrared (IR), acoustic, or combined sensors detection.[61] Identification requires creating, maintaining, and frequently updating a library of communication signatures, flying patterns, and shapes to correctly identify the drone. Neutralisation involves a number of technologies, divided into hard-kill and soft-kill options.[62] RF jamming, satellite link jamming, 'spoofing' (allowing one to take control of or misdirect the drone by feeding it a spurious communications link), and 'blinding' by using a high-intensity light beam may be counted as soft-kill options; high-powered microwave (HPM), laser-based directed energy weapons (DEW), nets, projectiles, and collision drones are termed as hard-kill options.[63] An integrated system combining more than two such systems in tandem, or as part of an integrated whole can also be considered.

In India, as of date, there is no C-UAS doctrine (joint or service-specific) or philosophy within the Indian military, either in the conventional or CI/CT domain. C-UAS measures can be viewed, in their current avatar, in two formats. In the CI/CT domain, especially in Kashmir (no drone threat has manifested in the North East so far), C-UAS measures have been rudimentary, and have been based on the visual acquisition and identification of drones, and the use of small arms (such as infantry rifles) to counter them. The drone threat is considered as part of the CI/CT continuum, and UAVs are treated as an extension of the "bad actors", that is, terrorists, over ground workers (OGWs), financiers and propagandists, since a majority of the incidents have involved the dropping of counterfeit currency, AK-47s, and drugs across the LC and IB.[64] Even the Jammu drone attack was termed as a 'terror' attack.[65]

In the conventional domain, certain voids have been attempted to be fixed through indigenous radars, such as Bharani Low Level Light Weight Radar (LLLR), low flying detection radar Indra II, 3D low level light weight radar Ashlesha, 3D tactical control radar (TCR), and the Rajendra 3D Phased Array radar.[66] These radars, along with ground-based AD systems have been placed in fixed assets, such as airbases and other important installations. However, the Jammu airbase attack has highlighted the inability of these radars to pick up quadcopters or improvised drones. There is, therefore, a need to work on developing alternate systems focusing on aspects mentioned earlier, such as acoustics, communication signatures, IR, or EO.

The Indian Armed Forces have signed contracts worth almost Rs 300 crores for procuring C-UAS systems.[67] While the Indian Air Force (IAF) has concluded a Rs 155 crore contract with Hyderabad-based Zen Technologies for anti-drone platforms,[68] the Indian Navy has also inked a contract with Bharat Electronics Limited (BEL) for an indigenous Naval Anti Drone System (NADS).[69] This is to protect their onshore installations, since ship-based or offshore protocols deem UAVs as a 'sub-conventional aerial threat', to be countered by ship-based anti-aircraft systems. Additionally, the Navy has also procured "unknown quantities" of the Israeli SMASH 2000 Plus system, which can be fixed onto assault rifles, and by using a "new-age fire-control system", turn them into smart weapons. The Israeli firm Smart Shooter, is also planning to set up a manufacturing plant in India.[70] The IAF has also uploaded a request for information (RFI) for 10 counter-drone systems which need to be a multi-sensor, multi-kill solution, with the capability of generating a "composite air situational picture", consolidating "inputs from different sensors" on a "single screen".[71]

The Indian Army has also gone in for indigenisation on two parallel tracks. The Army Air Defence College located at Gopalpur, Odisha has integrated vintage 40mm Bofors L 70, and 23mm Russian Zu-23 guns with a counter-drone technology, designed by Hyderabad-based Zen Technologies—which is also supplying the same to IAF.[72] This has led to the development of an integrated soft-hard kill system which may prove effective against drone swarms. This is due to the comparatively high rate of fire of these guns, and the use of proximity-fuse ammunition, which detonates in the space surrounding the air threat, and exploding in more than 1,000 pieces of tungsten shards, and thereby hitting more than one target in a swarm. The Defence Research and Development Organisation (DRDO) has handed over a fixed quantity of D-4 (Drone Detect Deter and Destroy) systems to the Army.[73] The same was first deployed during the 2021 Republic Day parade.[74] The system, which uses a combination of hard- and soft-kill options, can detect micro drones, and uses a laser-based kill mechanism to terminate targets. It also employs RF/Global Navigation Satellite System (GNSS) to detect the communication frequency used by the drone controller, which are then jammed.[75]

The 'Counter' Challenge

Most 'counter' systems or solutions devised for conventional weapons platforms are against specific platforms, in conformation with the idea that most 'big-ticket' systems have retained their basic shape, functionality, and utility over the ages. For instance, an Anti-Tank Guided Missile (ATGM) is designed only for tanks since tanks have retained their functions, characteristics, and broad shape contours since they were first introduced during World War I. Similarly, artillery guns, airplanes have retained their basic designs, features, and functions since their very inception. As a result, their counters have been comparatively easier to design, field, and deploy. In case of UAVs, the challenge is of a different magnitude. Theoretically, even air force planes can be used to neutralise UAVs in a counter-air operations (CAO) mode. In fact, the latest indigenous light combat helicopter (LCH) has been touted as a drone killer.[76] Similarly, surface-to-air missile systems (SAMs) can also be used in battlefield conditions to counter the drone threat.

However, there are two issues with this mode of thinking. First, the cost–benefit analysis does not play out. Expending expensive airplanes and missiles for countering what are DIY airframes with rudimentary explosives or other payloads is futile in the long term, both in terms of finances and ammunition stockpiles. Second, all the conventional counter-drone systems are designed for battlefields, while the threat of drones is always 'in-being', that is, commercially available off-the-shelf (COTS) drones can be procured by almost anyone, and fitted to undertake a number of missions even in peacetime. Deploying round-the-clock conventional AD systems at all places is neither plausible nor feasible. UAS, today, can be used for a range of tasks: from obliterating tanks on the battlefield, targeted assassinations, cyber warfare, logistics, ISR, and other functions. The same airframe can be used for tactical, operational, and strategic effects in the same geographic environment or battlefield. In terms of C-UAS systems, it is currently a reactive approach, with countries and organisations procuring and deploying C-UAS systems on the go, based on previous incidents at the same place.

Case Studies

Russia has had extensive experience in drones and counter-drone systems in the various out of area contingency operations in Syria, Libya, Nagorno-Karabakh, and now the 'special military operation' in Ukraine. Before taking on specific examples, it is important that the Russian AD philosophy be explained in brief, in order to figure out the role of UAVs and the counters devised for them. The Russian concept of adversary air operations initially centred on the role of mass missile-aircraft strikes (MMAS) which used a combination of manned aircraft and a host of air-launched, surface-to-surface and cruise missiles to overwhelm Russian AD systems.[77] Instead, the Russians envisage that hypersonic vehicles, 'non-strategic' missiles, and UAVs will try and dominate Russian airspace through suppression of AD systems.[78] In fact, there is an expectation that in the pre-emptive phase, a large number of decoys and swarms of mini- and micro-UAVs will be used instead of manned aircrafts. The second phase visualises the use of 'temporally fuzzy' platforms, such as UAVs and ballistic and cruise missiles, to target Russian assets using the principles of net-centric warfare.[79] UAVs are expected to be present in Russian airspace for taking out opportunity targets and ISR. As a result, the Russian Armed Forces have undertaken a review of their existing AD philosophy, which takes into account the low radar cross section (RCS), low speed and operating altitude of the current generation of UAVs, the use of UAVs both as decoys and AD penetration vehicles, saturation multi-directional strikes by UAV swarms to overwhelm Russian AD, spreading out of Russian AD assets to cover more installations, the need for the modification of existing radars, and increased electronic counter-measures (ECM).[80] Though a number of systems have been developed for countering the UAV threat, an overarching philosophy remains to be enunciated and applied. However, a few serving and retired officials of the Russian forces have called for a nation-wide Drone Fighting Concept[81] and road-map which will include subsuming C-UAS under a joint aerospace defence formation, changing the profile of AD weapons systems currently in Russia's inventory, and stopping all ad-hoc procurement of C-UAS systems.

Drones were used extensively in Syria between 2011 and 2020.[82] Between 2018 and 2020, Russian AD neutralised over 150 drones, with almost 60 alone in 2019.[83] Most of the attacks were directed against Russian bases in Tartus and Khmeimim. During the Turkish campaign against Syria in March 2020, Syrians used Russian AD systems to shoot down 10 Turkish drones.[84] Both hard-kill and soft-kill options were utilised. An important facet that was highlighted in the Syrian campaign—especially during the Turkish offensive—was the use of supporting capabilities to facilitate easier operations by Turkish Anka-S and Bayraktar drones. Turkish troops used a variety of techniques, such as geo-locating Syrian soldiers by hacking their phones, and blinding Russian AD using KORAL EW systems to ensure that their drones had a comparative edge in the airspace.[85] Russia has been preparing for anti-drone warfare since 2015, as is evident from a number of statements and press releases from their Ministry of Defence (MoD). In fact, Russia used a layered AD system (three echelons of defence) at its Khmeimim base as it had anticipated attacks, and was ready for them.[86] During the war between Armenia and Azerbaijan in 2020, Armenia's outdated legacy AD systems, with poor ECM and EW measures and lack of detection capabilities, were the reason behind Azeri success on the battlefield, which it exploited using drones.[87]

The US approach towards C-UAS systems is somewhat similar to India's. Both countries are yet to define UAVs as a primary threat, in league with say, a plane or tank. As a result, piecemeal acquisitions of C-UAS from various vendors have been made, with still no overarching threat perception of UAVs as a separate category. In terms of EW capabilities, the US has, surprisingly, lagged behind Russia and China. There has been an active decline in EW capabilities even in the US Air Force (USAF). The last working EW platform for USAF—that is, the EF-111 Raven fleet—was retired in 1997 without replacement and, as of date, there are no dedicated platforms for jamming radars.[88] It is envisaged that the same is applicable when it comes to countering UAVs. In fact, by their own admission, the US is now imagining an era where their ground forces will not enjoy complete air supremacy, something which has not happened since the end of the Vietnam War.

Current C-UAS Thinking in India

As discussed earlier, India faces a major threat both from conventional as well as DIY drones, in peace, war, and CI/CT scenarios. Unfortunately, an integrated counter-drone, or C-UAS doctrine, has still not been officially enunciated or released. Though some retired officers from the three Services have given the broad outline of a counter-UAV philosophy, these suffer from the drawback of being useful only in the conventional context.[89] The current approaches, therefore, are limited to confining the UAV threat in pre-existing operational setups. While drone threat in CI/CT is visualised as a 'terror' threat, to be countered by using rifles, in the conventional domain, it is believed to be a joint task, to be shared between the Army's Air Defence arm and the IAF's fleet of SAMs and fighter jets. For peacetime, a mixture of indigenous and imported ad-hoc equipment has been deployed in limited places.

There is also a perception regarding India's baby steps in understanding unmanned systems. Devising a solution for the same is not a priority, due to which already available solutions have been used to counter the current threat. A major limitation for the Forces is their inexperience in handling drones in combat settings. Most of the drone pioneer nations have had extensive experience in drone and counter-drone operations in real-life settings, while the Indian Armed Forces' experience has been limited to exercises, demonstrations, with the only operational experiences provided against the Chinese People's Liberation Army (PLA) in Doklam,[90] and the disengagement phase along the Pangong Tso in 2021.[91] In keeping with the emphasis on self-sufficiency under the 'Atmanirbhar Bharat' flag, a number of defence industry start-ups have expressed interest, both in drone and C-UAS systems. Some have even developed robust systems. However, most counter-drone technology demonstrations already assume the presence of a drone, and the effectiveness of the particular technology is based on the knowledge of the same. In case of an emergent or suddenly appearing threat, the same methodology cannot be used with equal efficacy.

C-UAS Philosophy for India

In a race between offense and defence, there can be no ideal or permanent solutions, especially when it comes to technologies, or their novel uses in warfare. Similarly, one can only sketch the broad contours of a counter-drone philosophy for India, with the specifics being handled by respective agencies. Keeping into consideration the various threats faced by India, the introduction of liberalised Drone Rules, and the impetus to indigenous defence industry, an ideal C-UAS system should have the following parts.

(a) The interactive Drone Airspace Maps, which depict the red, yellow, and green zones for the operation and the flying of drones needs to be supplemented with C-UAS systems.[92] These can be further sub-divided into a combined hard kill–soft kill option for border states, with only soft-kill options for the rest of India. Since the finer details are updated every five minutes, a combination of fixed and roving C-UAS systems can be deployed. While flying in the green zone requires no permission, the yellow zone is the airspace above 400 ft in a green zone; above 200 ft in an area located between 8 and12 kms from the perimeter of an airport; and above ground in areas located between 5 and 8 kms from the perimeter of an operational airport.[93] Flying here requires clearance from the concerned air traffic control authority, including the IAF, Navy, and the Airports Authority of India (AAI), etc. The weight category cleared for flying is up to 500 kgs. Red Zone are no-go zones for drones. Flying in these areas requires permission from the Central government.[94]

(b) Even in the designated yellow zones, especially airports and important political, administrative, or commercial installations, indigenous fixed C-UAS systems may be installed.

(c) There are a number of ministries and agencies viz. the Ministry of Defence (MoD), the Ministry of Home Affairs (MHA), the Ministry of Civil Aviation (MoCA), and the Bureau of Police Research and Design (BPRD), AAI, etc. which are dealing with drones and C-UAS systems. A number of indigenous vendors have already been approached for agency-specific requirements. This system should work if two requirements are met. First, an overarching command and control authority is designated to coordinate the C-UAS grid for the entire country. Since the IAF is currently responsible for the AD of the country, and has an extremely well-positioned and enmeshed network of long and medium range radars, it is best placed to be designated the national agency for C-UAS systems. One of its major roles will be to ensure deconfliction in airspace management, frequency range, and types of flying objects. The second will be to pass on a composite air picture to compatible devices which can be used by various lower-level agencies to deploy their own C-UAS systems.

The second requirement is of layering. Since the IAF possesses mostly long and medium range radars, which currently are unsuitable for detecting and identifying low-level threats, it is important to ensure a plug-and-play grid based on an open systems architecture which will ensure that inputs from specialised radars and other drone-detecting mechanisms are compiled and converted to a single graphic user interface (GUI) based application, accessible to all major players. This can also be used for standardising detection and identification protocols which, after approval, can be used as terms of reference (TOR) for industry players applying to create future C-UAS systems. This system will be applicable in both peacetime as well as in a conventional war scenario.

(d) Local agencies such as the State Disaster Relief Forces (SDRF) and the National Disaster Relief Force (NDRF), Home Guard, and Police need to be involved in educating common citizens on the dangers posed by drones, and the various passive measures that need to be undertaken to mitigate the threat.

(e) It is most likely that air approaches along the IB and the Line of Control (LC) can be appreciated, and any radar gap may be plugged using tactical and low-level radars. In the CI/ CT scenario, the IAF grid can be extended down to the battalion level, using wearable wrist devices; and, using the inputs of low-level radars and other counter-drone sensory inputs, operations can be undertaken.

(f) The defence industry must be encouraged to come up with innovative hard- and soft-kill solutions that are mobile rather than being static, since the focus is to detect, identify, and neutralise mini, micro, and nano drones. Bigger drones can be identified and attacked using the conventional AD grid.

(g) Challenges of collateral damage may need to be examined. The use of Laser and HPM may lead to the fratricide of our own drones, which might distort or destroy relevant ISR capabilities or assets in the air.

Conclusion

Drones and C-UAS systems in India are in a nascent stage. Due to limited combat exposure of the Indian Armed Forces with these technologies, attempts at devising C-UAS systems have so far been ad-hoc, and devoid of an overarching philosophy of employment or procurement. Since drones always present a threat-in-being, both in peace and wartime, it is imperative that an integrated C-UAS philosophy be enunciated, and relevant portions be opened for the perusal of academia, industry, and the general public. In keeping with the ubiquitous nature of the threat, it is equally important to designate a central agency to facilitate operations. The impetus given to indigenous defence industry by 'Atmanirbhar Bharat' is a great opportunity to harness the creative potential of the industry by combining it with the professional acumen and experience of the Indian Armed Forces to come up with ingenious indigenous solutions against this formidable threat.

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