hard to catch on radar, and hard to shoot at with conventional weapons, particularly in swarms. During the opening ceremony of the Winter Olympics at Pyeongchang, South Korea, a spectacular display by a quad-copter drone swarm comprising 1218 drones left spectators astounded. In January 2017, the US Air Force carried out trials with 103 Perdix quad copter drones functioning as a swarm. The trial included airdropping of these drones in the battlefield from canisters carried by three F/A-18 fighter aircraft, gathering the drones in a swarm and then proceeding to engage targets in the battlefield.[5] In 2016, China demonstrated drone swarming using 119 larger, fixed wing, drones. Russia has reportedly been working on a concept of drone swarming wherein the Scandinavian countries have seen Russian drones flying in formation over their skies.

Military UAS

Armed UAS or Unmanned Combat Air Vehicles (UCAVs) such as the General Atomics Predator and Reaper carry air-to-ground missiles and have great combat abilities. MQ-1 Predator is armed with Hellfire missiles and is being used as a platform for ground attack, including assassinating high-profile individuals (terrorist leaders). UAS like RQ-9 Reaper are being used to patrol and secure borders. Payloads like synthetic aperture radar can penetrate clouds, rain or fog and in daytime or night-time conditions. On the other hand, the Northrop Grumman Global Hawk operates virtually autonomously giving live feedback and only needs a command to 'Take-off and Land'. Advances in technology have enabled more capabilities and Small Unmanned Aircraft Systems (SUAS) are being deployed on the battlefield. UAS roles have thus expanded to include strike missions, suppression and/or destruction of enemy air defence, electronic warfare, network node or communications relay, combat search and rescue, and combinations of these. The US military operates large numbers of combat UAVs. As a measure of relative cost, the MQ-9 Reaper costs US $ 12 million while an F-35 costs around US $ 95 million. In 2013, the US Navy launched a UAS from a submerged submarine. Since 1997, the US military has used

more than 80 F-4 Phantoms converted into UAS as aerial targets for combat training of pilots. In 2013, unmanned F-16s joined as more realistically manoeuvrable targets.

UAS Evolving Operational Advantages

UAS have become too attractive and potent military asset; for any significant power to ignore. USAF trains more UAS pilots than fighter and bomber pilots combined. UAS have much lower training costs and can best concentrate on Intelligence, Surveillance and Reconnaissance (ISR), close air support and take on some strike missions while air superiority could be handled by manned fighters. Manned aircraft are certainly better in dynamic environment. US Predators and Reapers were designed for counter-terrorism operations and in war zones in which the enemy lacks sufficient firepower to shoot them down. Full-fledged air-to-air combat capability, increased autonomy and UAS-specific munitions are part of the roadmap. UCAV is now a "first day of the war" force enabler which complements a strike package by performing the Suppression of Enemy Air Defence (SEAD) mission and pre-emptive destruction of sophisticated enemy integrated air defences in advance of the strike package. It operates at a fraction of the total Life Cycle Cost (LCC) of current manned systems.

The Unconventional UAS Threat

Terrorists, criminals, fanatics, and others find UAVs versatile, stealthy, and cheap airborne weapon. UAVs are also on the shopping lists of drug cartels, human smugglers, and corporate spies. Their prices have dropped to less than that of a TV set. UAS can threaten airspace security through unintentional collision, or even a deliberate attack or it could be loaded with dangerous payloads, and crashed into vulnerable targets. Payloads could include explosives, chemical, radiological, biological hazards, or even nuclear payloads. Decision makers must take into account the possible use of UAS by terrorists or unfriendly regimes. Ethical concerns and UAS-related accidents have driven nations to regulate the use of UAS. The export of UAS or technology capable of carrying a 500 kg payload at least 300 km is restricted in many countries by the Missile Technology Control Regime.

Most countries have clamped down on all illegal UAS. The immediate concern for all is a possible low-level drone attack. Many countries are working on high powered lasers to damage UAS and send them out of control.

Counter Drone Technology

Counters to UAVs (C-UAV) have been evolved. Detection requires combination of radar, radio frequency (RF), electro-optical (EO), infrared (IR), and acoustic sensors. Interdiction would be through direct bullet firing, jamming RF and Global Navigation Satellite System, spoofing, lasers, cyber attacks, physical nets to entangle the target, projectiles, electromagnetic pulse (EMP), camouflage and concealment, water projectors, birds of prey or using another drone for direct hit, and combinations of those. C-UAVs could be ground or air-based. Drone swarms have some weaknesses and limitations too. Their offensive could also be blunted through a counter drone swarm. In January 2018, Russia confirmed a swarm drone attack on its military base in Syria. Six of these small-size UAVs were reportedly intercepted and taken under control by the Russian Electronic Warfare (EW) units. The drones had satellite navigation electronics and carried professionally assembled improvised explosive devices (IEDs). USA is now deploying new radars like Q-53 system that can detect and identify such small objects and then initiate the kill chain using laser weapons. Lockheed Martin 'Skunk Works' engineers are doing research, to develop and implement the technology that will detect and defeat swarms. A 60-kilowatt system that combines multiple fibre lasers to generate the high power weapon of parallel beams. The laser weapon system can fire over and over, essentially creating an unlimited magazine of bullets. Cyber solutions to defeat drones are by using multi spectral sensor systems to detect and then using cyber electromagnetic to either disable the drone or physically take over and divert. The C-UAV mission relies heavily on advanced sensors; long-endurance platforms; data fusion to provide a view of the airspace being guarded; and some form of artificial intelligence (AI) to sort through and analyse incoming data. Hundreds of companies in more than 30 nations are reportedly

working on more than 230 C-UAV products. US Defense Advanced Research Projects Agency (DARPA), the Russian Foundation for Advanced Research Projects and China's Scientific Research Steering Committee are leading research.

Ethical and Legal Issues and Regulation

With no pilot inside, there is a risk of lowering the bar to using force. There is a risk that a drone operator, sitting in a safe haven at thousands of miles from the actual action, could treat the entire event like a video game. As per existing international law, the drone is in many ways no different from other systems. There is a need to make sure the target is legitimate and it's a proportional strike to the benefit to be gained, and there is a need to protect as much as possible the lives of innocents. In case of autonomous weapons guided by AI, could they make decisions on their own that are detrimental to humanity ? The technology is here, and it is being refined on a day-to-day basis. Most countries including India have put in place regulations for UAS operations. UAS weighing below 250 grams will follow the powered aero-model regulations. Larger sized will have to be registered with DGCA or equivalent foreign agencies. They will require air traffic clearances and also have to follow air route like other aircraft.

India's UAS Status

No one shares high-end UAS technologies. Indian Armed Forces operate nearly 150 Israeli Heron and Searcher UAS which are also operating in insurgency prone Jammu and Kashmir to sanitise the border and in remote regions of Ladakh helping incursion management. Indian Navy is covering part of the coastline. Indian Air Force (IAF) also uses them for target lasing, Battle Damage Assessment in addition to ISR functions. In Naxal prone areas UAS are tracking possible movements and also directing security forces to the targets. India is looking at more sophisticated systems like RQ-4 Global hawks that will help it monitor much larger area. Even the numbers have to increase significantly. Chinese UCAV designs are aggressively taking shape. WZ-2000 is a long endurance version Global hawk class UAS. Shenyang's 'Dark Sword' is the stealth forward swept wing UCAV of Boeing X-45 class. Developed in Pakistan, 'Burraq' (Chinese UCAV design) and 'Shahpar' surveillance UAS were

inducted in late 2013. The Indian Defence Research and Development Organisation's (DRDO) UAS 'Nishant' is tasked with intelligence gathering over enemy territory, reconnaissance, training, surveillance, target designation, artillery fire correction, damage assessment, Electronic Intelligence (ELINT) and Signal Intelligence (SIGINT). It has an endurance of around four hours. DRDO is also developing autonomous stealth UCAV for IAF named 'AURA'. It will be similar in design to Northrop Grumman 'B-2 Spirit' flying-wing and capable of releasing missiles and precision bombs. DRDO's 'Rustam' UAS is meant to replace the Israeli 'Heron' in all three Services one day. A large number of Indian companies showcased small UAVs at the Aero India Show 2019. They have entered joint ventures with foreign companies for technology, but all found difficulty in managing India's complex bureaucratic red tape and procurement system. In view of small defence expenditures and the persisting duplications of military capacities, mixed manned and unmanned air formations might be opportunity for future conflicts. India has to make a serious beginning to develop AI based weapon systems and platforms to stem excessive technological gap. DRDO has to get its act right.

Future of Unmanned Systems

Lethal Autonomous Weapons (LAWs) that can independently search and engage targets based on programmed constraints and descriptions, may operate in the air, on land, on water, under water, or in space. The autonomy of current systems as of 2018 is restricted in the sense that a human gives the final command to attack; though there are exceptions with certain 'defensive' systems. Autonomous weapons are today capable of deciding a course of action, from a number of alternatives, without depending on human oversight and control, although these may still be present. Soon B-1, B-52 or C-130 flying aircraft carriers will launch and retrieve drones. The US is developing new undersea drones that can operate in shallow waters, where manned submarines cannot. Russians have robots armed with grenade launchers and Kalashnikovs. China too is investing heavily in automated weapon systems and platforms. There are also UAS which operate at hypersonic

speeds and sub-orbital altitudes, or even faster in low-earth orbit. Newer ones also employ stealth technology. There are miniature UAS of around 25 kilograms and micro air vehicles weighing as low as one gram. The flapping-wing micro-UAS imitate birds or insects; have inherent stealth for spy missions. The Nano Hummingbird is commercially available, and sub-1g micro-UAS inspired by flies, albeit using a power tether, can land on vertical surfaces. Other projects include unmanned 'beetles' and other insects. Research is exploring miniature optic-flow sensors, mimicking the compound insect eyes which can transmit data. Next-Generation UAS rotorcraft will have great tactical role including for the armies and navies who cannot continue to be dependent on runways. Unmanned surface ships are already on sea trials. The 132 feet unmanned Sea Hunter is designed to missions of up to 10,000 miles on a single tank of fuel. Autonomous ground convoys which are prone to IED attacks is another important area of autonomous systems.

Endnotes

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@Air Marshal Anil Chopra, PVSM, AVSM, VM, VSM (Retd) is a former Air Officer-in-Charge Personnel. He also served as a member of Armed Forces Tribunal.

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