UAVs and Counter UAVs Technologies in the World and the Indigenous Capability

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> *Drones ply the liminal space between the physical and the digital—pilots fly them, but aren't in them. They are versatile and fascinating objects—the things they can do range from the mundane (aerial photography) to the spectacular—killing people.*
>
> *—John Battelle*

At any time of history, the concepts of waging a war keep changing by the centuries. It adapts its hue to the socio-political environment and the current military capabilities prevalent in the zone of conflict. Modern wars are characterised by swift and intense conflicts unlike the long enduring battles of the past. The battles are unlikely to be openly declared wars on another nation or entity but border on small intrusions and incursions. The present-day environment has witnessed the concept of multi-state armies fighting under one umbrella as happened in the Gulf War and Global War on Terror (GWOT) in Afghanistan. Moreover, the emerging hybrid nature of warfare beckons use of innovative ways of fighting in conventional as well as unconventional conflicts, as we witness on the Northern borders of our country.

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Today, and more so in the future, the battlefield is likely to be highly mobile and extremely fluid in nature, which mandates the requirement of integrating sensor, shooter, Post Strike Damage Assessment (PSDA) and re-strike capability on a single networked platform. This will shorten the Observe-Orient-Decide-Act (OODA) loop and provide a decisive edge to the commanders in operations. This is the niche area where the Unmanned Aerial Vehicles (UAVs) are likely to play a contributory and decisive role.

One way to engage an enemy with minimum casualties is through the use of UAVs. They are the most visible members of the family of unmanned and autonomous systems either employed or under development. These powered aerial vehicles carry no human operators, use aerodynamic forces for lift, fly autonomously or are piloted remotely, are either expendable or recoverable, and carry both lethal and non-lethal payloads.

Currently, UAVs are employed by militaries around the world for intelligence, surveillance, reconnaissance, electronic warfare and strike missions. In future, they could be employed for resupply, combat search and rescue, aerial refuelling and air combat. The availability of advanced navigation and satellite communication technologies has made remote operations of UAV more practical. The changing nature of military operations where it becomes necessary to conduct search and destroy missions in populated areas has increased the demand for UAVs. The capability of a UAV to loiter, search, identify and strike targets while minimising collateral damage, makes it an invaluable weapon system for military commanders. Today's UAVs can remain on mission for 30 to 40 hours, far beyond the capabilities of any human crew. Research into in-flight refuelling and ultra-efficient solar power, could help extend the range of UAVs, limited primarily by maintenance needs.

Technology plays an important role in defining the way various militaries will be employed in future conflicts. All modern armies are trying to incorporate different facets of technology in military operations.

The future battlefield will be a high-technology environment in which diverse technologies, engagement platforms and delivery technologies will enable seamless and timely engagement. Rapid advancement in technology and fast pace of development is limiting the conventional employment of UAVs.

Evolution of UAV Tech

UAVs originated mostly for military applications and have expanded their use in commercial, scientific, agricultural, research and other applications. Recent advancements in UAV technology have ensured high endurance, capable of autonomous flights, high-resolution video transmission and payload. Modern UAVs now include the best technology available in aerodynamics, materials science, control systems, computing and networking and are a result of innovation done in various fields like aerodynamics, materials sciences, telecommunication, artificial intelligence, etc.[1]

Existing World Tech

UAVs have extensively been utilised in military operations during the last decade for surveillance, monitoring enemy activities, collecting information, and even attacking military targets and terrorist hideouts. They are increasingly finding uses in civil applications, such as policing and firefighting, inspection of power lines and pipelines. Furthermore, they are being used in commercial applications such as agriculture, highways and roadways, logistics, delivering small packages to rough terrain locations, and medication to emergency locations. UAVs are often preferred for missions that are too dull or dangerous for manned aircraft.[2]

The combination of greater flexibility, lower capital and lower operating costs of UAVs in the present day have made it possible for them to be deployed in a variety of terrain conditions and without requiring expensive and prepared runways. UAV systems used in ground surveys, aerial surveys and the satellite images on various parameters have proved that this technology would actually be cheaper than the use of satellites or aircraft.

Globally, countries like USA and China have created a conducive environment for organisations to benefit from the applications of UAV and its associated technologies, and hence these markets have seen much capital invested in these systems, and are driving innovation in this market. UAVs have a wide range of uses in many fields, including commercial or military purposes. While they can be used for several different types of inspection, primarily visual inspection, they tend to be equipped with incredibly high-resolution cameras, which allow them to get a close-up, accurate view of a structure, even from a great distance. There is an increasing trend of adopting UAV technology across industries both in India and abroad and there are multiple drivers pushing for the adoption of UAV.[3]

There are a host of opportunities to leverage UAV systems and associated technologies across some key industries. The focus is mainly on technologies in development, in and across the world, which include alternate navigation low-cost surveillance, sense and avoid, low-cost avionics, hybrid propulsion, GPS denied, secure remote connectivity and autonomous cooperative control.

The rapid advancement in technology has led to a revolution in UAV technology. UAVs being developed range from nano insect-sized UAVs to UAVs large in size like Global Hawk, which is comparable in size to any modern medium-sized passenger jet aircraft. UAVs persistent type which can stay aloft up to three months or more at a time. The UAV technologies which are currently used the world over are enumerated below:

Power and Utility

- GIS data from drones to optimise tower layouts.
- 3D models for effective site planning and estimating scope of work.

- UAVs and its associated technologies can facilitate better scheduling of further work stages while simultaneously highlighting potential delays in construction.

Agriculture:[4] In order to keep up with increasing demand, optimising farm yield in a way that is sustainable and prevents environmental damage becomes critical. Challenges such as climate change make it harder to grow crops due to an increasing number of unexpected weather events all over the world. As an ecosystem there is a need for close collaboration between governments, technology and industry to collectively overcome these challenges. UAVs and its associated technologies today can provide solutions to these challenges.

Highways and Traffic Monitoring: Highway networks by design are complex linkages spread over vast areas. The nature of the assets makes it difficult to monitor them quickly and efficiently. UAVs provide a unique solution to help in better planning of highway layouts and more accurate scope of work estimation at key sites like mountains, etc. Such ground exploration work will lead to accurate contract valuations thus helping reduce costs of the project.

Mining: UAVs provide a faster and more cost efficient solution than traditional methods and the potential for their application in the mining industry cannot be overlooked. UAVs are currently being tested and implemented mostly in open-cast mining, where they are replacing labour-intensive methods of inspection, mapping and surveying, as well as ensuring safety on the extraction site. Information gathered from UAVs can also assist with blast planning at the site and help minimise the risks associated with such activities.

Railways: Like highways, UAVs have a natural application in managing and providing insights across the life cycle of a railway network. UAVs become the natural choice of the platform to provide information about this system in a quick and cost-effective manner.

Military Applications: Military applications include Unmanned Combat Aerial Vehicles (UCAV) with the main features being stealth modes, weapons carrying ability. UAVs are employed on military missions for missile detection, radar based long-range target detection and chemical detection. UAVs have been extensively utilised in military operations during the last decade for surveillance, monitoring enemy activities, collecting information, and even attacking military targets and terrorist hideouts. What makes them lethal and effective for warfare are advancements in video camera techniques, precision operations with improved GPS, stealth operations and faster speeds. Their lethality can be best explained by supposed deployment of 18 low-cost drones (along with cruise missiles) by Houthi rebels in Yemen to attack the Saudi oil facilities, causing oil prices to jump more than 10 per cent in a day. Some of the latest trends in UAV technology are enumerated in succeeding paras.

Satellite Communication: Satellite communication data link system permits UAV to fly beyond electronic line of sight (ELOS) and enhances its operational range. Satellite Communication infrastructure is limited to specific hardware component modification on UAV and AGCS. Capability to operate satellite communications exist within our country as the footprint of our indigenous satellite INSAT-4B covers the entire boundary including parts of neighbouring countries. Reliable satellite communications are a critical enabler for medium and high-altitude UAVs. Increasing demand for UAVs and the employment of sophisticated sensor packages have dramatically increased demand for satellite services. On induction of satellite communication, the basis for classification of UAVs will change from operating range to endurance as there will be a quantum jump in the ranges achieved by satellite communication enabled UAVs and the only restricting factor will be the endurance of the UAV.

Tilt Rotor Aerial Vehicles: Tilt rotor provides a Vertical Take Off and Landing (VTOL) capability combined with efficient forward flight. This technology combines the advantages of rotary wing and fixed-wing aerial vehicles. They take off and land vertically like a rotary wing; however, after leaving the ground the rotors tilt forward and perform the task similar to propellers in a fixed-wing aircraft.

Flapping Wing Type Aerial Vehicles: These are powered by flapping wings and are being evaluated for micro-UAVs.

Rotary UAV: Unmanned helicopters are perfect for tasks such as surveillance, observation and EW which require hovering of the platform in air. Their advantage is the inherent characteristic of VTOL. A rotary UAV can hover at low altitudes using sensors customised for these types of missions. Rotary UAV can scan difficult terrain with various sensors and day/night cameras. The system is compact and mobile making it suitable for mobile search and rescue units. The ability to hover and move in all directions give the payload operator more time and ease to scan objects and track the required object.

Persistent Stratospheric UAV: These are class of UAVs which fly for extended durations at stratospheric operating altitudes. Their propulsion system is based on solar power or fuel cells (liquid hydrogen powered). The endurance of these devices which are under development is from five days to five years and they operate at an altitude of about 65,000 feet. These UAVs are also known as atmospheric satellites or pseudo-satellites, for example, Global Observer, Vulture, Pathfinder, Pathfinder plus and NASA Helios.

Solar-Powered UAVs: Solar-powered UAV under development could, in principle stay aloft indefinitely, as long as it has a power storage system to keep it flying at night. Solar UAVs under development will provide long endurance operations of two to three months at altitudes above weather and air traffic (above 50,000 feet) offering low-cost persistent military capability. The tasks envisaged for this category of UAVs include surveillance, communications relay platform, remote sensing, mapping and atmospheric sensing mission.

Air-to-Air Refuelling of UAVs: Technological advancements are underway to increase the range and endurance by developing technology for mid-air refuelling or recharging battery-powered UAVs in air. Converting some UAVs into tankers will greatly extend the range of other mission UAVs. Such technology could lead to high-altitude and long-endurance unmanned systems with hover capability that may extend to many weeks.

Nano UAVs: Nano UAVs measure around 10 cm by 2.5 cm and provide troops on ground with local situational awareness. They are small enough to fit a palm and weigh about 16 grams including batteries, for example, the Black Hornet Nano. It is equipped with a camera which gives the operator full motion video and still images with night vision capabilities. It can transmit video and high-resolution still images through a digital data link up to a range of approximately 1.5 km.

Swarm UAVs: The concept involves overwhelming the enemy defences with a swarm of UAVs which assault the adversary with a cloud of cheap and disposable drones, and paralyse the defences by the sheer quantity of unmanned attackers in the air. Once airborne, the UAVs begin communicating with each other autonomously and begin to fly in formation either to recce or attack an enemy target. The breakthrough technology utilises information-sharing between the UAVs, enabling autonomous collaborative behaviour in defensive or offensive missions.

Technological Advancements in Payloads

COMINT Payloads: COMINT Payloads will enable interception, location and identification of emitters. They can also enable intelligence in respect of Electronic Order of Battle (EOB) by tracking, processing, monitoring and direction finding of the signals.

Foliage Penetration (FOPEN) Radar: FOPEN radar is a SAR system that penetrates through foliage to track people and vehicles on the ground. It utilises Wideband VHF/UHF SAR imagery. It is being developed and fielded as part of the special payloads for UAVs. It can locate man-made structures under dense foliage, peer through trees to detect slowly moving troops and ground vehicles as well as characterising the foliage itself. These orders can identify targets hidden in a clutter. This capability provides surveillance day and night in adverse weather.

Multiple EO Payload Capability: UAV payload technology developers are developing a wide area surveillance sensor system known as Gorgon Stare. Gorgon Stare payload consists of a 24-inch diameter surveillance turret with 12 cameras which can operate simultaneously. It can cover about four-kilometre radius of ground and can track about 64 targets at a time.

Pico SAR: Pico SAR is an ultra-lightweight SAR based on active array antenna technology. The complete system including waveform generation, two-channel receiver, inertial measurement unit, real-time signal processing and motion compensation is housed in a compact unit weighing less than 10 kg which can be easily installed in a wide range of tactical and short-range UAVs. The system delivers excellent performance with ranges in excess of 20 km and resolutions under 0.3 metre.

Hyper Spectral Imagery (HSI): HSI payload enables remote material detection, identification, characterisation and quantification of any military target including foliage penetration and camouflage detection. The image captured by hyper-spectral sensor can be analysed by correlating it with hyper-spectral signatures of various targets available in the hyper-spectral library, thereby enabling automatic recognition and identification of targets.

Other Civil Applications: UAVs have a role in disaster management solution, early warning rescues and post analysis in rescuing people after a disaster. Other civil applications include monitoring sensitive communal situations for maintenance of law and order, anti-Maoist operations and coastal and maritime security.

Counter UAV Technologies

With the advantage in employment of UAVs and the enhanced utilisation during battle, both of our adversaries have started equipping themselves with a large variety of these assets. The future battlefield is likely to witness an increased employment of unmanned flights in various roles. The potential security threats posed by the UAVs to both civilian and military entities will rapidly create a new market for Counter UAV (C-UAV) technology.

C-UAV technology generally refers to systems that are used to detect and intercept unmanned aerial objects. UAVs are susceptible to both hard and soft kill C-UAV technology. Thus, there is a need to plan and cater for C-UAV measures against enemy UAVs.

Different Counter UAV systems rely on a variety of techniques for detecting and/or intercepting UAVs. The succeeding paras describe the main detection and interdiction methods employed by products currently available in the market.

Detection and Tracking Systems

Radar: It detects the presence of small unmanned aircraft by their radar signature which is generated when the aircraft encounters RF pulses emitted by the detection element. These systems often employ algorithms to distinguish between UAVs and other small low-flying objects, such as birds.

Radio Frequency: Identifies the presence of UAVs by scanning for the frequencies on which most UAVs are known to operate. Algorithms pick up and geo-locate RF emitting devices in the area that there are likely to be UAVs.

Electro-Optical: Detects UAVs based on their visual signatures.

Infrared (IR): Detects UAVs based on their heat signatures.

Acoustic: Detects UAVs by recognising the unique sounds produced by their motors. Acoustic systems rely on a library of sounds produced by known UAVs which are then matched to sounds detected in the operating environment.

Combined Sensors: Many Systems integrate a variety of different sensor types in order to provide a more robust detection capability. For example, a system might include an acoustic sensor that cues an optical camera when it detects a potential UAV in the vicinity. The use of multiple detection elements may also be intended to increase the probability of a successful detection, given that no individual detection method is entirely fail proof.

Interdiction[5]

- **RF Jamming:** Disrupts the radio frequency link between the UAV and its operator by generating large volumes of RF output. Once the RF link, which can include Wi-Fi links, is severed the UAV will either descend to the ground or initiate "return to home" manoeuvre.
- **GNSS Jamming:** Disrupts the UAV's satellite link, such as GPS or GLONASS, which is used for navigation. UAVs that lose their satellite link will hover in place, land or return to home.
- **Spoofing:** Allows one to take control of the targeted UAV by hijacking its communication link (also called Protocol Manipulation).
- **Laser:** Destroys the vital segments of UAVs airframe using directed energy, causing it to crash to ground.
- **Nets:** Designed to entangle the targeted UAV and/or its rotors.
- **Projectile:** Employs regular or custom designed ammunition to destroy incoming aircraft.
- **Combined Interdiction Elements:** A Number of C-UAV systems also employ a combination of interdiction elements—most commonly, RF and GNSS jamming systems that work in tandem.

Platform Types

- **Ground Based:** Systems designed to be used from either stationary or mobile positions on ground. This category includes systems installed on fixed sites, mobile systems and systems mounted on ground vehicles.
- **Hand Held:** Systems that are designed to be operated by a single individual by hand. Many of these systems resemble rifles or other small arms.
- **UAV Based:** Systems designed to be mounted on UAVs which can hover into proximity with the targeted unmanned aircraft in order to employ interdiction elements at close range.

Broadly, the Counter-UAV technologies can be divided into soft kill and hard kill technologies which are enumerated as under:

Soft Kill Technologies[6]

- **Drone Gun:** It jams the signal between UAV and UAV pilot, 1 km is rifle-shaped device that uses RF jamming and GPS jamming to counter drones and UAVs. After breaking the link, it activates the "fail safe" to send the drone home and has the capability to jam signals. Drone gun has been developed by Australian company Drone Shield and has a range of 1 km.
- **Skywall 100:** It is an Automated net launching system that physically captures the drone intact, uses compressed air to launch a projectile using on-board smart scope. It can be used as stand-alone system/integrated using sky link module for highly capable counter-drone package.
- **Drone Catcher:** This is a net gun armed Multi-Copter which eliminates illegal drones from the air. With the help of multiple on-board sensors, a net gun locks on the target and then the drone is caught by shooting a net. In case the target drone is heavy, it drops it with the help of a parachute.

- **Sky Droner:** It detects, distracts and disables drones from flying into a protected area. Range is 1 km.
- **Sky Fence System:** Basically the system is for prison security. It incorporates a number of signal disrupters, designed to jam flight control signal of a drone and prevent it from flying over the installation and disrupt their navigation transmissions. It uses multiple low-power radio transmitters which interfere with radio transmissions of a drone thus preventing their control from the operator.
- **Drone Sentry:** It provides integrated detect and defeat solution by automatically detecting and disabling the incoming drones. It has swarming capability and is weather resistant.

Hard Kill Technologies/Engagement of Hostile UAVs

On positive identification of the flying object or UAV by the Air Defence Control and Reporting network, the hostile UAVs may be engaged in any of the following manners:

- An interceptor aircraft/helicopter.
- A surface-to-air missile (SAM).
- UAVs in Counter-UAV role.
- An airborne/ground ECM Jammer.
- Unconventional means like Directed Energy Weapons (DEWs)/ microwave weapons.

Indigenous Capability in UAV Technology[7]

Current challenges and opportunities for India are stealth features and interoperability, autonomous communications and airspace integration. The development of UAV with a few examples of their work include Black Kite, Golden Hawk, Pushpak and SlyBird mini and micro UAV in collaboration with ADE (Aeronautical Development Establishment). A variety of state-of-the-art Electro-Optic (EO) sensors, Electromagnetic Intelligence (ELINT) and Communication Intelligence (COMINT) payloads, SAR or maritime patrol radar (MPR), will be fitted onboard UAV to provide multi-mission performance capabilities. The technical challenge lies in the design and development of lightweight airframe and systems that operate reliably for long durations. During development of Nishant and Lakshya, ADE has developed a large number of technologies in the field of flight telemetry, control system, sensors, and composite materials that have aided in the design, testing, analysis, and manufacturing of UAV. The technologies developed and implemented in the UAV subsystems are:

Aerodynamic Design: The country has expertise in aerodynamic configuration design, performance evaluation, and analysis of a UAV using advanced computer-aided design (CAD) tools and powerful computational fluid dynamics (CFD). The country has also undertaken design and development of multi-element airfoil and high lift resulting in enhanced endurance of UAV has been achieved.

Aero Structural Design: Aero structural design includes configuration design, equipment layout, sizing of components, and conventional and finite element (FE) analysis of airframe. Expertise has been developed in the fields of aero-elastic studies, impact studies, power plant configuration. Structural design and evaluation using composites have been extensively used. Gimbaled Payload Assembly (GPA) is a high precision optomechanical system used for reconnaissance purpose. A much optimised design has been achieved using latest CAD tools. This has been widely used in Nishant and Rustom Projects.

Composite Design: The country has developed various grades of synthetic foams for specific aerospace applications like microwave transparent foams (as core material in broadband sandwich redone), electrically conductive foams (as core material in electronic enclosures), and carbon nanotube, and reinforced nano composite foams, etc. The foams are typically used as the core materials in sandwich configurations designed for different applications. Use of improved and environmental friendly noncontact molding processes like Resin Infusion Molding (RIM) and Resin Transfer Molding (RTM) have been mastered. The processes were first validated by process experiments involving point infusion (radial flow) and directional flow (edge flow) techniques for monolithic and sandwich panels and then demonstrated successfully by developing different prototype UAV parts, and finally extended to develop actual UAV components.

Propulsion: Indigenisation of gas turbine and rotary engines is a major achievement towards propulsion. Development of a jet engine involves a coordinated effort among the designers, certification agency, and the users. Coordinated efforts of ADE have resulted in the development of an indigenous certified airworthy jet engine which meets all mission requirements including high-altitude tests. Indigenous development of a rotary engine is critical for UAV programme. ADE has set up test-bed facilities for testing gas turbines, and rotary and internal combustion engines of UAVs. Online Data Acquisition and Health Monitoring System (DAHMS) have been developed to monitor all engine parameters during engine testing on ground and integration runs.

Actuators: ADE has designed and developed electromechanical actuators for various UAV applications like engine throttle control and control surface actuators. The first indigenously designed, developed and produced actuators are rotary type and have been used in Nishant.

Antenna Design: ADE has achieved self-sufficiency in airborne and ground antennae development, aircraft-mounted antenna pattern studies, and radar augmenters development with antenna location optimisation. ADE has also established computational electromagnetics facilities, which includes Finite Difference Time Domain (FDTD) and designer software. Various passive and active radar augmenters have been developed indigenously.

Payloads and Image Exploitation: ADE has developed two types of scoring systems: Doppler Miss Distance Indicator (DMDI) and Acoustic Miss Distance Indicator (AMDI). The DMDI is used extensively for target practice applications. The AMDI picks up the shock wave generated by supersonic projectiles.

Ground Control Station and Associated Equipment: Ground Control Station (GCS) is used to track, control, and monitor the UAV. It also helps in mission planning and validation, payload information, exploitation and system diagnostics. The GCS receives telemetry data and generates the parameters display and trajectory display. The parameter display provides the status of subsystems.

Radio Frequency Packages: Some of the radio frequency packages designed include: fixed-frequency data link for UHF command uplink, and "P and l band" telemetry downlink, and FPGA based PCM encoder to transmit the telemetry information in PCM serial stream. Besides, the GCS operates in "l band" to track the UAV during flight.

Flight and Data Acquisition Processing: The flight telemetry data is very important to monitor the health of UAVs. Flight Data Acquisition and processing system is state-of-the-art mobile world class facility for ground telemetry data reception, storage, and processing and display. ADE has developed two such facilities to provide ground telemetry.

Ground Image Exploitation System: The country has developed image preprocessing algorithms for real-time enhancement of low-contrast imagery mathematical models for computing the ground location of targets and terrain measurements and a combination of the two for various applications. The ground image exploitation system has been successfully installed in an advanced GCS of Nishant to acquire, store, retrieve, process, analyse, interpret, display and disseminate information from imagery during UAV mission.

Development of Hardware and Quality Check of UAV

- Architecture-based hardware in the loop simulation (HILS) test facility meant for the complete testing of the FCS before being integrated on to the UAV has been developed. It is built using high-end industrial PCs with RT Linux as the operating system. The development telemetry link of the FCC

- Quality control (QC) plays a major role in the success of any product. All UAV systems go through tough quality checks before going for integration. Inspection at different stages ensures quality in every phase of development.

The potential of UAVs is vast. In the present scenario, DRDO is working hard to deliver state-of-the-art UAV systems to the Indian Armed Forces. The technologies described above are the base for future UAV development programmes. Predictions for the next decade envisage 50 per cent increase in endurance, silent engines, self-repairing, and damage-compensating structures with real-time monitoring of structural health, rotorcraft of high speeds, multichannel data acquisition systems, full automatic control of flight and mission, etc.

Latest Developments in UAV Technology the World Over

Adaptable Future:[8] A new concept technology for "Adaptable UAVs" is being developed that could see the next generation of mil UAVs be able to alternate between fixed and rotor flight modes within the same mission. Using this method, several individual UAVs can be released from a stick from the ground, surface vessels or submarines, or dropped from larger aircraft in a deployment module hanging beneath a parachute.

V Bat: The V Bat brings the operational convenience of vertical take-off and landing. It is driven by a propulsion unit that uses a single enclosed fan for both vertical and horizontal flight, the UAV requires no launch or recovery equipment and can operate from an area of just 1.8 sq. m.

Autonomous Landing of UAV on a Moving Platform: Developing methods for autonomous landing of UAVs on a mobile platform is an active area of research in recent years, as it offers an attractive solution for cases where rapid deployment and recovery of a fleet of UAVs and mobile fleet recharging stations are desired.

High Precision Survey Drone: The TRIUMPH–F1 UAV has been developed with high-precision GNSS receiver with 864 channels to track all current and future GNSS signals. It has a state-of-the-art high-resolution camera for taking high-quality photographs, two micro SD slots for image storage, a SIM card slot and a USB port for uploading flight plans and downloading collected images. Research in this field to improve upon the quality of photographs and to block receiver channels of all satellites operating in the area of operation of a UAV are also under progress vigorously.

Shipping and Logistics: Matternet, a Switzerland based company, is developing UAVs to transport small items like blood samples and medicines. A smartphone application is used to authorise pick-up and delivery. The item is then scanned for pick-up, the station automatically installs the item into the UAV for transport, the UAV then departs for the assigned destination and, on arrival, scanning is required to retrieve the delivered item at the other end.

Multi UAV System: Research in the field to enable usage of multiple UAVs for similar or dissimilar tasks is also being undertaken. A particular class of tasks for such multi-agent UAV systems involves surveillance of a region and tracking of targets corporately. Cooperative UAVs are required to handle a task with higher robustness, higher performance which cannot be achieved by single UAVs.

Indigenous Anti-Drone Capability[9]

DRDO is working on Directed Energy Weapons or DEWs which are laser-based or microwave-based weapons which can quietly disable enemy drones/missiles temporarily or permanently without leaving physical debris. The weapons are in the range of 10 kW and 20 kW. DRDO's

Hyderabad-based lab CHESS (Centre for High Energy Systems and Sciences) is the node for all related activities.

The capability was showcased to secure the VVIPs and high-value targets during the recent Republic Day parade to neutralise the growing threat from Unmanned Aerial Vehicles. The technology used is electro-optical laser pulses and radars to track hostile drones, and then either jam the radio frequency between the machine and the operator or destroy UAVs using laser technology. Interestingly, the classified drone weapon was on the day the DRDO showcased the anti-satellite weapon at the parade. The systems are also being considered to be deployed at airports.

Largely, there are no home-grown anti-drone solutions. Anti-Drone technology is mostly indiscriminate jamming technology for GPS and communications. So the emphasis is on customising the work to deeply integrate and reduce system redundancies. The anti-drone technologies being considered are different levels of soft kill and hard kill.

Conclusion

The future augurs well for the growth of the UAVs and UCAVs. The dictum—"Never send a man, where you can send a bullet"—will only get more and more emphasised in days to come. The miniaturisation of equipment, coupled with high cost of state-of-the-art aircraft and cost of training of pilots, has led to the development of UAVs. In the age of shrinking defence budgets and unacceptability of loss of human life, the Armed Forces around the world need to employ this affordable technology.

Notes

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