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CONCEPTUALISING A CLOUD COUNTER-AIR DECEPTION AND DISOREINTATION (CCADD) WEB

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INTRODUCTION

Disruptive technologies are in vogue amongst all the war-fighting operatives around the world. Deploying sophisticated weaponry in air, water or ground which have different operating paradigms and impenetrable systems, often bewilder the adversary. The Unmanned Combat Aerial Vehicles (UCAVs) are a big leap forward in air power and making them operate autonomously is the next jump nations are currently executing. Counter-drone measures use Unmanned Aerial Vehicle (UAV) jamming as their primary weapon. Fully Autonomous UAVs (A-UAVs) cannot be jammed by such measures. The systems on-board ensure complete autonomous flight and zero visibility during different regimes of the flight. The Light Detection and Ranging (LiDAR) sensors on-board provide for high-resolution pictures and Obstacle-Detection in Air (ODiA). The Inertial Navigation System (INS) facilitates a Global Positioning System (GPS) denied navigation for achieving the objective while not relying on GPS.

The Autonomous-UCAVs (A-UCAVs) do not require constant human monitoring and control during flight or while carrying out the task. The on-board sensing enables the aircraft to harness data in real-time while

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Cloud robotics can enable the 'one learns-all learn' capability in UAVs. If a UCAV detects enemy firing from a few hundred metres ahead, the data will be put on the cloud as all its computation would be done on the cloud, and the trailing UCAVs can subsequently alter their course to avoid getting shot.

undertaking the pre-planned actions that it is supposed to take. The on-board systems also carry AI sensors which can analyse real-time ground imagery and distinguish civilians from armed/ unarmed combatants and can identify the type of enemy ground or air vehicles.

Today, most nations are utilising this platform by operating it in swarms. Most of these swarms are human operated and comprise quad-copter UAVs instead of fixed wing UCAVs. For better synchronisation, centralised command and Machine-to-Machine (M2M) communication and Cloud Robotics (CR) is being inculcated in such systems. Cloud robotics can enable the 'one learns-all learn' capability in UAVs. If a UCAV detects enemy firing from a few hundred metres ahead, the data will be put on the cloud as all its computation would be done on the cloud, and the trailing UCAVs can subsequently alter their course to avoid getting shot. The contingency can be addressed either by the on-board Artificial Intelligence (AI) decision-making or a human mission supervisor on the ground, should the need arise.

A system or network based out of CR has encrypted servers that host enormous information databases. The saved data administers every aspect of the robotics machinery. The database stores an extensive amount of data including imagery, maps, navigational data and object data. The operation and analysis of the connected robotics machinery is also controlled by the data on the cloud. Cloud robotics offers on-demand human guidance for error recovery and regular evaluation.

When CR is blended with UCAV swarms, it cooks up something known as 'Swarm Robotics' (SR), which makes inter-operability of multiple autonomous unmanned systems easier by utilising cloud computing as a means of transferring data and centralised commands to every system on the network for better synchronisation and undertaking of the given task. When and if an unmanned system photographs an enemy build-up on the ground, the Geospatial Intelligence (GEO-INT) can be instantaneously shared with all the other systems operating on the network. It is possible that the rapid data sharing capability of these UCAVs can warn the friendly operators in the air as well as on the ground, preventing any loss of life and/or machine.

With disruptive technologies on the rise, there is less emphasis on the conventional means of warfare in a few countries. A better paradigm for these times would be to tailor hybrid operational plans which channelise the best of disruptive technologies while merging them with the conventional arms.

Nations may develop such high-tech and auto-decision making drones but it is not advisable to rely only on them during war-time. UCAVs today are equal to, or even bigger than, normal fighter aircraft. They can undertake Air-to-Air (A2A) and Air-to-Ground (A2G) missions with utmost precision. With an ageing fleet and growing challenges, a nation might tend to think of these UCAVs as a short-term solution to give impetus to its air power. With disruptive technologies on the rise, there is less emphasis on the conventional means of warfare in a few countries. A better paradigm for these times would be to tailor hybrid operational plans which channelise the best of disruptive technologies while merging them with the conventional arms.

Offensive and defensive operations by any air force in the world require intensive planning and training. All the air assets and resources are utilised optimally to address the situation in the air. In today's aerial warfare, it is the technology and strategic deployment of resources which win the war. On the contrary, it is not advisable to be so blinded by these novel technologies that we forget the timeless strategies, tactics and concepts.

The Cloud Counter-Air Deception and Disorientation Web (CCADD Web) is a concept carrying on itself the new concepts of cloud computing/robotics and unmanned systems, a rugged bag of years old counter-air strategies and a book with centuries old wisdom of deception and disorientation. The CCADD Web is a blend of UAVs, fighter aircraft and, if required, the Airborne Warning and Control System (AWACS). The whole concept of the web is designed on cloud computing and cloud robotics. Its functions are manifold and capabilities infinite.

WHAT IS THE CCADD WEB?

The CCADD Web (pronunciation similar to the word "cat") is an offensive/ defensive counter-air tactical group of manned and unmanned aircraft. Its sole purpose is to carry out air operations in enemy air space with maximum precision and minimum loss. For precision, it will require artificial intelligence driven A-UCAVs working as a group with the help of cloud robotics. The group will be led by a manned aircraft with modern Electronic Warfare (EW) suits. For minimum loss, there will be in-built algorithm in the softwares to protect the leader/asset when required and act as decoys to drive away the adversary fighter, giving friendly aircraft time for a quick escape.

Some may term the CCADD Web as an evolution of the three-decade-old military doctrine of 'Network-Centric Warfare', given by Admiral Cebrowski and John Gartska. Its operating theory may be the same but the web employs multiple aircraft sized unmanned systems as its main arm with an intent to operate with a single manned aircraft to carry out high-risk, high-priority, swift and successful penetration missions. The unique capability of CCADD is that the whole ecosystem will be based on cloud robotics where the mind of every UCAV in the air is connected to the mind of another. Each drone's sensor/camera will act as an eye for all. The whole swarm will be a single organism with multiple bodies but one mind.

DECEPTION AND DISORIENTATION IN AIR WARFARE (DDAW)

Military unmanned aerial systems flying around the world come under two broad categories: **Surveillance** (Heron, Searcher, Global Hawk, Sentinel, Eitan, Hermes, Rustom, Shadow, etc.) and **Attack** (MQ-1 Predator, MQ-9

Reaper, China's Soaring Dragon, X-47C, Harpy, the UK's Mantis, etc.). The concept of putting UCAVs directly into air-to-air combat was a dormant seed a few years ago which has begun to germinate and might sprout any moment. Today, AI is so capable that it can beat fighter pilots in a simulated aerial dogfight. In 2020, the United States' Defence Advanced Research Project Agency (DARPA) selected teams for AI trials in aerial dogfights. The Heron Systems' AI won the challenge by 5-0 against a human F-16 fighter pilot in a virtual dogfight. This technology of predicting the next manoeuvre, getting free from a tail chase and pushing beyond the flight envelop while still having a calculated approach is already being taught to AI systems and computers. But these are mostly in order to impart air combat practice to pilots virtually. If existing A-UCAVs have their on-board computers upgraded with newer AI enabled patterns for engaging bandits in the air; even if they don't shoot, it would prove to be a potent tactic for driving away Obstacle Clearance Aircraft (OCA) aircraft from a particular air space.

Warfare has always been about deception. The armed forces have used an array of methodologies to deceive their enemy. The most commonly used tactic is of Concealment, Camouflage and Deception (CCD). Nations have employed deception mostly in ground or maritime warfare. Aerial warfare was always about employing the right strategy to deliver the payload for offence or to shoot down aircraft for defence.

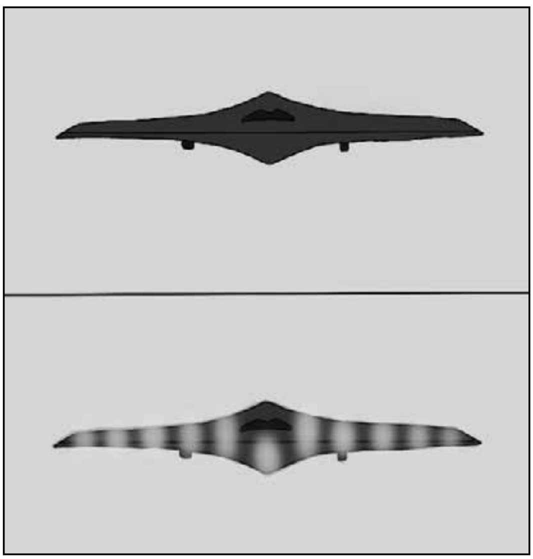
From the late 20th century, deception entered air warfare in the face of camouflage. Now, the doctrine of camouflage is for either simulation or dissimulation: the former focussing on creating dummies or decoys to mislead the adversary whereas the latter for hiding/concealing high value assets or to mask the reality. Nations have always tried to mislead the enemy to mask locations, time, strength, technical details and style of attack.

Deception and Disorientation in Air Warfare (DDAW) via A-UCAVs is easier and highly achievable as the stakes involved would be low. Using a manned aircraft as a decoy can prove fatal and any loss over enemy territory can lead to a Prisoner of War (POW) situation. It can affect the mass opinion of the nation, eventually weaking national security. A UCAV costs less than a modern fifth generation fighter and doesn't carry a human on-board.

Disorientation techniques in air combat will put to use 'manipulation of visual detection' and 'manipulation of radar detection' measures. The visual detection in the air can be challenged by the installation of Yehudi lights on the leading edges of the UCAV for automatically controlled brightness to match the average brightness of the sky to make an active camouflage through counter-illumination. A secondary measure could be to disrupt the bandit's vision via Infra-Red (IR) dazzler or high intensity laser.

Visual deception can be well-exploited against our western and eastern adversaries. The UCAVs can distract the enemy fighters in the air by jettisoning black smoke clouds in the shape of crab claws imitating the MiG-29's emission of visible exhaust smoke. The visual detection of such smoke at a distance either from the ground or from the air can prove to be a useful distraction.

Fig 1: Conceptualisation of Counter-Illumination Lights on the DRDO 'Ghatak'



Source: Author's creation.

Fig 2: Head-on Picture of a MiG-29 (Left) and an Approach of Dispensing Black Smoke Through a UCAV (Right)

Source: Author's creation.

While DDAW is a philosophical concept and an integral part of the CCADD Web, its implications are much wider when it becomes a part of swarm robotics. Its applications in the CCADD Web where it wears the mask of various offensive and defensive swarm modes are discussed in the latter part of the paper.

HOW DOES THE CCADD WEB OPERATE?

Composition

As the name implies, the CCADD Web aims to use cloud robotics for counter-air operations to deceive and disorient the adversary in the air. Cloud robotics enables multiple autonomous systems to be connected to each other at all times and the data sharing and communication between the systems are instantaneous. Swarm robotics is fundamentally the same but focusses more on synchronisation of multiple systems to operate as one or in close coordination with one another.

Modern Research and Development (R&D) of fighter aircraft in the West is starting to inculcate on-board systems which can work with Remotely

Most nations with fifth generation aircraft are trying to develop Network-Centric Warfare (NCW) capabilities to interoperate with other types of aircraft, ships, ground vehicles and unmanned systems.

Piloted Aircraft (RPAs)/UAVs and other war operatives on the ground and sea, using cloud computing and sophisticated networks. There are infrastructures which aim to operate fighter aircraft along with UAVs, but they aren't fully operational and fully reliable yet. France is working on the Future Combat Air System (FCAS) along with other European Union (EU) countries. The FCAS aims to utilise the NGF or the New Generation Fighter which is still under development. Most nations with fifth generation aircraft are trying to develop Network-Centric Warfare (NCW) capabilities to interoperate with other types of aircraft, ships, ground vehicles and unmanned systems.

Operational doctrines and strategies to put even a simple UAV in the battlefield for the benefit of the nation are not being discussed very widely. Much emphasis is laid on sophistication of software and hardware. The DDAW concept can be utilised even by existing surveillance RPAs if communication and synchronisation are precise, but it can be best exploited when the human error factor is eliminated and flawless systems take over.

The CCADDW is an airborne cloud-based ecosystem wherein manned fighter aircraft, multiple fixed wing UCAVs and AWACS will be flying as one "Web". A single web will contain a leader (fighter) and three web-clusters (UCAVs). The three web clusters will be following a centralised command regarding the mission objective. The flight controls of the UCAVs during different regimes of the flight will be fully autonomous. The Artificial Intelligence/Machine Learning (AI/ML) enabled computers on-board the UCAVs may follow certain pre-loaded Radio Telephony (RT) commands given by the web leader. The commands will be able to put the systems in different mission modes as per the requirements.

Instant upload and download of terrain photographs and videos, behavioural data, meteorological data and emergency calls can be undertaken seamlessly over the cloud. The data can be accessed by each UCAV as well as the fighter and AWACs in the air space. Commands from the leader or the ground controllers can be given to all or one of the units of the web.

Capability

Low stakes, high-tech unmanned aircraft and DDAW create an invincible blend. With no human life on the line, the commanders can go to any extent for the accomplishment of their objective. With such an ecosystem, the flexibility of operational usages is manifold. The web can be used to cater for almost all air power capabilities. The only variable factor determining the operational capability of the web is the technical specifications of the UCAVs involved. The UCAVs must be (1) autonomous and cloud based; (2) able to carry and deliver A2G weapons (like the MQ-9 Reaper); (3) they must have good endurance.

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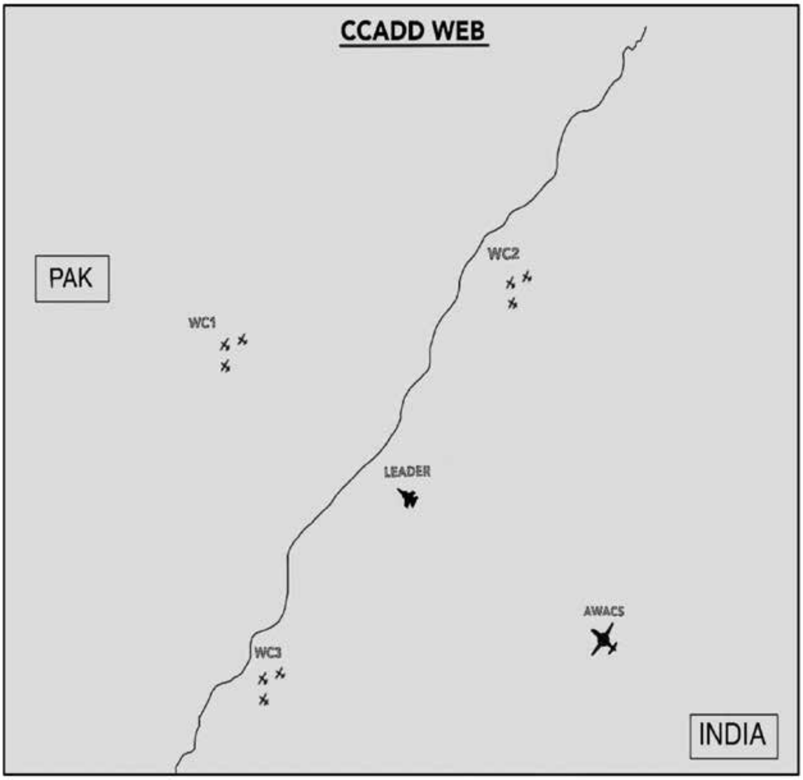
The capabilities of the CCADD Web depend on the level of imagination its operator has. The machines have cameras, weapons and a network through which data and commands can be shared right away. The same can be utilised for GEO-INT, pre-mission surveillance, leading-in party of a strike package, decoys and ground-attack.

The operational structure of the CCADD Web will be arranged as per mission parameters and requirements. For the most desired usages, penetration strike and Close Air Support (CAS), three Web-Clusters (WCs) will infiltrate the air space in an arrow formation with the leader (manned aircraft) in the centre. The suggested gap between the clusters is a few kilometres. The leading-in party or the WC in the forefront will comprise one UCAV constantly monitoring the ground and uploading the GEO-INT over the cloud, while the other two UCAVs will monitor the radar and air space.

Fig 3: Organisation of the CCADD Web for Air Space Infiltration During War



Source: Author's creation.

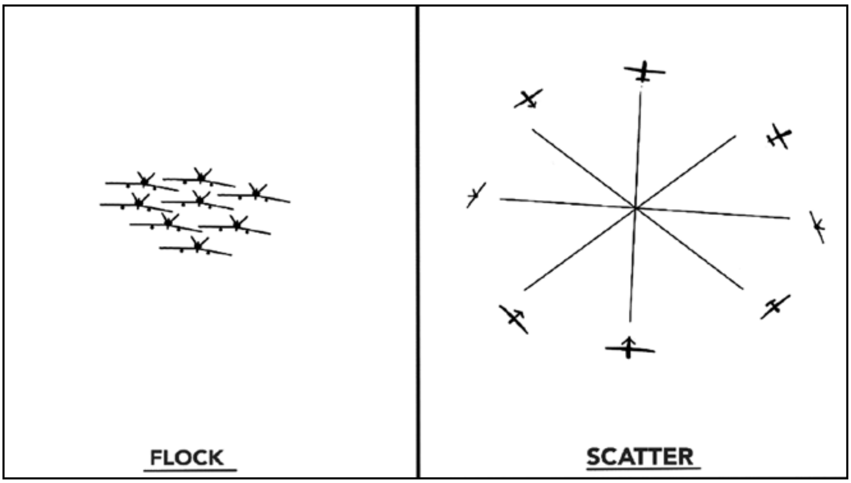
While carrying out any sort of mission, the CCADD Web management and organisation will lie with the web leader, and he may decide the same as per the contingency.

For best exploitation of cloud robotics in the UCAV swarms, certain modes can be installed in the on-board computers to initiate different flying patterns and formations. Some cutting edge technology and DDAW usage through the web are as follows:

1. **Flock and Scatter Mode (FSM):** The FSM is a distraction and disorientation tactic of flying wing-to-wing while in hostile air space

and doing a quick 360 scatter or 'break formation' when intercepted. It is similar to the decades-old air combat tactic of flying in close formations and breaking when closed-in by the enemy. The FSM in the CCADD Web utilises command-over-cloud and automated synchronisation which means that the manoeuvres will be decided by the AI or they will be pre-fed. For developing efficient cloud-based and AI-enabled manoeuvres and tactics for the swarm, the nation's best fighter pilots, test pilots, engineers and members of the academia should collaborate to devise a formidable system.

Fig 4: Visual Presentation of FSM



Source: Author's creation.

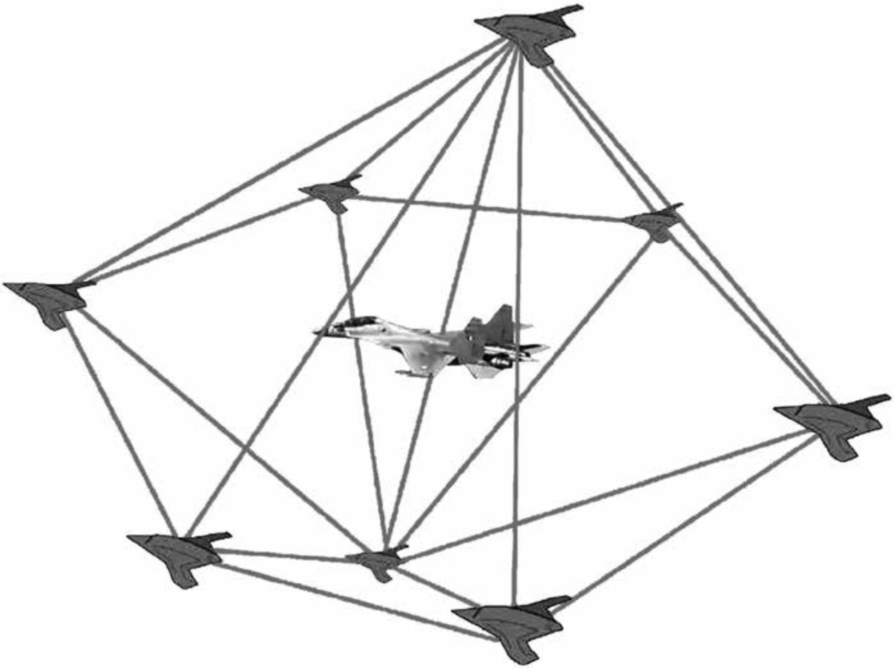
2. **Scarecrow Mode (SM):** Defending high value aerial assets is also one job that the UCAVs in the web can do. Whenever any aerial asset i.e., transport aircraft, VIP aircraft or AWACS is in a disturbed or risky air space, web clusters consisting of Air-to-Air (A2A) capable UCAVs may escort them. The UCAVs may possess an active radar that is able to lock on to enemy fighters or manoeuvre in such a manner or fire mock missiles/rockets to

scare away the enemy and buy time for friendly interceptors or Combat Air Patrol (CAP) aircraft to engage. Work on A2A offensive drones has begun in a few nations. The US DARPA started working on its LongShot air-to-air combat drone in 2021. The drone will be able to shoot down aircraft from extreme ranges. Turkey is also employing Air-to-Air Missile (AAMs) on its Bayraktar Akinci UCAV. The missiles, Bozdogan and Gokdogan, are Beyond Visual Range (BVR) missiles.

3. **GEO-INT Mode (GIM):** Rapid upload and download of imagery by the WC-1 via the cloud allows each and every machine on-line the web to remain updated with what is happening on the ground a few nautical miles ahead of it. The leading-in party (Web Cluster One) will recce the enemy territory several miles ahead of the leader and the other two web clusters. The high-resolution imagery of the terrain and Enemy Ground Build-up (EGBU) will warn the following clusters instantaneously via the cloud. The imagery or videography of the real-time ground situation will be visible and open-to-action to the commanders at base. The most practical and advantageous exploitation of this mode will be in hilly terrain, where three-360º cameras below the nose of the UAV can capture imagery of valleys while flying through them.
4. **Leader-Shield Mode (LSM):** Any penetration mission will bring certain risks and challenges, both of which are very well accepted by fighter pilots and the armed forces. National security and protection of the nation's interests are of paramount importance. Carrying out offensive actions gives rise to defensive actions from the other side. As a measure to defend the leader aircraft from AAMs or Surface-to-Air Missiles (SAMs), the CCADD Web will get into the Leader Shield Mode (LSM) wherein the UCAVs will surround the fighter and form a bubble. The LSM would be effective during escape from hostile air space after carrying out a strike mission. The shield can be used to provide cover to high-value air assets such as airborne radars and transport aircraft.

Fig 5: Presentation of the Leader Shield Mode

LSM



Source: Author's creation.

5. **Strike Package Mode (SPM):** The SPM in the CCADD Web will comprise a unique utilisation of conventional strike doctrines. The different responsibilities shared by different types of A-UCAVs in the different web clusters would ease the process of delivering the payload to a particular target with utmost precision. The whole web, consisting of three web clusters, will possess eyes, ears, limbs and explosives governed by one mind. The composition and strength of each type of CCADD UCAV, whether it is a GEO-INT UAV, A2A armed UCAV escort, A2G UCAV or a deception UAV, must be determined as per the requirements of the task. Ease of communication via cloud enables the synchronisation and swiftness of the attack to be remarkable. Autonomous UCAVs

India and most countries today possess loitering munitions in their arsenals. The whole concept of loitering munitions is to fly over a target area or battlefield and crash onto the target and explode.

can be pre-fed with navigation details and information related to the ground or maritime target and be ready for counter-counter-air measures by the adversary. The measures can be engineered to initiate counter-SAM manoeuvres as and when the radar picks up a missile. The autonomous decision-making or decisions by the mission control on the ground can change through the modes whenever the need arises.

6. **Suicide Attack (Fidayeen) Mode (SAFM):** India and most countries today possess loitering munitions in their arsenals. The whole concept of loitering munitions is to fly over a target area or battlefield and crash onto the target and explode. The Israel Aerospace Industries (IAI) Harop which is a newer version derived from the IAI Harpy is a potent platform and a good option for targeting the enemy ground vehicle build-up in the battlefield. The CCADD Web can utilise such platforms for a good implementation of DDAW. The surveillance UAVs which will be the leading web cluster shall have the capability to get into the SAFM if there is an urgent need to neutralise the troops on the ground. The surveillance UCAVs in WC-1will be the first lot to see the troops and they will be possessing good optical sensors. A precise strike mode will act as a life saver during an unprecedented contingency.

COMMAND AND CONTROL

The CCADD Web will be operating in three clusters commanded in the air by the leader aircraft. The command set-up of the CCADD Web would be three layered:

Layer 1: Command in Air: The three airborne web clusters with three UCAVs each would be led by one fighter aircraft with a modern EW suite. It is preferred that the aircraft is a twin-seater so that EW, command of the web and allied tasks are undertaken by the Weapon Systems Operator (WSO).

Layer 2: Airborne Radar Control: For scanning the air space and keeping a vigilant eye, a trailing AWACS inside the friendly air space can provide an additional supervision and vector control if required.

Layer 3: Ground Cloud Control: Commanders and fighter controllers on the ground can provide the primary decision-making regarding change of plans or aborting of the task. For any unprecedented loss of the command in-air, a subsidiary command and control should be in the hands of trained ground controllers.

A skilled pilot is able to fly wing-to-wing in a normal cockpit but when he's flying a UCAV through a screen, the level of alertness, precision and coordination with others become very challenging.

WHY AUTONOMOUS UCAVs ARE BETTER THAN RPAs IN THE CCADD WEB?

1. **Autonomous UCAVs are Hard to Jam:** Counter-drone measures use UAV jamming as their main weapon. Fully A-UCAVs would not have a debilitating degradation because of jamming. The systems on-board ensure complete autonomous flight and zero visibility during different regimes of the flight. The on-board systems including LiDAR sensors and Inertial Navigational System (INS), along with AI computer piloting the UCAV help in providing a complete autonomous flight without navigating through GPS and relying on ground control.
2. **Maintaining Extremely Close-Formations:** Human RPA operators may not be able to operate in close coordination with other RPAs in close formation flying. A skilled pilot is able to fly wing-to-wing in a normal cockpit but when he's flying a UCAV through a screen, the level of alertness, precision and coordination with others become very challenging. AI is already well skilled in obstacle detection and self-piloting. The CCADD Web is a single organism with multiple bodies but one mind. With swarm robotics, the Flock and Scatter Mode (FSM) becomes a fully automated procedure.

3. **Rapid Communication of Command and Control**: The leader/ commander of a web may communicate verbally to the UCAV operator regarding change in flight/mission parameters and any misunderstanding can change the trajectory of the mission. Whereas in an autonomous AI and CR enabled UCAV, mission modes can be changed and commands can be given at a press of a button on the multi-functional display.
4. **The Attention Span Challenge:** The human attention span is limited and mental fatigue would be a hindrance for achieving goals. Keeping the UAV airborne for extended periods would be a test for the operator's mental stamina and endurance. While flying in a fighter aircraft, the pilot's attention and focus are naturally heightened as there are physical risks involved and constant inputs (RT, visual sights, etc) and outputs (RT, flight control) are given to and by the pilot. While operating an RPA from a chair and working at screens, the hours of input and output can cause mental fatigue and reduce alertness.
5. **Synchronisation and Collaboration During Different Modes:** Initiation of any certain CCADD mode should be rapid and well synchronised. Even a split-second delay can hinder the accomplishment of the objective. The manoeuvres to be made by the UCAVs should be pre-fed so that it can beat the 'Human-Reaction Time' (HRT) of the enemy.

The CCADD Web requires instantaneous manoeuvres whenever the units in the web are instructed to do so. Making rapid movements in an unprecedented manner will not only disorient the enemy but will make him engage the wrong aircraft.

CHALLENGES TO OVERCOME AND THE WAY AHEAD

The CCADD Web provides an advanced and operationally flexible use of conventional and disruptive means of warfare. The newest and most sophisticated technologies will be exploited in this web in a hybrid manner.

Advanced technological manufacturing and development infrastructure is required to operationalise such systems. The first challenge would be to develop and integrate the technologies together to make them work with each other. Autonomous UCAVs are already flying around the world. Cloud and swarm robotics are fully operational with UAVs since a last few years. A very basic utilisation of swarm robotics is also seen in aerial drone displays around the world where all the drones are piloted by one system in a very synchronised and pre-decided pattern. Combat fixed wing UAVs are very well operationalised in many air forces and navies. The idea of developing an entirely new UCAV for such usage is not required. A potent surveillance, A2A, A2G or loitering UAV is required which can operate autonomously. The computers flying such UAVs need to be inculcated with cloud computing technology and subsequently swarm robotics so that all command, control and in-flight actions are taken through the cloud and executed by all. The second challenge to overcome would be successful integration of the swarm with the computers of the fighter aircraft which will be leading the CCADD Web in battle. The aircraft, as already discussed earlier, needs to be a twin cockpit aircraft wherein the responsibilities of flying, fighting and control of the web are shared. This set-up can be done in a single pilot aircraft as well, but more advanced AI will be required to oversee the UCAVs. Only a human, fully aware of the situation in the air and ground, can make logical decisions which are far beyond any AI's capability. Lastly, the third challenge is to make operational plans of the CCADD Web keeping in mind the terrain and urban planning of South Asia. The towns and semi-urban areas of India and our western neighbour are not planned in a structured manner. An airborne AI system might find a large number of inter-connected brick houses confusing if the data is imported from a country where streets and avenues are named in a structured manner.

UAV R&D is exploring newer possibilities to use these systems in myriad roles. Installation of disruptive software like AI, ML and cloud computing into autonomous unmanned systems might create something as good as a live eagle in the sky.

The potency and flexibility of usage that the CCADD Web brings far outweighs the challenges that follow. Setting up the CCADD infrastructure might be easily achievable if the right systems are chosen and/or developed. It asks for only a blend of existing technologies, developers of which are abundantly available in our country.

CONCLUSION

Military air traffic today is seeing more machines than men. Every leading military possesses unmanned systems in its arsenal. UAV R&D is exploring newer possibilities to use these systems in myriad roles. Installation of disruptive software like AI, ML and cloud computing into autonomous unmanned systems might create something as good as a live eagle in the sky, and the only difference would be that this bird can deliver firepower, capture imagery and lead its flock in battle.

Deception has been used in battle for centuries. The deception techniques were mostly for ground and/or maritime warfare. Deception in air combat was thought of a few decades ago, and it started with simple camouflage to mislead the enemy by either simulation or dissimulation. Now a newer doctrine is required by tailoring a strong fabric of deception techniques with a tapestry of disorienting tactics. For such purpose, this paper has put forth the concept of Deception and Disorientation in Air Warfare (DDAW). For a complete utilisation of this concept, bringing technology to the forefront would be the right step ahead. When technology is bred with the older philosophical wisdom, it gives birth to formidable and inevitable deception techniques. The paper has discussed six modes that the UCAVs in the web can go into for strike, defence, surveillance and disorientation. A centralised command and control infrastructure provides synchronised flying and conduct of tasks. Swarm robotics help in the swarm's objective by enabling sharing of data and command. It provides the 'one learns-all learn' capability. This capability will be most beneficial for the safety of the aircraft and UCAVs flying in a hostile air space.

The web will fly in separate clusters (web clusters) with ideally three UCAVs each. Three clusters would be commanded by a single fighter aircraft. The responsibilities of keeping an eye on the enemy on the ground and in the air, for conducting surveillance, for deceiving the enemy and for delivering payloads or shooting down the enemy will be shared amongst the UCAVs. The whole array of operations which can be undertaken by this web has been discussed elaborately, but even with the flexibility of usage that it offers, a wide variety of tasks still remain.

Autonomous systems provide a certain level of precision and do not face hindrances such as attention span, fatigue and communication errors. They can overcome and avoid jamming measures by the enemy as they do not rely on radars or GPS.

Command and control for such an intricate set-up of airborne machines would be a frantic task to undertake. For a structured way of doing that, the paper has put forward a three-layered chain of command wherein the primary commander would be the leader aircraft; the second would be the AWACS; and the third would be the commanders and cloud controllers on the ground. Even though the leader and AWACS are the main source of in-air command as they are the only ones to know the real-time situation up in the air, the auxiliary command and full control over the data on the cloud will be with the commanders on the ground.

Autonomous systems provide a certain level of precision and do not face hindrances such as attention span, fatigue and communication errors. They can overcome and avoid jamming measures by the enemy as they do not rely on radars or GPS. Proper close formations can be maintained by the UCAVs in the swarms if they are governed and flown by computers connected to a single cloud.

The CCADD Web will use existing technologies in a non-existent manner. The web will blend AI/ML, UCAVs, cloud and swarm robotics and pair these with conventional air power means. The blend of disruptive and conventional means of air warfare will not only evolve the operational doctrine of the operating air forces but will ease the safe, precise and covert accomplishment of the objective.