AIR SPACE CONTROL: CHALLENGES AND WAY AHEAD

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Air Space Control (ASC) refers to regulating the use of air space by multiple users. The need for regulation arises because of the finite resource of 'air space'. From the military operations' point of view, the objective of air space control is to maximise the effectiveness of combat operations without adding undue restrictions, and with minimal adverse impact on the capabilities of any component. The emphasis is on close coordination that must exist among air space control, air traffic control, and area air defence units to reduce the risk of fratricide and balance those risks with the requirements for an effective air defence. The balance required between restrictions on ASC and flexibility has to be jointly determined and evolved. The ASC plan specifies air space control procedures, joint Services procedures for integrating weapons, and other air defence actions within the operations area. The geographic arrangement of air defence weapons within the battle space and procedures for identification and engagement are integrated into the ASC plan.

During conflict, the air activity in the Tactical Battle Area (TBA) is extremely dense. Both friendly and enemy aircraft are transiting. The horizontal and vertical air space is not only fully covered but the variations

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in time and space are dynamic. Most flights are launched at very short notice, based on the evolving tactical situation. There are fast moving jets, slow moving helicopters and many Uninhabited Aerial Systems (UAS). Also occupying the air space are high velocity long and medium range artillery shells and a variety of missiles. Ground-based air defence weapons are on hot standby, and some are operated from remote locations close to the Forward Edge of the Battle Area (FEBA). Military operations will get priority but the civil air operations could be allowed to continue albeit with small restrictions and regulations in time and space. There is, therefore, a need for quick timely information sharing. There have to be clearly designated agencies for direct and procedural control.

AIR DIMENSION EVOLVES

Intercontinental operations became possible in World War II because of the maturing of air power which, in a great way, decided the outcome of the six-year war. More recently, the Arab-Israeli Wars of 1967 and 1973, Bekaa Valley operations, the Falkland War, the Bosnian conflict and the post 1990s wars in West Asia, Afghanistan and Libya have been predominantly air wars. Closer home, the Indian Air Force (IAF) played a significant role in saving the Kashmir Valley in 1948, and in the victory in the 1965, 1971 and Kargil Indo-Pak Wars. The coordinated 9/11 aerial attacks against the United States by Al Qaeda brought a new dimension to the air threat. Meanwhile, today, the fighter bomber has become faster, more agile and stealthy. Transport aircraft have global reach. Helicopters in the TBA are using Nap-of-Earth (NOE) techniques. The proliferation of inexpensive UAS for surveillance and targeting has added a cheap but potent weapon. The world is engaged in developing counters to the ballistic and tactical missile threat. The threat of an aerial attack launched from space today is real. Therefore, the air threat essentially includes weapons launched from aerial and space-based platforms, and surface-launched weapons. Meanwhile, there has been an exponential increase in civil air traffic. The air space exclusive to the military is shrinking. Plans are afoot for space tourism. Air taxis are a reality. The UAS have also begun playing a greater role in day-to-day product deliveries and also for aerial policing, among many other roles. The Chinese have flooded the markets with hand-held UAS for hobbyists. The density of air traffic is, thus, increasing at a very high rate. With this intense environmental background, military and civil aviation has to coexist without severely hampering the efficient operations of either. ASC, thus, poses fresh challenges and is constantly looking for fresh solutions.

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AIR THREAT TO INDIA

At the strategic and tactical levels, China's air power can now achieve a variety of effects. Though its current concentration is on operations on the eastern seaboard in the South China Sea, the same weapons will be used against India. China wants to exploit the advantage of using its tactical/strategic missile force, which is easier to use for offensive than for defensive purposes. Like the IAF, the People's Liberation Army Air Force (PLAAF) is switching from net-enabled to net-centric offensive air defence, placing greater reliance on integrated attack. China's ambition is to build its air power like the USA for an asymmetric advantage. It is aiming to be one of the world's foremost air forces by 2020, made up of at least 1,000 'modern' combat aircraft. In the long term, it will settle for 80 fighter/bomber squadrons. The Russian Su-35 aircraft, along with its advanced IRBIS-E passive Active Electronically Scanned Array

(AESA) radar system has entered service and will enhance the PLAAF's capability. Of greater concern about China is the offensive capability in terms of Precision Guided Munitions (PGMs) and surface-to-surface missiles. China already has two indigenous fifth generation fighters – the J-20 and J-31 – nearing induction, a large transport aircraft, the Y-20, already flying, and a host of utility and attack helicopters under development. China is also evolving as the Wal-Mart of the UAS, making nearly 50 percent of the world's UAS for hobbyists. The Pakistan Air Force (PAF), with 20 combat squadrons, comprising around 450 combat aircraft, essentially remains an air defence-centric air force. It is heavily dependent on China for all hardware and support. The F-16, JF-17 and FC-20 will finally be the main types. Pakistan has been in talks with China to acquire the JF-31 stealth fighters and with Russia for the Sukhoi Su-35 air-superiority multi-role fighters. Pakistan has an evolving surface-to-surface missile force, including tactical nuclear ones. Pakistan and China could act in collusion, forcing India into a two-front war, and India has to cater for such a scenario.

MILITARY AERIAL PLATFORMS

The fighter-bomber aircraft remains the main instrument of prosecuting the air war and conversely also for air defence. In addition to creating air superiority for unhindered operations of surface forces, these aircraft have the capability to deliver very lethal and accurate aerial weapons deep into enemy territory to destroy the enemy's capacity to wage war. Consequently, the fighter fleets consume major portions of defence budgets. Their main characteristics are agility, super cruise, stealth, multi-function AESA radars, network-centric systems, integrated glass cockpits, fibre-optics data-transmission, multi-spectral sensors, fused situational picture, helmet mounted sights and PGMs. Fighters strive to have 'first-look, first-shoot, first-kill' ability. Other significant airborne platforms that support air operations are the Airborne Early Warning and Control (AEW&C) systems, electronic warfare platforms and aerial refuellers.

The special operations aircraft can induct Special Forces (SF) and cause havoc behind enemy lines. Transport aircraft are used for inter-theatre movement. Helicopters have a great role in tactical attack, battlefield logistics, surveillance and casualty evacuation, among others. More and more of these roles are gradually being taken over by unmanned or optionally-manned aircraft. Most army units have hand-held UAS. A large number of Surface-to-Surface Missiles (SSMs) could be in the TBA. Sometimes, long-range missiles may be used. Each of the armed forces has Surface-to-Air Missiles (SAMs). These could be long to medium range or short-range systems, including man-portable shoulder-fired ones. A big part of the ASC is the avoidance of fratricide. Most military operations evolve from tactical situations and are launched at short notice. The air force, army and navy have their own aerial platforms. There is, thus, a need for air space coordination between them, especially in the TBA and over the sea when air force elements are launched in support of naval operations.

PERMEATION OF UAS

Permeation of UAS has brought in a new challenge for ASC. The central issue contained in this is the fact that uninhabited vehicles are growing at a fast pace even in India and are likely to register an even higher growth in the times to come. Till very recently, there was a total ban on the operation of UAS in the National Air Space (NAS) system which is being gradually lifted. If these vehicles were to cohabit the same finite air space where manned aircraft (civil and military) also operate, then there is a looming danger of a collision between them. What even a perception of such a looming danger can result in was seen on August 21, 2017, when, at the Indira Gandhi International Airport (IGIA), Delhi, the pilot of an Air Asia Goa-Delhi flight sighted a Unmanned Aerial Vehicle (UAV)-like object on its approach landing path. A panic situation ensued. All the three runways of the IGIA were closed down for nearly an hour, 20 flights got delayed and 20 police and Central Industrial Security Force (CISF) teams were hurled into action to investigate the incident.

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The growth of the UAS sector is driven by the demand for such platforms in multifarious functional areas, in both the defence and civilian domains. For the military, it is going much beyond the traditional Reconnaissance Surveillance and Target Acquisition (RSTA) role to Electronic Warfare (EW), deception operations, nuclear cloud surveillance, to a host of other military applications leading to the mother of all the teaming of the manned and the unmanned vehicles in joint operations.

AIR SPACE CONTROL METHODS

ASC requires that air space is used efficiently and effectively. ASC coordinates, integrates and regulates activities in the defined air space by identifying and monitoring all air space users. It exercises a degree of authority necessary to achieve effective, efficient, and flexible use of air space. Integration is the key. Regulation is required to supervise activities in the air space and provide for flight safety. Timely identification allows early engagement of enemy aircraft and also prevents potential for fratricide. ASC measures and procedures are disseminated to all air space users and control agencies. Essentially, there are two means to exercise control: positive control and procedural control. Positive control relies on positive real-time identification and tracking. It is conducted using radars; identification, Friend or Foe (IFF) interrogators and receivers; beacons; computers; digital data links; and communications equipment. Positive control facilities are subject to attack and sabotage. They may be restricted by line of sight coverage, electronic interference, and limited communications. Positive air control agencies must have back-up procedures to compensate for failure of part or all of their positive control systems. Procedural control relies on previously agreed upon and promulgated orders and procedures. Included in these orders and procedures are ASC measures, fire support coordinating measures, and air defence control measures. Procedural control divides the air space by volume and time, and uses the weapons' control status to manage aviation operations. It is less vulnerable to interference by electronic and physical attack and ensures continuity of operations under adverse environmental conditions. It also serves as a back-up system if positive control is lost. Usually, procedural control is implemented to cover positive control limitations.

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UNITY OF CONTROL

Air space command and control requires unity of control for the myriad actions performed by the various military elements. It requires qualified people, information, and a support structure to build a comprehensive picture of the battle space. Other field elements provide planning resources. The IAF's tactical air elements with the Indian Army and Indian Navy support coordination between the Services. Several types of control exist that can be used exclusively or combined to achieve the desired degree of autonomy in operations. Control could include directing the physical manoeuvre of in-flight aircraft or directing an aircraft or surface-to-air weapons unit to engage/disengage targets for a specified period.

Agencies and individuals that perform air control functions include the Tactical Air Centre (TAC), Maritime Elements of the Air Force (MEAF) and the early warning and control radars. Designated controllers and coordinators such as tactical air coordinators (airborne), assault support coordinators, forward air controllers (airborne and on the ground), air traffic controllers, radar controllers, information communications technology managers, the aircraft flight leader, and surface-to-air weapons units are involved. They perform air control by directing subordinate elements.

LAYERED AIR DEFENCE

Air is a complex medium. With many active players, the density of air operations, especially in the TBA, has increased phenomenally. Air defence of a vital asset or an area is normally built around a system of concentric layers. The outer layer will usually be handled by fighter aircraft with AESA radars and combinations of Air Defence (AD) missiles supported by AEW&C. If an attacker is able to penetrate this layer, then the next layers would come from surface-to-air missiles. The area-defence missiles could have ranges in excess of 150 km. The S-400 Triumf class which has a family of missiles covering different height and range bands could neutralise targets at 400 km. Other shorter range missiles would have ranges around 30-50 km. Finally, there will be the Close-in-Weapon-System (CIWS), the Very Short Range AD System (VSHORADS) missiles, the man-portable missiles and the radar controlled anti-aircraft guns firing several thousand rounds per minute.

SURFACE AND AIRBORNE RADARS

Ground-based radars are an important element to manage both the air threat and ASC. High and medium powered surveillance radars, tethered aerostat radar balloons, missile acquisition and guidance radars, tactical battlefield mobile radars and ship-based radars are all part of the ground sensor network. Radars such as Raytheon AN/MPQ-35 can detect high/ medium-altitude threat for the MIM-23 Hawk surface-to-air missile system. The Northrop-Grumman AN/TPS-75 is a transportable three-dimensional air search radar. The S 400 has a panoramic radar detection system (range 600 km) with protection against jamming. The Chinese ground-based radars include the very powerful REWY-1 long range surveillance radar and YLC-18 medium range low-altitude 3D radar. The Russians have the 'Duga' series of over-the-horizon radars and Don-2N and Voronezh anti-ballistic missile radars. To cater for the stealth aircraft threat, Russia, China and Israel are developing very long-range L, UHF and VHF (Low, Ultra High Frequency and Very High Frequency) wavelength radars.

Air Traffic Control (ATC) radars and controllers perform a significant role in air space management. India has a large number of ground radars such as the indigenous Rajendra and Rohini, Elta Medium Powered Radars (MPR), and the GS100 Low-Level Transportable Radars (LLTR) – developed jointly between Bharat Electronic Limited (BEL) and Thales – are under induction. The Defence Research and Development Organisation (DRDO) is developing the 'Arudhra' MPR. Low Level Light Weight Radars (LLLWRs) have been developed for the mountainous and high altitude regions. High-powered radars with a range of more than 500 km, to replace the THD-1955, are being identified. The IAF already has Israeli Rafael aerostat radars with a range of 400 km. The DRDO is also working on the indigenous 'Akashdeep' aerostat.

The AEW&C system is an airborne radar picket system designed to detect aircraft, ships and vehicles at long ranges and perform command and control of battle space and air engagements by directing fighter and attack aircraft strikes. The AEW&C is also used for surveillance and frequently performs the Battle Management and Command and Control (BMC2) functions similar to an ATC. It also allows the operators to detect and track targets and distinguish between friendly and hostile aircraft much farther away than a similar ground-based radar. Because of its mobility, it is much less vulnerable to counter-attack, though it will be targeted by enemy fighters and missiles. AEW&C aircraft are used for both defensive and offensive air operations. The Northrop Grumman E-2 Hawkeye, the Russian A-50, the IAF's IL-76-based Phalcon, the Chinese KJ-2000 and the Indian DRDO's Embraer-145-based Netra are some examples of AEW&C aircraft. The US Air Force's (USAF's) E-3 Sentry mounted on the Boeing-707 aircraft platform – or more recently on the Boeing 767 – is a frontline Airborne Warning and Control System (AWACS). There is a large number of helicopter Airborne Early Warning (AEW) systems such as Sea King ASaC7, Agusta Westland EH-101A and Russian Kamov Ka-31.

AIR SPACE AND FIRE SUPPORT COORDINATION

A critical part of ASC is to outline hostile criteria for identifying targets and coordinating fires. The ASC area is laterally defined by the boundaries of the component's area of operations. Air control points are earmarked on the ground for the aircrew to route to their targets and provide a ready means of conducting fire support coordination. The points must be easily identified from the air and support the ground tactical force scheme of manoeuvre. Each control point is based on the tactical situation and promulgated through the daily orders. Air control points can be designated separately for entry/exit, en route, orbit/holding, contact point, rendezvous, egress control, penetration, ingress, and return. Friendly aircraft en route to, and returning from, combat missions need to avoid enemy air defence systems yet be visible to friendly air defence systems. These control procedures must allow friendly aircraft to move safely throughout the TBA by utilising predictable flight paths for positive identification. Inter-Service aviation operations could be based on coordinating altitudes to operate to create buffers, restricted operations area/ zone, designating minimum risk routes. Fire support coordination allows opening areas of the battle space for rapid engagement of targets or to restrict and control fires. Fire support coordinating measures also safeguard friendly forces and favorably impact directly on operations, especially Suppression of Enemy Air Defences (SEAD). Permissive fire support coordinating measures facilitate the attack of targets, especially at the Forward Edge of the Battle Area (FEBA). Restrictive fire support coordinating measures provide safeguards for friendly forces. The no-fire area serves to protect friendly resources. In the air defence action area, friendly aircraft or surface-to-air weapons are normally given preference to conduct air defence operations.

WEAPONS CONTROL AND COORDINATION

An attempt is made to decentralise control of assets in most situations to allow the maximum flexibility to attack or counter the threat from aircraft and missiles. Decentralised control is the normal war-time mode of control for air defence. Even under centralised control, the right of self-defence is never denied. An Air Defence Identification Zone (ADIZ) consists of air space that requires ready identification, location, and control of aerial platforms. Typically, an ADIZ is used for sovereign national boundaries, or in the case of areas of operations, for identification while entering the air space of rear areas. In the weapons engagement zone, responsibility for engagement normally rests with a particular weapon system. There are areas where fighter aircraft have the clear operational advantage over surface-based systems. Surface-to-air missile systems will not be allowed to fire weapons in this area unless targets are positively identified as hostile. In the missile engagement zone, the responsibility for engagement normally rests with missiles. This could be a high-altitude or low-altitude zone. There are areas where multiple air defence weapon systems are simultaneously employed to engage air threats through sector separation. The Base Air Defence Zone (BADZ) is an air defence zone established around an air base and limited to the engagement envelope of short-range air defence weapon systems defending that base. Low Altitude Air Defence (LAAD) assets are employed at the BADZs. Emission Control (EMCON) regulates the use of electromagnetic, acoustic, and other emitters to optimise command and control capabilities, thus, minimising the detection of assets by enemy sensors and reducing mutual interference among friendly command and control systems. EMCON also aids in executing a military deception plan.

AIR SPACE CONTROL AND TECHNOLOGIES

Air defence interface is critical to effective combat zone air space control. Communications data-link architecture enables this process. Timely, tailored and fused intelligence is integral to all operations. There is a need to produce and disseminate aviation-specific all-source intelligence, including assessments of adversary capabilities and vulnerabilities, target analysis, Battle Damage Assessment (BDA), and the current status and priority of assigned targets to assist in execution daily changes. The same is meant for marine tactical air operations, related to the landing force during amphibious operations.

The sector air defence commander is responsible for air defence warning and weapons release conditions, launching the Operational Readiness Platform (ORP) aircraft or diverting airborne aircraft to attack time-critical

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targets. They provide positive air space control, management, and surveillance. They also provide en route air traffic control and navigational assistance for friendly aircraft. They also provide close, broadcast, tactical or data-link control to Defensive Counter Air (DCA) missions. They can provide control for sweeps and escort missions and routing or coordination for SEAD or surface strikes. They are also normally responsible for activating a designated BADZ and providing early warning and cueing to surface-to-air weapons units within the BADZ. Command and control systems are susceptible to electronic attack (jamming) and electronic warfare support (deception, intrusion, and interference) operations. Effective training in recognising and acting on electronic warfare actions, along with proper employment of active and passive measures, i.e. electronic protection, deception, and operations security, can minimise or negate enemy electronic warfare effects. Among the technology requirements are the primary and secondary radars for control and situational awareness, aircraft transponders, flight data processing systems, special software for fully automated systems and conflict alerts and algorithms for possible vectoring solutions. Controller pilot data-link communications and Operational Data-Links (ODLs) allow digital messages to be sent between platforms and ground systems. Screen content recording allows better reconstruct and post event analysis.

AIR SPACE CONTROL IN THE TBA

The air space control handles all issues related to the air-tasking cycle. De-confliction is a critical part handled at the Air Operations Centre, and later at the Control and Reporting Centre (CRC), AWACS and ATC levels. Air space control and area air defence operations should be capable of functioning in a degraded Command and Control (C2) environment. The air component commander must ensure that items on the surface commander's defended asset list and critical asset list are protected from attack. It is important to define the theatre-specific area map reference system in use so that air and surface elements remain geographically on the same grid. Proper coordination with civil air operations is especially important during transitions into, or out of, war-time status or during non-war-time periods of heightened tension. Additionally, allowing maximum use of navigable air space by civil aircraft is necessary.

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TBA: INDIAN SCENARIO

In the TBA, the enemy air tries to engage our surface forces. Similarly, the IAF will support the Indian Army through air operations. There will be many joint or special operations. Between the Indian armed forces, the domains are clearly demarcated. The army manages the surface coordination, the navy manages the maritime picture and the air force coordinates the ASC. The air defence of the nation is the IAF's responsibility. The air defence of the army's and navy's integral assets is their own responsibility. The big situational air picture is created by the IAF using its own, civil and other Services radars. Such a picture is made available at the Tactical Air Control (TAC) level to the army and at the Maritime Element of the Air Force (MEAF) level to the navy. The air defence clearance for all air movement is given by the IAF. Very low flying army air assets within a small bubble of air space do not require any clearance but the flight information has to be digitally communicated. Similarly inter-ship naval helicopter flights are managed by the navy. All flights within the ADIZ require IAF air defence clearance. Naval flights beyond the ADIZ are managed by the navy. IAF attack and support aircraft flying in support of the Indian Navy beyond the ADIZ are coordinated by the Indian Navy. Such coordination is very necessary to avoid fratricide. Any hold-fire order passed by the IAF would be for short durations over a small geographical area so that full-scale operations of the army/navy are not hampered. Low-level routing of IAF aircraft through the TBA is normally through points in joint knowledge. The IAF aircrew acting as Forward Air Controllers (FACs) also support ASC at the tactical level. There is interface between the IAF and the army at Corps HQ and Command HQ levels to iron out day-to-day issues and jointly monitor the progress of the battle. Similarly, air elements operate with the Indian Navy. The IAF is in the process of aligning the ASC function through its Integrated Air Command and Control System (IACCS) designed for controlling and monitoring air operations by the air force at the strategic and tactical levels. The ASC organisation also takes in its fold the civil aviation with detailed and institutionalised tie-up between the IAF and the Directorate General of Civil Aviation (DGCA).

CIVIL AIR TRAFFIC

According to aviation analysts, the total number of civil and military aircraft currently in service around the world is approximately 39,000 aircraft; this does not include light aircraft. Some 4,100,000,000 passengers flew in 2017. The International Civil Aviation Organisation (ICAO) says that the "global air transport network" doubles in size at least once every 15 years, and that it is expected to do so again by 2030. Boeing, one of the world's biggest aircraft manufacturers, says that there is a need for 39,620 new planes over the next 20 years, so by 2037, there could be 63,220 aircraft in the world. According to FlightRadar24 – which tracks aircraft around the world – during the peak July/August months there could be 16,000 flights in the air at a given time. The Federal Aviation Authority's (FAA's) Next Generation Air Transport System (NAS) will transform the current air space and shorten air routes. Currently, pilots and controllers mostly communicate using VHF and UHF radios. Controllers and pilots also communicate using data-links to reduce radio congestion. The Global Positioning System (GPS) navigational aids are used for air navigation. The NextGen programme is meant to reduce both flight time and congestion and, in turn, fuel consumption and emissions. There have been many incidents during the Cold War and, more recently, near conflict zones where airliners have been shot by air defence aircraft and missiles. Any air space management has to ensure civil aircraft safety and allow maximum freedom of operations in time and space.

TERRORISTS IN THE AIR

The September 2011 coordinated air attacks over America by terrorists hijacking airliners and making suicide attacks against ground targets brought a new dimension to the air threat. Any aerial platform or weapon falling into terrorist hands could, thus, have implications. An immediate concern is terrorists acquiring weapon-laden Unmanned Aerial Vehicles (UAVs) or commandeering a manned aircraft. Motivated terrorists could train to join civil or military aviation and later indulge in suicide attacks. A terrorist has the advantage of choosing the time and place of attack. While response to the threat would be conventional, better surveillance, policing, and prevention of weapons going into their hand is more important. Air defence procedures have to be tailored to tackle possible rogue aircraft manoeuvres at short notice.

SPACE-BASED MILITARY AND CIVIL APPLICATIONS

Space has been used for positioning satellites using a variety of optical, Infra-Red (IR) and radar-based sensors for surveillance, accurate mapping, communications, data networking, GPS, etc. The dependence on space for ground operations has become phenomenal. For any war between major rivals, it will be important to decapitate such systems to degrade the enemy war effort. The number of satellites is increasing every day. The day is not far when hypersonic airliners will transit through near space. Space tourism is already on the 'horizon.' The line dividing space and atmosphere is thinning and, therefore, the new reality is that space-based systems have a direct bearing on operations on the ground, adding a new dimension to the ASC.

Cyber war doesn't require huge armies with attendant logistics and can be launched by a single operator with a simple computer. All networked civil utilities like water, electricity, banking, trade, transportation, etc. can be ground to a stop through a cyber attack which could have an impact as devastating as a nuclear bomb.

Space weapons can be categorised as those that attack targets in space (anti-satellite); or attack targets on the ground from space; or attack targets transiting through space (anti-ballistic missile). The US and the Soviet Union began developing Anti-Satellite (ASAT) weapons in the early 1960s. They were in the form of directed-energy lasers to decapitate; kamikaze satellites for hard-kill; and possible orbital nuclear weapons. Ground-based Air Defence (AD) weapons have to cater for long range ballistic attacks transiting through space. The Russian ASAT research has reportedly been resumed under President Putin to counter the renewed US strategic defence efforts post US' withdrawal from the Anti-Ballistic Missile (ABM) Treaty. The National Aeronautics and Space Administration (NASA) space plane X-37, now with the US Department of Defence, is akin to a space version of a UAS and its employability is evolving.

Research is on into directed energy weapons, including a nuclear-explosion powered X-ray laser. Many countries like the USA, Russia, China, India and Israel have anti-ballistic missile programmes, with exo-atmospheric interception capability. International space treaties limit or regulate positioning of weapons or conflicts in space. The air defence assets required to defend against a ballistic missile, SSM or a cruise missile may be similar.

NETWORK-CENTRICITY AND CYBER THREAT

All operations today are based on network-centricity. Platforms are electronically talking to one another and sharing critical data. Commanders are taking operational decisions based on Situational Awareness (SA) created by networked sensor inputs. Each Service has its own secure dedicated net.

The DRs also specify certain restricted areas for operation of drones. They cannot be operated within an area of 5 km from an airport or within permanent or temporary prohibited, restricted or danger areas as notified by the Airports Authority of India (AAI) or without prior approval over densely populated areas or over or near an area affecting public safety, or where emergency operations are underway

Also, there are inter-Service networks for sharing common domain information. The entire aerospace management is based on connectivity. A major part of the cyber war will, thus, be to attack the surveillance and control systems of the enemy. Any attack on the military networks can be critical for the outcome of the war. Cyber war doesn't require huge armies with attendant logistics and can be launched by a single operator with a simple computer. All networked civil utilities like water, electricity, banking, trade, transportation, etc. can be ground to a stop through a cyber attack which could have an impact as devastating as a nuclear bomb. Military communication and surveillance networks can be infected or blanked out with disastrous results. Organisational or personal hardware and networks can be targeted. Malicious bugs can be inbuilt into computer systems or in microchips at the manufacturing stage. The time and place of attack can be chosen and, therefore, some also call it 'cyber-terrorism'. For any ground-based air defence network to succeed, it has to defend its various elements from cyber attacks.

UAS CIVIL REGULATION APPROACH

The problem of regulation of the UAS is the biggest challenge in the ASC domain today. India's Directorate General of Civil Aviation (DGCA) announced Draft Regulations (DRs) on the civil use of UAS in the NAS on November 1, 2017. The same will be finalised after comments from the environment. A large part of the document is on the lines as announced by the Federal Aviation Authority (FAA) in the USA. According to the DRs, the UAVs have been classified according to their weight, i.e. nano

(250 gm or less), micro (250 gm-2 kg), mini (2 kg-25 kg), small (25-150 kg) and large (greater than 150 kg). All UAS (referred to as drones in the DRs) are proposed to be operated in visual line of sight during day time only and below 200 ft. All commercial drones, except those in the nano category and those operated by government agencies, have to be registered by the DGCA as per the International Civil Aviation Organisation (ICAO) regulations in the form of a Unique Identification Number (UIN). The mini and higher categories will require an Unmanned Aircraft Operator Permit (UAOP). The DRs mandate that all the remote pilots must undergo requisite training except for those using drones in the nano and micro categories. All micro and higher category drones will have to be equipped with Radio-Frequency Identification/Subscriber Identity Module (RFID/SIM) with a return to home option and anti-collision lights.

The DRs also specify certain restricted areas for operation of drones. They cannot be operated within an area of 5 km from an airport or within permanent or temporary prohibited, restricted or danger areas as notified by the Airports Authority of India (AAI) or without prior approval over densely populated areas or over or near an area affecting public safety, or where emergency operations are underway, or within 50 km of the international borders and beyond 500 m (horizontal) into the sea along the coastline. Also, drones cannot be operated within a certain distance from a mobile platform such as a moving vehicle, ship or aircraft. Military drones will follow guidelines as for manned military aircraft.

MILITARY-CIVIL COORDINATION

Any threat to India will require an integrated approach of all national air assets. The Indian armed forces will requisition airliners and cargo planes for inter-theatre movement. Similarly, civil helicopters will be used for communication and air ambulance duties. Expressways will be used for operations in emergencies. A key element will be civil radars and ATC networks. Networking, liaison and peace-time training will make the process more efficient. Military aircraft would be accorded direct routing priority. There will be height band restrictions on civil traffic during operations.

DUAL-USE AIRFIELDS

A large number of military airfields are being used for civil traffic. Conversely, a few civil airfields are being used for military operations. Dual-use airfields have typical operational peculiarities. Most fighter aircraft require arrester barriers or tail-hook cables. There are peculiar security issues for military airfields. Also, many air bases will have fully armed aircraft on Operational Readiness Platforms (ORPs) for take-off at short notice. Procedures for approach and landing of a battle-damaged aircraft are considerably different. Civil aprons may be used for dispersal of IAF assets. The ASC has to factor in all these peculiarities.

ARTIFICIAL INTELLIGENCE IN AIR SPACE MANAGEMENT

The development of computer systems to be able to perform tasks that normally require human intelligence such as visual perception, speech recognition, decision-making, and translation between languages, i.e. Artificial Intelligence (AI) has great scope for ASC. Intelligent machine systems can interpret complex data, perceive the environment and take appropriate action using learning and problem-solving techniques. AI processes include perception, reasoning, knowledge, planning, learning, statistical analysis, computation and, finally, manipulated output. AI has evolved using expertise in fields like computer sciences, mathematics, psychology and neuroscience, among many others. AI applications already exist in industrial machines, automotive industry, surgery and aviation, among others. Another school of thought is to use the phrase 'extended intelligence' to signify how AI is used to augment human decision-making rather than replace it. The London Air Terminal Control operations are already using AI for air space infringement monitoring. AI will help Go-No-Go decisions. AI will relieve the air traffic controller from the current chronic fatigue. The US Defence Advanced Research Projects Agency (DARPA) has been working with Lockheed Martin's Advanced Technology Laboratories to develop AI technology that keeps air space operating safe despite UAS and other airborne weapons.

CHALLENGES AND WAY AHEAD

Manned aircraft and UAS are going to operate in the same air space and at the same time, and avoiding collision between them will be a major issue and a major challenge. Onboard collision avoidance and advanced traffic display systems will support the effort. The cockpit will be 'information rich' and it will be critical that we ensure the integrity and security of data. The human-computer interface will be crucial. For emerging powers like China and India, the big challenge is to get all the agencies and systems to switch to newer technologies together. The TBA will have very accurate lethal weapons. The air traffic and projectile density in the TBA will continue to increase. Humans' reliance on machine intelligence will only increase in the days ahead. The air space in future will be 'dense and dynamic' and platforms will follow point-to-point navigation.

All sensors are becoming more accurate, allowing a very realistic day and night, all weather, 3-D situational picture to manage the air space more efficiently. AI will support the human controller for quick decision-making. It will give greater freedom of operation to all operators. The 'hold-fire' orders will get minimised in time and space. De-confliction will be automatic and continuous in real-time. Networks will allow the control centres to be secure and placed at long distances from the fog-of-war. Technology will allow civilian pilots and military aircrew greater freedom to choose flight paths and diversions even in real-time. While the NextGen initiatives will be more automatic, they will be flexible enough to accommodate a wide range of users. More and more UAS will have to be controlled or ordered through data-links. Cyber security will have to be ensured. Procedural back-ups will have to remain in place. The technologies are evolving very quickly. It is imperative for any emerging nation to move with the times.

To effect better air space control in the evolving high density environment, greater flight and target information flow through secure networks would be important. The weapon performance and safety information once fed into the system will allow computers to predict the safe bubbles, thereby, improving situational awareness and allowing better decision-making. Also, it will greatly reduce the restrictions imposed on ground-based weapon systems and aircraft. It will be much faster and will greatly reduce target-to-shooter time. It will also reduce the risk of fratricide. All communications with UAS will have to be through the consoles of the operators. Digital flow of information and decision-making, supported by AI, will help the commander and operator for making the best choice between myriad options. The basic structure and level of decision-making is well evolved and time-tested and requires no change.

Till such time that these systems are in place, reliance on the time-tested super-computer – the human brain – will be necessary. Training will be imperative to ensure that those at the sharp end of the stick are able to perform their functions to ensure the highest level of air space control to not only challenge an intruder, but, more importantly, to avoid any blue-on-blue kills.