AIR SPACE MANAGEMENT IN MILITARY AVIATION

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Nations have always depended on one another for their unlimited needs. Since aviation has made it possible to meet our demands as quickly as possible, the significance of international borders is now limited to maps. Aviation is at the very centre of our socioeconomic fabric. Numerous aircraft constantly fly safely from one place to another in order to meet these needs. The global economy is boosted by air travel, which flies both passengers and cargo around the globe. The social and economic sustainability of a region can all be significantly impacted by air travel. Air space is becoming more congested as the number of aircraft grows over time, demanding conducive Air Space Management (ASM) solutions. Therefore, the air space is carefully monitored, and each aircraft is directed to its destination using a networked system of air traffic services and carefully selected air routes.

In order to serve the interests of all users of air space, which is a limited sovereign resource, it must be used efficiently. The two primary users of air space today are the civil and military. The development and use of military aircraft is referred to as 'military aviation,' while all other non-military aviation is referred to as 'civil aviation.' Private, commercial, and government-owned aircraft that primarily transport passengers and cargo are a part of civil aviation. Military aviation refers to state-owned military

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aircraft and other flying machines that are used for conducting or enabling aerial warfare. This includes the transportation of military personnel as well as the nation's airlift (air cargo) capacity to supply forces stationed in a war zone or along international borders with logistical support. Even though military and civil aviation cannot coexist in the same air space, both sectors are crucial to the stability and economies of the world. Therefore, there is need to have cohesive air space, with relevant checks and balances.

CONGESTION OF INDIAN AIR SPACE

The air space over India is experiencing increased congestion as a result of a substantial increase in the volume of military and civilian aircraft in flight. The aviation sector loses billions of dollars each year due to severe weather, which is responsible for more than 70 per cent of air traffic delays; 33 per cent of these losses are the result of lightning alone. In addition to making sure that every flight lands safely, air traffic controllers are constantly working to minimise weather-related delays. The Air Traffic Service (ATS) workforce makes sure that commercial aviation continues to be the safest mode of transportation despite the serious difficulties posed by weather and airport congestion.[1]

Over 100,000 commercial flights take off and land worldwide every day in the modern world. This equates to more than 400 departures per hour. Aviation has truly been at the forefront of innovation, emerging as one of the most dependable and safest modes of transportation today.[2]

The International Civil Aviation Organisation (ICAO) believes that aviation has a promising future and that the air transportation industry is expanding. In 2017, approximately 4.1 billion people travelled on

1. "Air Traffic Control", Smithsonian, https://airandspace.si.edu/explore/stories/air-traffic-control. Accessed on January 29, 2023.
2. "Future of Aviation", ICAO, https://www.icao.int/Meetings/FutureOfAviation/Pages/default.aspx. Accessed on January 29, 2023.

aeroplanes worldwide. In addition, 56 million tonnes of freight were transported by 37 million commercial flights. Every day, planes transport over 10 million people and about US$ 18 billion worth of cargo. This shows the substantial economic impact aviation has had on the world economy, which is further supported by the fact that aviation contributes 3.5 per cent of the global Gross Domestic Product (GDP) (US$ 2.7 trillion) and has created 65 million jobs globally.[3]

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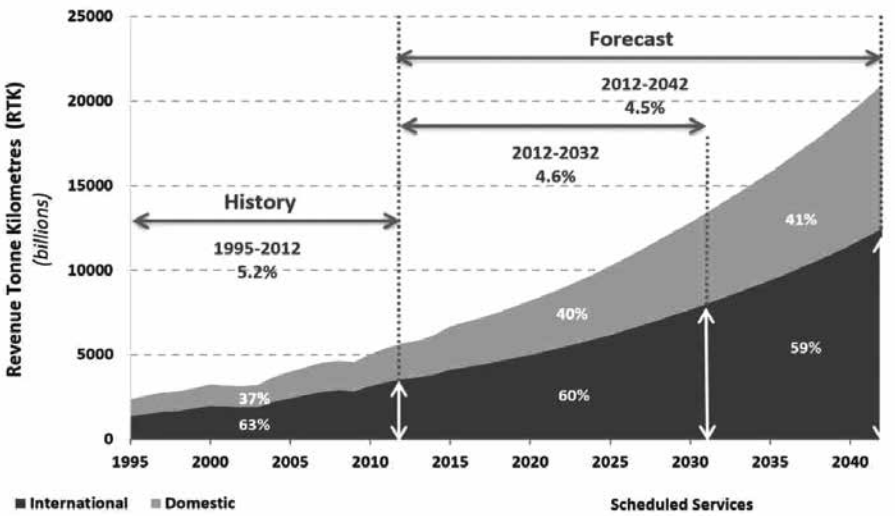
The aviation industry is expanding quickly and will continue to do so in the future. The demand for air travel is expected to increase by an average of 4.6 per cent annually over the next 20 years, according to the most recent ICAO projections (Fig 1).[4]

Fig 1: Air Travel Demand Projection



Source: "Future of Aviation", www.icao.in

3. Ibid.
4. Ibid.

Aircraft Movement in India

The Indian aviation sector is also growing rapidly. With the increase in air passenger traffic, as projected by the Airports Authority of India (AAI), the Indian aviation industry is on a high growth path (Table 1).[5]

Table 1: The Indian Aviation Industry Growth Path (Aircraft Movement)

Year	Intl (x1000)	Dom (x1000)	Total (x1000)
2018-19 (BASE YEAR)	313.91	1,164.9	1,478.81
Growth Rate	**6.00 per cent**	**8.00 per cent**	**7.60 per cent**
2018-19	424.67	1,530.66	1,955.34
2019-20	450.15	1,653.11	2,103.27
2020-21	477.16	1,785.36	2,262.53
2021-22	505.79	1,928.19	2,433.99
2022-23	536.14	2,082.45	2,618.59
2023-24*	568.31	2,215.41	2,783.72

Source: "Aircraft Policy", www.aai.aero/en/content/airport-policy
Note: * Interpolated data

International: AAI has predicted that international aircraft movement would increase at a 6 per cent annual growth rate for the block of five years (i.e., 2018-19 to 2022-23). For the year 2023-24, it is likely to be around 568.31 thousand flights.

Domestic: The total number of domestic aircraft movement at all Indian airports was expected to increase at a rate of 8 per cent in a 5-year period (up to 2022-23). For the year 2023-24, it is likely to be around 2,215.41 thousand flights.

Total aircraft movement, including both domestic and international flights, was expected to be 2,783.72, respectively.

According to annual seat capacity, India is the ninth-largest aviation market in the world. The Centre for Aviation's (CAPA's) projections show

5. "Airport Policy", AAI, January 6, 2023, https://www.aai.aero/en/content/airport-policy. Accessed on January 6, 2023.

that it will overtake China as the third-largest market by 2025. Today, nine domestic airlines with a combined fleet of about 400 aircraft operate scheduled services to about 80 Indian airports. Greater growth is made possible by improvements in Air Traffic Management (ATM) practices and technology.[6]

To satisfy the current and projected rise in demand for commercial air travel, the Indian civil aviation sector is proactively required to gear up in terms of resources and wherewithal.

THE UNIQUENESS OF MILITARY AVIATION

Military pilots must be prepared for all types of combat situations. Basic flying skills are a part of air operations in extremely stressful circumstances. Military aviation equips the pilots with skills and teaches them to deal with pressure, difficulty and challenges so that they can encounter a storm of any intensity. It also teaches them not to take short cuts in operations; to replace words with actions.[7] This facilitates the full freedom of operations in the allotted air space.

Therefore, the goal of air space control for military aviation is to enhance the effectiveness of combat operations while minimising the negative effects on the capabilities of any component and removing unnecessary constraints. For effective and smooth air space control, both air traffic control and local air defence forces work closely together to strike a balance between the vulnerabilities and the responsibilities of an efficient air space management system. Maximum flexibility and reactivity are offered by carefully thought-out engagement techniques.

By encouraging safe, effective, and flexible use of air space with the least amount of restriction placed on friendly air space users, air space management in theatres where military operations are taking place increases to combat effectiveness. Coordination, integration, and regulation of air space are

6. "India Air Traffic Management, Unique CAPA Report: The ATM System and AAI's Plans for Integration", CAPA, May 25, 2015, https://centreforaviation.com/about/press-releases/india-air-traffic-management-unique-capa-report-the-atm-system-and-aais-plans-for-integration-217602. Accessed on January 30, 2023.
7. Indian Air Force, "Explore Career", 2022, https://afcat.cdac.in/AFCAT/index.html. Accessed on January 30, 2023.

all parts of air space management, which increases war-fighter efficiency on all fronts. Joint air space control measures should be covered prior to talking about who controls the air space for Unmanned Aerial Vehicle (UAV) operations.[8]

Military flying training involves two-aircraft combat to long corridors or air walls of intense packages of 12 to 28 aircraft, depending on the objectives of the training. Large air space is needed for these combat training missions. There shouldn't be any other plane in the area where the exercise is taking place. Any flying object present poses a risk to flight safety. Additionally, it can put people and flying objects in danger (aircraft). Because of this, military air operations are special and should be carried out without interruption.

There is an increase in air activity and traffic density when there is a war. Both friendly and hostile aircraft manoeuvre in unconventional ways. The time and space fluctuations are dynamic, and both the horizontal and vertical air spaces are fully covered. Most take-offs happen quickly in response to shifting tactical conditions. There are many Unmanned Air Systems (UAS). The air space is also used by a variety of missiles as well as high-velocity, long- and medium-range artillery projectiles. Some ground-based air defence weapons are in operation from the forward edge of the battle area, while others are on high alert. Civil aviation operations must be permitted to continue, even with minor restrictions and controls in terms of time and space.

The concept of considering the air space as a vast spectrum in which all users' requirements are accommodated to the maximum possible extent is the need of the hour. In India, civil and military air space users have benefited from the civil-military cooperation's effectiveness at all three levels of air space management—strategic, pre-tactical, and tactical.

8. "Airspace Management", Chapter-3, FM 34-25-2, https://fas.org/irp/doddir/army/fm34-25-2/25-2ch3.pdf. Accessed on January 29, 2023.

BASIC ARCHITECTURE

The Chicago Convention established the ICAO in 1944. The organisation sets the standards and guidelines required for aviation security, efficiency, regularity, safety, and environmental protection. In addition, the ICAO initiates measures to help its member states improve their air transportation infrastructure, fostering aviation's contributions to sustainable development as envisioned by the 2030 Agenda for Sustainable Development. Currently, 193 contracting states are signatories to this convention.

A statutory organisation of the Indian government, the Directorate General of Civil Aviation (DGCA), is responsible for overseeing civil or non-military aviation in India. The DGCA works with the ICAO to coordinate all regulatory activities. Air traffic in a nation is controlled by its Air Navigation Service Provider (ANSP). The Indian Civil Aviation ANSP is the Airports Authority of India.[9]

India will require 2,210 new aircraft over the next 20 years. The fleet could consist of 1,770 additional light aircraft in addition to 440 medium and large aircraft. By 2040, passenger traffic in India will grow at a rate of 6.2 per cent annually, the highest among the major countries and significantly higher than the global average of 3.9 per cent due to the country's growing population. India would require 34,000 more pilots and 45,000 more technicians by the year 2040.[10]

India only has about 1/10th the wide-body fleet deployed in comparable international markets, depriving domestic carriers of a larger share of the lucrative long-haul routes currently controlled by foreign airlines.

According to a company statement, Airbus will ship more than one aircraft to India each week for the following ten years. According to an Airbus forecast, India will require an additional 34,000 pilots and 45,000

9. "Policy on Upgradation of CNS/ATM Infrastructure at Airports", AAI, May 2022, https://aim-india.aai.aero/sites/default/files/ais_docs/Airport%20infrastructure.pdf. Accessed on January 30, 2023.
10. "India Will Need 2,210 New Aircraft in Next Two Decades: Airbus", *The Hindu*, March 24, 2022, https://www.thehindu.com/business/Industry/india-will-need-2210-new-aircraft-in-next-two-decades-airbus/article65256687.ece. Accessed on January 30, 2023.

UAVs can now perform a variety of complex tasks, including surveillance, surveying, spraying, mapping, inspections, and deliveries, especially in low level air spaces.

technicians by 2040 to meet the needs of the nation's growing aviation industry.[11]

CHALLENGES FROM UNMANNED AERIAL VEHICLES OPERATIONS

Over the past ten years, the unmanned aircraft sector has had an impact on the aviation sector by introducing technological advancements at an unprecedented rate. UAVs can now perform a variety of complex tasks, including surveillance, surveying, spraying, mapping, inspections, and deliveries, especially in low level air spaces, etc. Such usages have enabled stakeholders and businesses from a variety of industries, including agriculture, construction, disaster management, healthcare, security, telecommunications, etc., to increase their productivity and provide improved services. As a result, it is normal for the density of UAVs in the atmosphere to rise over time.

ICAO has ruled that no aircraft capable of flying without a pilot shall be flown over the territory of a contracting state without special authorisation by that state and in accordance with the terms of such authorisation, according to Article 8 of the Convention on International Civil Aviation, signed at Chicago on December 7, 1944, and amended by the ICAO Assembly (Doc 7300). Under the same guidelines, a UAV is an aircraft that is flown without a pilot-in-command on board and is either remotely and fully controlled from another place (the ground, another aircraft, or space), or programmed, according to the Global Air Traffic Management Operational Concept (Doc 9854). Based on these guidelines, regulations are to be structured.

Additionally, it is obvious that unmanned aircraft will need to start flying alongside manned aircraft as UAS usage rises and the world starts

11. Mihir Mishra. "India to Replicate Domestic Success of Past 20 Years in International Now: Airbus", *The Economic Times*, March 24, 2022, https://economictimes.indiatimes.com/industry/transportation/airlines-/-aviation/india-to-replicate-domestic-success-of-past-20-years-in-international-now-airbus/articleshow/90417679.cms. Accessed on January 29, 2023.

to think about advanced sectors like unmanned aerial mobility. Serious threats to individual safety, social order, and national security have emerged as a result of the rise in unmanned aircraft activity in Very Low Level (VLL) air space. The main factor in actively integrating manned and unmanned aircraft in the national air space would be maintaining acceptable levels of aviation safety in such situations.

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The integration of UAS into the national air space system is complicated, with numerous technical and practical difficulties. It might be necessary to equip UAS with extra hardware on board and even qualify them to the much higher manned aviation standards in order to integrate UAS operations with the current ATM systems. Additionally, ATM systems might not be able to handle millions of UAV flights as the density of UAVs in the air space increases due to different UAVs demonstrating their effectiveness in various consumer, commercial, and security scenarios. This case illustrates the necessity of creating an additional system to the existing ATM systems for the management of unmanned traffic and its subsequent integration with ATM systems.

In order to improve the current ATM systems, the UAS Traffic Management (UTM) ecosystem is, therefore, considered to be a crucial requirement. As an interface between the UAS, remote pilots, regulatory systems, and ATM systems, it will play a significant role in managing the traffic of UAVs across the designated UTM (in some cases, ATM) air spaces and offering various services to remote pilots. This would enable many UAV operations because software-based UTM systems automate the majority of UTM functions.

UTM is yet another facet of the growth of the drone industry in China. In this area, there are projects that concentrate on real-time coordination of drone operations over different cities. One example of this is 'Drone Cloud,' which is mentioned in a report published by the Civil Aviation Administration of China (CAAC). Along with the government, businesses like Unify and Huawei are

collaborating on UTM systems, drone identification, and tracking. This serves as the foundation for the growth of the commercial drone industry.[12]

Basically, all users of the air space are prevented from interfering with one another by air space management, which also makes it easier to identify air defences and allows all air traffic to move safely. UAV missions are immediate and pre-planned. UAVs frequently operate from tactical field locations where it is difficult to maintain constant or immediate communication with the air space agencies in the theatre.[13]

Regulators are understandably concerned about drones flying over people, operating remotely, and doing so at night or in bad weather. In addition, the threat of randomly timed flights interfering with other aircraft is a crucial element. For this reason, especially for autonomous drone flights, regulators typically approve drone flights in any of the circumstances on a case-by-case basis.

ASM CHALLENGES IN MILITARY AVIATION

In the field of military aviation, a high level of operational autonomy is essential. This is necessary to address operational demands and maintain a conducive environment for training activities. A greater proportion of the world's population can now access aviation. In the entire world, 51 per cent of people reside within 100 km of an international airport, and 74 per cent do so within that distance of any airport. As a result, air space is already becoming crowded, and over the next 20 years, air traffic is expected to double. Therefore, we must consider air space management. Airports have been constructed in the areas surrounding major cities and are already operating at full capacity. Realistically, airports and air traffic control will need to be drastically improved and made more efficient in order to accommodate the predicted growth. Innovation is necessary for this.[14]

12. Bojan Kitanovic, "Drone Industry In China: A Pioneer In The World Of Drones", *The Drones World*, May 8, 2021, https://thedronesworld.net/drone-industry-in-china/. Accessed on November 29, 2022.
13. n. 8.
14. n. 2.

The significant air space challenge will be a combination of manned-unmanned operations, including UAS swarms. The structural and flow characteristics of the air space affect how complex it is. The physical and spatial attributes of the sector, such as the terrain, the number of airways, the number of airway crossings, and the navigational aids, determine the structural characteristics, which are constant for a sector/centre. The flow characteristics change over time and depend on elements such as the numbers of aircraft, the types of aircraft, the weather, the distance between aircraft, the closing rates, the speeds of the aircraft, and flow restrictions. The controller workload is influenced by a combination of these structural and flow parameters.[15]

Air traffic control and management systems will be put under more strain due to the anticipated increase in air traffic and the desire for more user-preferred routes to enhance cost-effectiveness. Alternate air space arrangements, altered traffic patterns, and staff reassignment may all be used to meet this demand. Therefore, understanding the impact of changing traffic patterns and air space configurations on the workload of air traffic control centres is necessary.

ICAO'S PROCEDURAL APPROACH TO ASM

The air space is divided into Air Traffic Control Centres in order to carry out the ATC and Traffic Flow Management tasks. Low-altitude, medium-altitude, and high-altitude strata make up the centre air space. The horizontal sectors and/or sub-sectors of each vertical layer are further divided into multiple horizontal layers. These sectors serve as the ATM system's fundamental control points.

By separating it into controlled and uncontrolled air spaces, ICAO has established the classification of air space. Class A, Class B, Class C, Class D, and Class E are the controlled air spaces, while Class F and Class G air spaces are the uncontrolled air spaces. The categories and types of air

15. Banavar Sridhar, Kapil S. Sheth and Shon Grabbe, "Airspace Complexity and its Application in Air Traffic Management", 2nd USA/Europe Air Traffic Management R&D Seminar, December 3, 1998, http://web.mit.edu/16.459/www/sridhar.pdf. Accessed on January 27, 2023.

space are influenced by factors such as the complexity or density of aircraft movements, the nature of the operations carried out in the air space, the level of safety required, and the interests of the country and the general public.[16]

Air space is divided into two categories and sub-categories:

- Regulated air space:
  - Controlled air space
  - Uncontrolled air space
  - Special use air space:
    - Prohibited areas
    - Restricted areas
    - Warning areas
    - Controlled firing areas
- Unregulated air space

In view of the various categories, the management of air space gets streamlined and better coordinated when more operators are involved. It also differentiates among the various types of operators according to the degrees of freedom over which they have control.

RECOMMENDATIONS

Air space is no longer solely classified as civil or military but rather is viewed as a continuum and is distributed in accordance with user needs. The world's aviation system requires fundamental change and is about to undergo it. To make such a change possible, a comprehensive analysis of the demands of a developing and changing air transport sector is required. In order to advance the development of a global consensus on the future of air traffic and aerospace management, it is crucial that all the stakeholders contribute to effective and constructive solutions to the ASM problems during the crucial ongoing period of development.

16. "Chapter 15: Airspace—Federal Aviation Administration", AIP, 2022, https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/17_phak_ch15.pdf. Accessed on January 30, 2023.

Domestic operations have significantly increased as a result of the country's liberalisation of air transport operations. There will likely be a multifold increase in the number of civil and military flying objects using the Indian air space. The flying density of unmanned flying objects will also increase. The interaction between manned and unmanned aircraft must be managed with the utmost consideration for international safety standards. ATM systems in India will be essential in achieving this.

A formal and systematic methodology for the Flexible Use of Air space (FUA) must be established for users to reap the tangible benefits of being able to plan and carry out flights when special user air space(s) are conditionally available if we are to make the best use possible of the limited amount of air space that is available. The system is unquestionably more effective as a result of the FUA implementation.[17]

The available air space may be shared, ensuring optimal use by military and civil aviation operators. Jointly both must decide the use of air space based on mutually agreed principles. Defending the sovereignty of the country, the economy of efforts and the cost-effectiveness of resources will have priority consideration during the formulation of Standard Operating Procedures (SOPs). Military aviation is asked to safeguard the 'Indian Air Space', which includes air space used by both military and civil operators.

UTM systems are intended to make operations in the UTM air space safe and complex. The following objectives will help with:[18]

- Enabling seamless communication between identified stakeholders.
- Assisting in the discrimination of unmanned aircraft from manned and unmanned competitors.
- Providing the concerned stakeholders with situational awareness of the Very Low Level (VLL) air space.

17. "Implementation of Flexible Use Airspace in India", ICAO, July 8, 2016, https://www.icao.int/APAC/Documents/edocs/icd_aidc_ver3.pdf. Accessed on January 19, 2023.
18. "National Unmanned Aircraft System Traffic Management (UTM) Policy Framework", October 24, 2021, https://www.civilaviation.gov.in/sites/default/files/National-UTM-Policy-Framework-2021_24_Oct_2021.pdf. Accessed on January 18, 2023.

The aim of air space control operations is to guarantee the safest, most effective, most efficient use of the air space to support the accomplishment of defence priorities and objectives.

Over high-speed digital data links, intelligent on-board systems will transmit processed data to air traffic and fighter controllers. Pilots and controllers will have much better situational awareness thanks to on-board collision avoidance and cutting-edge traffic display systems. Integrity and security of data will be necessary for the 'information-rich' environment.[19]

THE IMPETUS TO FLEXIBLE EXPLOITATION OF THE AIR SPACE

Defending a nation's goals is how military forces direct their operations. By promoting the safe, effective, and flexible use of air space, air space control is defined as 'capabilities and procedures used to increase operational effectiveness.' The aim of air space control operations is to guarantee the safest, most effective, most efficient use of the air space to support the accomplishment of defence priorities and objectives.[20]

Coordination among many users and air traffic facilities may be necessary for safe operations in the air space control area. On a regular basis, efforts are made at execution levels by both, the military and civil ATS agencies, to accommodate each other's operational requirements. The scheduled civil air traffic is handled at 14 of the 59 IAF airfields, which are in dual use.[21]

A large number of international and national flights overfly or transit through India, which has caused congestion in the Indian air space. In order to establish an integrated command and communication ecosystem among

19. "Managing a Congested Airspace over the Future Battle Area", *Indian Defence Review* (IDR), January 9, 2022, http://www.indiandefencereview.com/news/managing-a-congested-airspace-over-the-future-battle-area/. Accessed on January 18, 2023.
20. "Airspace Control", Air Force Doctrine Publication 3-52, December 31, 2021, https://www.doctrine.af.mil/Portals/61/documents/AFDP_3-52/3-52-AFDP-AIRSPACE-CONTROL.pdf. Accessed on January 18, 2023.
21. Air Marshal BK Pandey, "Military Aviation and National Growth", IDR, vol 20.2 April-June 2005, October 4, 2012, http://www.indiandefencereview.com/spotlights/military-aviation-and-national-growth/2/. Accessed on January 18, 2023.

the ATM system, stakeholders, and regulators, it is critical to consider the introduction of cutting-edge technology for effective and uninterrupted connectivity. To ensure that both military and commercial aviation operators are making the best use of the available air space, it may be shared. The use of air space must be jointly decided upon using mutually accepted principles. Defending the nation's sovereignty, saving time and money, and making the best use of available resources will unquestionably be given top priority when developing SOPs. The Indian air space, which includes air space used by military and civil operators, is to be protected by military aviation.

Rerouting is a common method used by flight operators who are not users of activated air spaces to avoid them, but doing so typically adds extra miles and has an adverse impact on the environment.

In view of the exponentially increasing air congestion, instead of always being purely civil or exclusively military, the FUA introduced the concept of activating civil and military air spaces for a predetermined time. Rerouting is a common method used by flight operators who are not users of activated air spaces to avoid them, but doing so typically adds extra miles and has an adverse impact on the environment. Thus, the issue of congestion needs to be addressed with a well-defined method.

GUIDING PRINCIPLES

Having established an appropriate approach for a safe and smooth ATM sharing the air space on merit, the following guiding principles and techniques ought to be used in the management of air space.

- Flexibility should be used to manage all available air space.
- The processes used to manage air space should consider changing flight paths and offer the best possible operational options.
- Regulations for that air space's dimensions, configuration, and timing should be so chosen as to have the least possible negative effects on operations when conditions call for different types of traffic to be segregated by the air space organisation.

- Air space use should be coordinated and monitored to meet the varying needs of all users and to minimise any operational restrictions.
- When possible, changes to air space reservations should be made dynamically rather than at the last minute. The system must also be able to accommodate last-minute, unforeseen needs.
- The degree of flexibility may be constrained by the complexity of operations.

Considering the above factors, the following measures merit consideration by civil and military regulatory bodies.

- **Review of the Earmarking of Air Space Dedicated for Military, Civil and Joint Operations:** Maximum freedom of operations is necessary for both military and civil air operations. Should there be an operational requirement, one operator must consider the operational necessity of another operator. For agencies responsible for ASM, in view of strategic or tactical requirements, a review of earmarking of the air space merits consideration.
- **The primary difficulty for the ASM will be balancing manned and unmanned operations**, perhaps with swarms of UAS. The same needs to be addressed and reviewed regularly.
- **Cyber Security:** The 'information-rich' setting necessitates safeguarding and protecting sensitive information. Technologies are evolving very quickly; it is imperative for ASM teams to prepare for upgrades and their professional adoption in day-to day operations.
- **Mandatory Requirements of Secondary Sensors:** For ATM and other drone regulation organisations to be able to recognise and track drones, they need to be fitted with an Air Traffic Control (ATC) responder, Automatic Dependent Surveillance-Broadcast (ADS-B), or other airborne equipment.
- **Use of Anti-collision Systems:** The AAI, like the Federal Aviation Administration (FAA), continuously updates and modernises the Indian air traffic services and related facilities to guarantee the safety of aircraft operations in the Indian air space. Therefore, it is also thought necessary to update the airborne equipment of civil and military aeroplanes and UAVs

to lower the risk of mid-air collisions between aircraft. Mid-air collisions can be avoided by installing the Airborne Collision Avoidance System (ACAS), an airborne device that operates independently of the ground-based air traffic control system. However, the type of transponder the intruder aircraft is carrying determines the degree of protection offered by the ACAS equipment.

- **Highly Efficient and Credible Communication Network:** Information needs to be shared more quickly, with accurate dissemination of vital information. Good situational awareness is the first necessity of flight safety, and communication is a lifeline for the same.
- **Advanced Air Traffic Command and Control:** All relevant information must be made available to control teams at the nerve centre of the ATM. The introduction of progressively more automated and integrated human-machine interfaces and interactions on board civil and military aircraft has been made possible by technological advancements in avionics systems and components. For both manned aircraft (fixed and rotary wing) and UAS specificities, the four most fundamental flight tasks, viz. fly, navigate, communicate, and manage, are thoroughly covered. A greater emphasis is placed on safety-critical displays, command, and control capabilities, as well as related technological advancements due to the numerous specific mission requirements. The need is to integrate the operational requirements and state-of-the-art technology. The associated displays of current systems are not very adaptable, even though they can combine and integrate data from various sources to perform a variety of different functions. Further research to increase the adaptability of the human-machine interface could significantly increase the effectiveness of the human operator, resulting in operations that are safer and more efficient.
- **Simplification of Performance-Based Navigation (PBN):** The objective of PBN is to establish a navigation infrastructure that aligns with both regional and global operational requirements, in order to facilitate the efficient functioning of the Communication, Navigation and Surveillance (CNS)/ATM system. PBN will improve overall safety, particularly on

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approach through a reduction of controlled flight into terrain.[22]

- **Strict Adherence to the Air Rules to be Ensured:** The lives of passengers and aircraft are of paramount importance. To ensure that there is no risk of any nature, strict air management regulations must be formulated and implemented. Strict compliance with air traffic regulations is to be ensured by punishing defaulters.

CONCLUSION

Regardless of the location, aviation creates special opportunities for empowering nations and people. It provides a way for people to get what they require, such as better access to food, healthcare, education, safe neighbourhoods, and other necessities. Aviation is well-known for being a tipping point for technological advancement and innovation on a global scale. The aviation industry is at a turning point in its history, with 4.3 billion passengers expected today and nearly 6 billion in 2030. It must, therefore, overcome a formidable obstacle: to satisfy users' increasing demand while minimising its environmental impact.[23] Therefore, keeping abreast of the latest technological advancements is essential.

Visual Flight Rules (VFR) has been adequate since the advent of air traffic control in 1920 to permit safe operations. At that time, the pilot was in charge of keeping clear of other aircraft, obstacles, and meteorology. The Instrument Flight Rules (IFR) allowed pilots to fly in a safe manner as air traffic increased and technology advanced. As a result, all responsibility

22. "Performance Based Navigation (PBN) Implementation Road Map", AAI, September 1, 2008, https://www.icao.int/safety/pbn/PBNStatePlans/India%20PBN%20implementation%20plan.pdf. Accessed on January 30, 2023.
23. "How Will Air Traffic Management Change in the Future?", Coflight, November 2022, https://coflight-cloud-services.com/future-airtraffic/.

for preventing collisions shifted to ATC as surveillance and communications capabilities improved. However, the aviation community will need to revisit systems and assumptions in order to ensure that air space remains safe and effective and provides equitable access as a result of the use of high levels of automation and the resulting redistribution of some functions among operator, pilot, and ATC.

Military aviation spending is typically seen to protect freedom and sovereignty from external aggression. Without a stable and peaceful environment, no type of growth, whether economic or otherwise, can be sustained.

Upgradation of ATS technical resources is of paramount necessity to ensure aviation can contribute towards the enhancement of the healthy living of mankind. Along with the social structure, economic activity, and industrial paradigms, military aviation is completely integrated with all these elements as well. It offers the country the tactical foundations necessary for long-term economic expansion. Military aviation spending is a crucial component of overall defence spending. The level of defence spending in India is low and typically falls below 3 per cent of the GDP.[24] Military aviation spending is typically seen to protect freedom and sovereignty from external aggression. Without a stable and peaceful environment, no type of growth, whether economic or otherwise, can be sustained.

24. http://www.indiandefencereview.com/spotlights/military-aviation-and-national-growth/2/. Accessed on January 29, 2023.