Chapter Five

Application of Space Technology in Civil Aviation: Emerging Legal Issues
I. Introduction

The aviation industry has always been dynamic, assimilating rapidly expanding technologies and opportunities in man's voyage into space and planets. The developments in aviation technology have brought about improvements in communications, navigation, surveillance, air traffic control, and airspace management. Technology also played a visible role in the efficiency of fuel management and in monitoring the passenger and cargo booking of air transport. These technological changes helped practically every aspect of civil aviation achieve high efficiency, integrity, safety and security over the past few decades. However, in recent years with the liberalization of the economies, trade and aviation, coupled with problems in the existing technologies and facilities, the aviation industry has been unable to provide efficient services to the increasing number of travelling public. Hence, the ICAO in the 1980s initiated a process to employ satellite communication technologies to improve international air navigation.

Civil aviation has borrowed heavily from space technology in developing its Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) system for the Future Air Navigation System (FANS). This marks the beginning of a new era in the history of aviation, and a challenge to global society in the 21st century. The FANS constitute a sound vision in the growth of aviation and air safety. This new technology will greatly enhance capacity -
particularly in oceanic airspace - and reduce airspace and airport congestion.

The application of satellite technology in civil aviation is not a new concept, but assumes special significance in the face of the aerospace industry's rapid expansion in the changing global aviation scenario. The role of global organizations such as the Inmarsat, the Intelsat, the ITU and the WMO in the application of satellite technologies to develop air navigation is significant. The present technology is unable to cope with the growing demands of air traffic. Recognising the increasing limitations of the current system and the need for its improvements, the ICAO formed a FANS committee in 1983. The exploitation of satellite technology, according to the committee, is the only viable solution to overcome the shortcomings of the present terrestrial system on a global basis in the foreseeable future.¹

The establishment of the FANS committee apart, the future communications, navigation, surveillance and air traffic management (CNS/ATM) concepts are milestones in civil aviation. The future CNS/ATM system will provide much closer interaction between ground stations and airspace users before and during flight. The future air traffic management improvements will promote more flexible and efficient use of airspace, improve air traffic control practices and facilities with the help of enhanced data exchange and enhance air safety.

The legal basis of the CNS/ATM system involves the rights and obligations of states currently engaged in civil aviation, universal

accessibility of this system; the ICAO's responsibility for Standards and Recommended Practices (SARPs); legal regimes of air and space, tele-communications laws; liability claims; and institutional framework. Rapid advances in science and technology have opened up new vistas in air travel for mankind. Yet there is a serious danger of a few nations monopolizing the technologies, resulting in vast inequalities among the majority of nations.

II. Application Of Satellite Technology In Civil Aviation

(A) Historical Evolution of Satellite Technology in Civil Aviation

Civil aviation needs a system allowing aircraft to navigate and land accurately and safely, communication networks to help position information communicated to the ground and link air traffic control [ATC] units, and an accurate meteorological and ATC framework to integrate the whole.² The international telecommunication services seek to ensure telecommunication and radio aids to air navigation.³ The special radio technical (COT) division of the Provisional International Civil Aviation Organization (PICAO) had launched an ambitious proposal, aiming to use satellite technology.⁴ The proposal, accepted and enthusiastically implemented by the states, has served the civil


aviation industry well in the intervening years.5

To ensure standardization in ATC, navigation and communications, the ICAO has developed the norms which are incorporated as annexes in its convention. At the dawn of space age in 1957, the ICAO Council, in its 1958 report, drew attention to the potential use of satellites to provide worldwide communication transmissions for civil aviation.6 In early 1960s, the National Aeronautics and Space Administration (NASA) and Pan American Airlines conducted experiments to demonstrate the feasibility of satellite communications for aircraft. Successful tests of aeronautical mobile communications were carried out utilizing VHF frequencies via geostationary satellites early in 1964, and numerous attempts have since been made to develop a practical system for aeronautical mobile communications. It has proved a daunting task.7

In 1966, the ICAO's communications/operational division meeting examined the possible application of space technology to civil aviation. Attention was given to aeronautical mobile communication problems, especially over oceans and sparsely populated land masses, and this subject was identified with great potential.8 In 1967, an


8 See ICAO Doc. 8646, Recommendation 1914 - Establishment of System Parameters, Com/OPS Divisional Meeting, Montreal, 4 October- 7 November 1966.
American satellite, ATS-1, demonstrated the feasibility of a future network of operational satellites for civil aviation. In 1968, the ICAO formed an expert panel to consider and make recommendations for the application of space technology relating to aviation [ASRAT]. Its mission was to develop a framework of technical characteristics for an aeronautical satellite system. The panel produced a paper -- *Functional Aeronautical Application of Space Techniques* -- which was presented to the ICAO's seventh air navigation conference in 1971. The meeting, for the first time, discussed the question whether international civil aviation should have an exclusively dedicated satellite system - or it should share the system, with other users.

The work of the panel was reviewed in 1972 by the seventh ICAO air navigation conference, which recommended an international programme for research into and development of an aeronautical satellite. Pursuant to this recommendation, Canada, the United States, and the then European Space Research Organization (now the European Space Agency), representing ten European states, signed an MoU to create the AEROSAT Council. The purpose of AEROSAT was to lead the planning and realization of an experimental aeronautical satellite system for providing mobile communications, and position determination services. Established in 1974, the project was hit by the

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10Application of Space Techniques Relating to Aviation (ASTRA) panel third meeting, Paris, 23 February- 6 March 1970. See ICAO Doc. 8873 ASTRA/III.


12Ibid.
1975 oil crisis and the subsequent recession in the air transport industry and collapsed in 1977.\textsuperscript{13}

The first organized attempt by the international civil aviation community to apply satellite technology thus did not succeed, yet it vividly exposed the shortcomings in the existing air transport communications. First, it led to the suspension of the UHF (L band) frequency allocation for aeronautical mobile satellite services. Second, it focused on the fact that while the VHF/HF aeromobile service was considered adequate, the strains of its overuse were showing up and the HF aeronautical mobile procedures were becoming more and more unsatisfactory. Finally, it served as a reminder that some innovative means of meeting the demand would have to be found.\textsuperscript{14}

During the 1970s, many states recognized the synergy that could be created by co-operation between Inmarsat and the aeronautical community. In the early 1970s, the ICAO called for efforts "to identify common or closely related requirements of the two services (maritime and aeronautical) which could be satisfied by the application of common techniques on the most economical basis".\textsuperscript{15} In 1977, the ICAO Assembly adopted Resolution A 22-20 on the applicability of space technology to civil aviation.\textsuperscript{16} Even then experiments were conducted

\textsuperscript{13}See Matte, n. 3, p. 197. Also see Jean-Louis Magdebnor, INMARSAT and Satellites for Air Navigation Services", \textit{Air Law}, vol. XII, 1987, p. 276.


internationally, using satellite communications (SATCOM) for civil aviation. The Boeing 747 aircraft entered airline service with provision for an aeronautical earth station (AES) satellite antenna behind its upper deck. However, despite the fully developed satellite and ground station technology, two factors delayed large-scale SATCOM use by the civil aviation community: the costs and complexity of the airborne terminal, and the lack of a suitable satellite for aeronautical use.\(^{17}\)

In the 1980s, an Aviation Review Committee (ARC) was set up by the AEROSAT Council, which urged an authoritative endorsement of satellite technology as a viable option. Its report was submitted first to the ICAO Air Navigation Commission and then to the Council.\(^{18}\) The report also mentioned the possibility of using Inmarsat satellite as a cost-efficient short-term solution. The second United Nations conference on the exploration and peaceful uses of outer space in 1982 thus stated: "ICAO is responsible for developing the position of international civil aviation on all matters related to the study of the questions involving the use of space technology for air navigation purposes including the determination of international civil aviation's particular requirements in respect of space technology."\(^{19}\) In December 1982, the ICAO secretariat invited ICAO technical specifications for any future aeronautical satellite system. Responding to the recommendation of the ARC, the ICAO established a special committee on future air

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navigation systems (FANS), which held its first meeting in 1983.20

(B) ICAO and Annex 10 - Aeronautical Telecommunications

In recent years, communications have come to play an important role in air navigation and airline operations. The air transport industry's need to meet greater levels of operational efficiency and service requires greater reliance on Communications. Further, it necessitates an overhaul of the present aeronautical communications infrastructure. If correctly implemented and utilized, the latest communications revolution would allow the aviation industry to achieve greatest benefits in the form of increasing efficiency and better services.

The Chicago Convention 1944 recognizes the provision of air navigation facilities as a significant part of the governmental functions. Article 28 of the Convention mandates each contracting state to undertake, so far as it may find practicable, to -

(a) provide - in its territory - airports, radio services, meteorological services, and other air navigation facilities to facilitate international air navigation in accordance with standards, practices recommended or established from time to time pursuant to this convention;

(b) adopt and put into operation the appropriate standards, systems of communications procedure, codes, markings, signals, lighting and other operational practices, and rules from time to time; and

(c) collaborate in international measures to secure the publication of aeronautical maps and charts in accordance with standards, which may be recommended or established from time to time.

Under Article 37, the ICAO is empowered to adopt international standards, and recommended practices and procedures dealing with communication systems and air navigation aids, including ground marking. Pursuant to this, the ICAO adopted in 1949 Annex 10 dealing with aeronautical telecommunications, including navigation and surveillance.\(^{21}\) The object of the international aeronautical telecommunication services is to ensure telecommunications and radio aids for safe navigation.

The ICAO's Annex 10 covers three most complex and essential elements yet of international civil aviation i.e. aeronautical telecommunications, navigation and surveillance. Two general categories of communications which serve civil aviation are: (a) the aeronautical fixed service (AFS) between points on the ground, and (b) the aeronautical mobile service (AMS) between aircraft in flight and points on the ground.\(^{22}\) The AMS provides the aircraft in flight with all necessary information to conduct flights in safety, using both voice and digital data. The important element of the AFS is the aeronautical fixed telecommunications network (AFTN) -- a worldwide network organised to meet the specific requirements of civil aviation.\(^{23}\) All messages required to assure safety, regularity and efficiency of air navigation shall


\(^{23}\)Ibid.
be handled through the AFTN operated under the authority or control of a state. This is an obligation undertaken in conformity with Articles 28 and 37 of the Chicago Convention.

The material contained in Annex 10 is under constant review to ensure that new systems and technology are necessarily introduced to improve the safety of air navigation. Annex 10 consists of two volumes. Volume I specifies equipment, systems and radio frequencies. It is a technical document defining for aircraft operations the systems necessary to provide communications and radio navigation aids used by aircraft in all phases of flight. Part I of volume I lists essential parameters for radio navigation aids, and includes power requirements, frequency, modulation, signal characteristics and monitoring needed to ensure that suitably equipped aircraft will be able to receive reliable navigation signals in all parts of the world. Part II of volume I deals with radio frequencies, which have been allocated by the ITU.24

Volume II describes the communications procedure to be used in international civil aviation operations. It contains detailed operational procedures and standards and recommended practices (SARPS) for communications used in the aeronautical fixed and mobile services and ensures that ATS personnel and pilots can establish contact on appropriate radio frequencies in a mutually acceptable language and effectively carry out the air-ground voice communications.25

25ICAO Annexes see n. 21.
(C) Emergence of International Organizations: Recent Satellite Technology Experiments in Civil Aviation

Technical progress has enabled the development of an affordable application satellite system in civil aviation over the past two decades. The FANS phase I committee, in its report to the ICAO Council, concludes that the application of satellite technology alone offers the cost-effective solutions to the CNS requirements in future for flexible and efficient air traffic management. 26 This conclusion is no doubt based on the proven application of satellite technologies, such as the global point-to-point communications (Intelsat), the global mobile satellite communication (Inmarsat), the mobile navigation system (TRANSIT), national domestic satellite systems for communications, TV/radio and weather observations. There are other national programmes with global implications, such as GPS [US] and GLONASS [Russia], which promise a great deal to fulfil the requirements of civil aviation.27

1. International Mobile Satellite Organisation (Inmarsat)

The International Mobile Satellite Organisation (Inmarsat) - formerly called the International Maritime Satellite Organisation - is an inter-governmental organisation established by two interrelated international instruments: the Inmarsat Convention and the Inmarsat Operating Agreement. Both instruments came into force on 16 July 1979, and the organization commenced its operations on 1 February


1982. In October 1985, the Inmarsat Assembly, at its fourth session, adopted and confirmed amendments to the convention and the operating agreement, which extended Inmarsat's competence to aeronautical satellite communications. These amendments took effect on 13 October 1989 and as such provided a basis for the development and implementation of Inmarsat's aeronautical satellite communications system.28

The objectives of the organization include: improving maritime, aeronautical and land mobile communications, thereby assisting in communications for distress and safety of life; communications for ATS; the efficient management of transport by sea, air and on land; maritime, aeronautical and other mobile public correspondence services; and radio determination capabilities. The Inmarsat is also required to serve all geographical areas, while there is a need for mobile satellite communications to act exclusively for peaceful purposes. The Inmarsat space segment is open to use by ships, aircraft and land mobile users of all nations on a non-discriminatory basis.29

Inmarsat's aeronautical satellite communications system, commonly called Inmarsat-Aero system30 and developed by Inmarsat and the aviation industry to form an industry-defined standard for aeronautical satellite communicators, provides two-way voice and data services for aircraft operating anywhere in the world. It consists of

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three basic elements: 31

(a) Inmarsat satellites and associated ground support facilities;
(b) ground earth stations (GESs) providing interconnection between the Inmarsat satellite system and the international telecommunications network; and
(c) aircraft earth stations (AESs) i.e. aircraft-installed equipment capable of communicating via satellite with a ground earth station for access to the international telecommunications networks.

The Inmarsat aeronautical satellite communication system provides two-way voice, facsimile and data services for aircraft. It fully complies with the ICAO standards and has built-in redundancy and back-up, providing a robust communications backbone. The Inmarsat system is based on four groups of satellites, giving global coverage up to latitudes 84 degrees north and south. There are currently 23 aeronautical ground earth stations (GES) spread across the globe. 32

Inmarsat is currently running a programme to launch new satellites. These new satellites are the third-generation Inmarsat satellites, offering a capacity 10 times more than the second-generation satellites. Additionally, the third-generation satellites carry an on-board navigation package to allow the broadcast of augmentation and integrity data related to the current GPS and GLOSNASS satellite navigation system. 33

31 Ibid.
33 Ibid.
Inmarsat has contributed ideas and expertise to all of the ICAO's FANS committee activities since the latter's inception, particularly in the development of the CNS/ATM concept and application of satellite technology to CNS problems. Inmarsat has participated actively in the work of the FANS phase I and II committees to ensure that the technical standards and criteria for the Inmarsat system are consistent with their international regulatory requirements. It has also actively participated in the ICAO aeronautical mobile communications (AMS) panel, the ICAO ADS panel, the ICAO legal committee work on institutional aspects of implementing the concept and the planning work now under way in ICAO regions. These panels were established to develop satellite CNS systems standards and recommended practices (SARPs).34

In addition, Inmarsat has been encouraging experiments in aeronautical satellite communications under an established policy, whereby the space segment is provided free of charge. A number of projects of this kind have been completed.35

2. International Telecommunications Satellite Organization (Intelsat)

Intelsat was established by UN Resolution 1721 (1961), with the General Assembly expressing its belief that communications by means of satellites should be made available to all nations of the world as soon as possible on a global and non-discriminatory basis.36 The aim of

34Featherstone, n. 30, p. 117.

35Olof Lundberg, n. 15.

36For a detailed history of INTELSAT see Joseph N. Pelton, Global Communications Satellite Policy (Mt. Airy, MD., 1974).
Intelsat is to achieve a global communications satellite system to provide, for the benefit of mankind, the most efficient and economical facilities, possibly consistent with the best and most equitable use yet of the radio frequency spectrum and orbital space. Its constitution was adopted on 21 May 1971. Intelsat has its headquarters in Washington. Its aim is to create a single global system, and its members have undertaken to consult the Intelsat organization in the event of their establishing, acquiring or using any satellite system separate from the Intelsat system in conformity to Article XIV of the Intelsat Agreement.\(^{37}\)

It has a four-tiered organizational structure: The assembly of parties, the meeting of signatories, the board of governors and an executive organ. The Intelsat Agreement has the inter-governmental element, reflected in voting based on the sovereign equality of its members; the Intelsat Operating Agreement governs the commercial part of the organisation, where decisions are reached by weighted voting reflecting the capital contributions of various members.\(^{38}\)

Intelsat is unique because it is an international organisation and a global enterprise, operating on a commercial basis and as a public utility. Intelsat's global network carries roughly two-thirds of the world's overseas telecommunications traffic, including telephone, telegraph, telex, TV data and facsimile services.\(^{39}\) At present, the organisation has 65 satellites put into orbit.

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\(^{38}\) Matte, n. 3, pp. 172-5.

Eilene Galloway has succinctly summarized the reasons for Intelsat's success thus: the demand for global communications, the solution for problems of equitable access, voting according to the type of decision to be made, efficient technical and economic operations, adoption of relevant UN principles, clear definitions, a realistic combination of governmental and non-governmental entities and co-operation with other relevant institutions, more so the ITU.  

3. **International Telecommunication Union (ITU)**

On 17 May 1865, the first International Telegraph Convention was signed in Paris by 20 European countries, which marked the birth of the ITU. Following the invention of telephone in 1876, the ITU began in 1885 to draw up international legislation governing telephone communications. After the invention in 1896 of wireless telegraph - the first type of radio communications - an international radiography conference was held in 1906, and the first-ever International Radiographic Convention was signed.  

The International Telephone Consultative Committee (CCIF), the International Telegraph Consultative Committee (CCIT), and the International Radio Consultative Committee (CCIR) were established in 1924, 1925 and 1927 respectively. These committees were made responsible to co-ordinate technical studies, tests, and measurements being carried out in various fields of telecommunications and to draw up international standards. At the 1932 conference in Madrid, the union decided to combine the International Telegraph Convention 1865 and

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40 Ibid.

41 Gorenewege, n. 28, p. 190.
the International Radiograph Convention 1906, and form the International Telecommunication Convention; and it changed its name to ITU on 1 June 1934 in order to reaffirm its commitment to all forms of communications: wire, radio, optical system - or other electronic systems. The ITU became a specialist agency of the UN on 15 October 1947. The ITU provides a forum for the regulation of radio frequency spectrum use. The organized utilization of this spectrum is of importance to communications satellites and is entrusted to the ITU which regulates satellite frequencies and the use of the geostationary orbit.

At the first ITU Special Radio Conference (Geneva, 1963), the 1540-1660 MHz was allocated to the aeronautical mobile (R) service for the use and development communication systems using space techniques. Also, at the second ITU Conference of 1971, the above 120 MHz of aeronautical mobile spectrum space was reduced to two small sub-bands of 15 MHz. The rest was divided between the maritime and other services. A further reduction was made to aeronautical allocation at the World Administrative Radio Conference (WARC) of 1979. At the 1987 WARC for the mobile services the frequencies allocated to the AMSS (R) were reduced. However, the impact on aeronautical interests of the decision taken at that conference is not nearly as severe as it might have been. Furthermore, at the 1992 WARC, additional radio

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43 See N.M. Matte, Space Activities and Emerging International Law (Montreal, 1984), p. 205.
frequency spectrum was allocated to mobile satellite services.\textsuperscript{44}

Concern has been expressed, however, over a recently initiated attempt to ease the introduction of a mobile satellite system in the Global Navigation Satellite System (GNSS) band, or the band immediately adjacent to it. With great appreciation, the aviation community has welcomed ITU protection for the operations of Global Positioning System (GPS) -- and in particular Global Orbiting Navigation Satellite System (GLONASS) -- against interference from mobile earth stations operating in the frequency band 1610-1626.5 MHz. Even more serious are developments in countries, which suggest that part of the band used for GNSS (1559-1567 MHz) can be used for the mobile-satellite service operating in the space-to earth direction. These developments will, if implemented, not only have a serious potential of interfering with the existing GNSS at a level that it can no longer be safely used by aviation, but also seriously restrict future improvements to be implemented in GNSS.\textsuperscript{45}

At a recent meeting, the ICAO GNSS panel identified these issues as a problem requiring urgent attention by aviation frequency managers and GNSS designers in the ICAO contracting states. The problem is not exclusively limited to aviation, since the GNSS services will be used by many different users. However, the aviation requirement is probably the most critical in terms of service availability, and integrity, and is least tolerant of interference. It is evident that the full availability of GNSS over the land areas where it will be needed to support the new


\textsuperscript{45}ITU News, 9/97, pp. 2-5 at p. 5.
CNS/ATM systems in the post-2000 era can only be guaranteed by action initiated now. Key initiatives needed: studies are required in ITU-R (study group 8), addressing in particular the capability of conference to provide the regulatory mechanism necessary to protect the GNSS. It is the aviation community's view that this work could be completed and submitted at the World Radiocommunication Conference of 1999.46

4. World Meteorological Organization (WMO)

The World Meteorological Organization has its origins in the International Meteorological Organisation (IMO) established in 1873. The international standards for aviation's meteorological practices have improved since the establishment in 1935 of the International Commission for Aeronautical Meteorology (ICMAe) of the IMO. It was established to provide guidance on international meteorology and co-ordination between the IMO and the International Commission for Air Navigation (ICAN). The ICMAe launched a document containing regulations of international meteorological service to aeronautics. Following the Chicago conference and the subsequent formation of the ICAO, the IMO's CIMAe was replaced when the WMO's first congress established the present Commission for Aeronautical Meteorology (CAeM) in 1951. The ICAO and the WMO have worked in close harmony since their establishment, contributing greatly to the success of postwar civil aviation.47

46 Ibid.

47 Charless H. Sprinkle, "Past and Future Issues in Meteorology" see Mark Blocklock, n. 2, pp. 184-98.
With the enormous increase in air traffic during the 1950s and 1960s, the ICAO and the IMO set out principles for an "area forecast system" in 1964. Another ICAO/WMO meeting in 1974 called for a review of the regional area forecast system. The culmination of this review was the establishment by the ICAO of the area forecast panel, which met in 1980 and 1981 and developed a plan for a worldwide area forecast system based on two world area forecast centres. 48

The development of the world area forecast system (WAFS) was formally agreed at the ICAO COM/MET division meeting, held concurrently with the seventh session of the WMO Commission for Aeronautical Meteorology in 1982. It officially came into existence following the implementation of various amendments to Annex 3 of the Chicago Convention on 22 November 1984. The WAFS aims to provide the states and other users with high quality global upper wind and temperature data as well as significant weather (SIGWX) forecasts to be used in pre-flight operational planning and flight documentation. 49

The WMO devised the aeronautical meteorology programme (AeMP), which provides meteorological support to meet aviation requirements for safe, economic and efficient air navigation. The AeMP is a coherent application programme, closely co-ordinated with the world weather watch programme (WWWP). The AeMP intends to provide a coherent and consistent framework for all of the WMO's activities in aeronautical meteorology, consisting of the following nine essential and closely linked elements. 50

48 Ibid., p. 195.
49 Ibid., p. 196.
(a) Assistance (jointly with the ICAO) in the implementation and operation of the WAFS -- including review developments of the aeronautical codes -- in co-operation with CBS, and the charts and forms used for the dissemination and presentation of WAFS output.

(b) The promotion of accuracy in aerodrome and flight forecasts-in particular forecasts for low-visibility operations and forecasts concerning weather which may effect the safety of aircraft operations.

(c) The development of a scientific basis and appropriate techniques for the provision of meteorological services for general aviation in accordance with requirements stated by the ICAO.

(d) The development of a scientific basis and appropriate techniques to meet operational requirements stated by the ICAO for the provision of meteorological support to helicopter operation.

(e) The review and development, in consultation with the Commission for Instruments and Methods of Observation (CIMO), of specification and methods of employment for specialist instruments, aerodromes, observing and display systems suitable to meet aeronautical requirements.

(f) Guidance on the use of automated interactive systems for the operational management, processing and retrieval of meteorological information.

(g) Research aimed at improvements in the application of meteorology to civil aviation.
(h) The promotion and assistance, in accordance with the ICAO, of trained specialists in aeronautical meteorology and other personnel engaged in civil aviation.

(i) The issuance of educational meteorological information used in the training of pilots -- including general aviation pilots -- and other aeronautical users.

III. Problems In The Existing Air Navigation System And Need For New System

A. Problems in the Existing Air Navigation System

The present air navigation system (ANS) provides international air traffic services (ATS) for civil aviation through a chain of national air traffic service (NATS) providers. The provision of these services is based on the availability of communication, navigation and surveillance (CNS) systems at various capabilities with the national providers. The functions of the ANS are supported by air space management (AMS) and air traffic flow management (ATFM), which on the whole constitute air traffic management (ATM).51

The current international civil aviation's ANS system began its operations in 1946, using the available technology for aircraft avionics equipment and CNS capabilities. All the CNS systems were ground based, and still remain so. The gamut of present systems - including the ground-based non-directional beacon (NDB), VHF omni directional rang (VOR), distance measuring equipment (DME), primary and

secondary tracking radars ILS, and VHF/VHF air-ground communications - do provide services with a sufficient degree of accuracy and reliability, but their coverage is limited by line-of-sight constraints. The other systems - radio homing stations, HF communications, the Loam and Omega systems, etc. - have limitations of accuracy and reliability due mainly to the dismal and seasonal variations of radio wave propagation.

These conventional communication/navigational aids have a limited range, and require to be installed to cover a given airspace. Their coverage over oceanic areas, and surveillance capability are limited. The position determination is an important element of the ATC. Conventional navigation aids used in the ATC suffer in this respect as reflected in poor time response to the ATC. Due to inadequacies in the ATC tools currently used by the ATS, aircraft have to follow alternate artificial, but not necessarily shortest routes.

In today's system, the position determination is achieved by the inertial navigation system (INS) and has no other means of its accurate cross-checking within the aircraft. Moreover, communication is achieved either by VHF radio line-of-sight communications, where it requires a large number of VHF surface stations, or by HF radio over oceans and thinly populated areas with attendant noise and congestion


problems. 55

There are very strong reasons to plan a replacement of the existing CNS system. The CNS system, introduced in the 1940s, requires thousands of ATC units, ground-based VHF relay stations, and an extensive network of navigational radio beacons around the globe. There are other limitations, too. Land-based radars neither see beyond the horizon, nor cover mountain ranges. Huge oceanic expanses and large tracts of the developing South remain unmonitored. The system is also unable to grow and beat the rising congestion at airports in the developed North. 56

One of the first tasks of the FANS committee was to investigate the existing CNS system and find the basic problems. The shortcomings of the present system, according to it, are:

(1) the propagation limitation of current line-of-sight systems - or the accuracy and reliability of propagation characteristics of other systems; (2) the difficulty, for various reasons, to implement the present CNS system and operate it in a consistent manner in large parts of the world; and (3) the limitations in voice communications and lack of digital air-ground data interchange systems to support modern automated systems in the air and on the ground. 57


Unless there are improvements in the present system, international civil aviation will continue to experience increasing airport and airspace congestion, which set to worsen progressively. This will result in higher operating costs and stifle the market of the aviation industry.\textsuperscript{58}

These problems apart, the current global air navigation system needs a change mainly due to three factors:

(a) the growth in air traffic which the current system will fail to tackle,

(b) the availability of new technologies, and

(c) the need for global uniformity in the provision of air traffic services.

The continuous growth of civil aviation has, since the adoption of the Chicago Convention in 1944, triggered demands and operational requirements, which can no longer be met by the existing facilities, techniques, and procedures.\textsuperscript{59}

The Aviation Review Committee thus made a perspective plan for air navigation in the early 1980s. The ICAO Council expressed its intention to form a special committee for the projection of air navigation requirements for civil aviation, over a period of next 25 years. This plan, the future air navigation systems (FANS), was reported to the 24th session of the ICAO Assembly in September 1983. It undertook a cost-benefit analysis of alternative future air navigation systems, in particular during the transition from the current to future systems. The

\textsuperscript{58}FANS Manual, n. 53, p. 2.

FANS committee has produced its study on new concepts and technologies, in effect concluding that the exploitation of satellite technology is the only viable solution to mitigate the drawbacks of the present terrestrial system on a global basis in the foreseeable future. The ICAO's CNS/ATM system, endorsed by the civil aviation community at the 10th Air Navigation Conference in 1991, has technical and operational capabilities to redress the intrinsic limitations of the present air navigation system.

B. The FANS Committee: Phases I, II and III

The ICAO formed the future air navigation systems (FANS) committee (phase I) in November 1983 under the ICAO Council as a subsidiary body. The Council defined the terms of reference of the FANS committee as follows:

To study technical, operational, institutional and economic questions including cost/benefit effects relating to the future potential of air navigation systems; to identify and assess new concepts and new technology, including satellite technology, which may have future benefits for the development of international civil aviation with the likely implications they would have for users and providers of such systems; and to make recommendations thereon for an overall long-term projection for the coordinated evolutionary development of air navigation for commercial civil aviation over a period of the order of twenty-five years.

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60 Brian O. Keeffe, n. 57, p. 16.

61 General Work programme of the Legal Committee was approved by the Council on 17 June 1992. See A29-WP/37 LE/3, p. 7.

According to the US Federal Aviation Administration, the goals of the future system must be to:

(a) maintain and provide the safety of flight operations;

(b) increase system capacity and fully utilize capacity resources as required to meet traffic demands in all visibility conditions;

(c) better accommodate user-preferred flight trajectories [i.e., cruise-climb vertical profiles following direct routes];

(d) better accommodate the full range of aircraft types and avionic capabilities;

(e) improve aviation information for users-weather observations and forecasts, traffic congestion and delays, status of facilities and airports, and inflight situational awareness - based on the cockpit traffic information display;

(f) improve navigation and landing capabilities - including curved approach, missed approach and departure guidance, and eventually satellite-based capability approaching category; and

(g) increase user involvement in decision-making, including computer-based, air-ground negotiation of flight trajectories.\(^63\)

The FANS drew its membership from 22 countries and international organizations, with 10 others given the observer status. The FANS committee first met in 1984 and submitted its final report to

the ICAO council in 1988, proposing a future air navigation system. It emphasized new concepts and new technologies - including satellite technology - for effective CNS services on a global basis. This would, it said, usher in a new era of safe, efficient air transport. This concept is firmly based on current technology, most of its component parts already demonstrated. Many challenges, of course, remain unredeemed, but the overall concept is entirely feasible even though technical barriers appear to exist. The development and implementation of new systems would, the committee stressed, require arrangements different from the present system. It thus recommended the establishment of a new committee to advise the ICAO on the overall monitoring, co-ordination of development and transitional planning to ensure that implementation took place globally in a cost-effective and balanced way between air navigation systems and geographical areas.

In July 1989, the ICAO Council established a special committee to monitor and co-ordinate development and transition planning for the future air navigation system (FANS, phase II) with wider terms of reference, as follows:

(a) to identify and make recommendations for acceptable institutional arrangements - including funding, ownership and management issues - for a global air navigation system;

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64See Keeffe, n. 57, p 15.
65Ibid.
(b) to develop a global co-ordinated plan with appropriate guidelines for transition, including the necessary recommendations, to ensure a progressive and orderly implementation of the ICAO's global, future air navigation system in a timely and cost-effective manner;

(c) to monitor the nature and direction of research and development programmes and trials in the CNS and ATM so as to ensure their co-ordination and integration; and

(d) to prepare, as required, the necessary documentation to support the ensuing ICAO air navigation conference in 1991.68

The FANS phase II committee, at its fourth meeting in September 1993, accepted a global co-ordinated plan, reviewed and accepted a comprehensive document on the ICAO CNS/ATM system to cope with air traffic demand, and also reviewed the results of all FANS activities by the states and the ICAO, including the status of research, development, trials, and guidelines for the acceptable GNSS (AMSS), and ATN.69

The FANS phase III has taken shape since 1993, focusing on the implementation of a satellite-based air navigation system. Trials and demonstrations, the prerequisite for sound implementation, are taking place in many parts of the world with encouraging results. International airline operators have begun equipping their fleets with CNS/ATM


69 Ibid., 9624, FANS (II)/4, p. 1.
avionics to match the pace of the fastest states and to reap benefits of the existing aviation infrastructure. This activity is, however, rather limited in states with scarce resources and knowhow. The situation could be improved by co-operation between states/international organizations with expertise and resources on the one hand, and states with limited resources on the other as called for by the 29th ICAO Assembly in September-October 1992.

The United States, an active participant in the working of the FANS phase II committee, has fully supported the call to develop GNSS systems and is currently working on a national CNS/ATM plan, which will contribute to the goals of a worldwide FANS. The US launched its first operational GPS satellite in 1989. The FAA has issued a national aviation standard for the GPS, officially making the GPS part of the US national airspace system. The GPS will allow aircraft to make curved approaches to airports, fly more efficient routes, and obtain positional information anywhere in the world. The FAA has been working closely with the airlines since 1990 to use GPS navigational information as part of operational trials for traffic movement over the pacific. Many other co-operative efforts have been completed or under way among the FAA, equipment manufacturers, airlines, and other users to develop, test and demonstrate applications of the GPS to aviation.

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72 See FAA, GPS contribution promises to be revolutionary, but full benefits will only be realized when it is used in conjunction with other technologies. ICAO Journal, June 1993, p. 26.
There are several European programmes with a crucial role in the implementation of the ICAO CNS/ATM systems. Fixed communications are evolving in Europe into technologies, using X-25 protocols and the ATN. The AMSS are already providing passengers with telephone communications over oceanic areas. All Eurocontrol member states plan to implement Mode "S" surveillance and Mode "S" stations, already in operation in the UK, Germany and France. The capability of VHF data interchange, a late addition to the CNS/ATM system, is acquiring considerable importance. The satellite navigation using GNSS is an exciting development. Its application, which involves monitoring the movements of aerodrome surface vehicles, is currently being tested by Sweden.

The introduction of MLS was planned well before the emergence of the CNS/ATM system concept. In Europe, the ICAO European Air Navigation Planning Group (EANGP) is overseeing a plan to introduce MLS. A few MLS have been installed for operational testing, one of them at Charles de Gaulle airport, Paris.\(^{73}\)

In the African region, the implementation of the ICAO's CNS/ATM has started replacing VHF communications with VHF data and voice communications to reduce the congestion of channels. Most communications will be in the form of data. HF voice communications will be replaced with the much more reliable AMSS data and voice. The African Planning and Implementation Region Group (APIRG), the African Civil Aviation Commission (AFCAC), and other ICAO regional

offices have been working to implement the CNS/ATM in the region.  

The Informal South Pacific Air Traffic Services Co-ordination Group (ISPACG) is co-ordinating the implementation of the CNS/ATM system in the South Pacific region. Representatives of the civil aviation authorities from Australia, Fiji, French Polynesia, New Zealand, and Papua New Guinea have formed a group to encourage the participation of airlines, communication service providers, aircraft manufacturers and interested professional organizations. The early successful introduction of the CNS/ATM system in New Zealand and its neighbouring states is the result primarily of the excellent preparatory work of the ISPACG, which led not only to agreement among the states for radical changes but the endorsement of such changes by the airlines and ATS providers.  

In Asia, Japan has initiated in the early 1990s a large project to establish a satellite system for the provision of aeronautical communications and supplemental air navigation throughout the Asia-Pacific region, known as the multi-functional transport satellite (MTSAT). The new technology was needed to cater to the region's ever increasing air traffic demands. For domestic purposes, the MASTA system is intended to serve as an alternative in the 21st century to the present terrestrial CNS system. The MTSAT is planning to launch and operate satellites for ATS.  

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74 Kabuga, n. 71, pp. 20-21.


C. Future Communication Navigation and Surveillance (CNS) System

The future air navigation system (FANS) concept comprises two elements. The first part, the communication navigation surveillance (CNS), envisages infrastructure, on the basis of which the second, the air traffic management (ATM), seeks to perform its functions. This concept has been developed by the ICAO CNS/ATM system. It essentially involves the application of today's high technologies in satellites and computers, data links, and advanced flight deck avionics to cope with the future operational needs of civil aviation. In doing so, it will make absolute use of much of today's expensive ground-based equipment [line-of-sight technology], which has inherent limitations. It also produces economies, efficiency and greater safety. It will have its impact as an integrated global system, transforming the way we organise and operate our air traffic services in quantum effect.

The FANS committee has set overall long-term projections for a co-ordinated evolutionary development of air navigation for the next century. This long-term plan is complementary to the existing terrestrial systems. The satellite-based CNS system also indicates that compatibility with the satellite-based navigation system will be of great benefit to civil aviation navigation, integrity, coverage, and accuracy. The plan requires investment in aircraft equipment by airlines and in ground

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77 See A vision document published by International Federation of Air traffic Controllers Association (IFATCA), undated, p. 8.

78 A. Koitate, "Mechanism to Provide Implementation Coordination and Assistance under Active Consideration", ICAO Journal, December 1993, p. 5.

infrastructure by civil aviation authorities to support the new air traffic environment. The airlines in return expect to see substantial improvements in today's inefficient air space management.\textsuperscript{80}

The CNS/ATM system as developed by the FANS committee was defined and endorsed by the international civil aviation community at the 10th ICAO air navigation conference in 1991. The key concepts of the satellite-based CNS system are:

(a) satellite technology enables aviation to achieve higher levels of worldwide coverage for communication and navigation otherwise not possible with today's standard line-of-sight radio communications and ground-based navigational aids;

(b) the synergistic combination of satellite-derived position information with satellite-based communication can be used to establish an automatic dependent surveillance (ADS) capability, and global surveillance coverage, so reducing the need for radars; and

(c) digitised data link communications will be used in conjunction with automation to facilitate and improve ATM, generating user-preferred routing etc.\textsuperscript{81}


\textsuperscript{81} M.T. Pozesky, "GPS Implementation for Use by Civil Aviation is on Fast Track", \textit{ICAO Journal}, December 1991, p. 15.
Evolution of CNS System

The evolution of the CNS system is explained in the table below:

### Table I

**Communications-navigation-Surveillance (CNS) System : Evolution**

<table>
<thead>
<tr>
<th>Type of Airspace</th>
<th>Current</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>N</td>
</tr>
<tr>
<td>Oceanic/continental en-route airspace with low traffic density (1)</td>
<td>VHF HF Voice</td>
<td>OMEGA/LORAN-C NDB VOR/DME Barometric altitude INS/IRS</td>
</tr>
<tr>
<td>Continental airspace with high density traffic</td>
<td>VHF voice</td>
<td>OMEGA/LORAN-C NDBVOR/DME Barometric altitude INS/IRS</td>
</tr>
<tr>
<td>Oceanic airspace with high density traffic</td>
<td>HF voice</td>
<td>MNPS OMEGA/LORAN-C Barometric altitude INS/IRS</td>
</tr>
<tr>
<td>Terminal areas with high density traffic</td>
<td>VHF voice</td>
<td>NDB VOR/DME ILS Barometric altitude INS/IRS</td>
</tr>
</tbody>
</table>

**Key:**
- AMSS - aeronautical mobile-satellite
- MNPS - minimum navigation performance specifications
- RNAV/RNCP - Area navigation/required navigation performance capacity
- GNSS - Global navigation satellite
- ADS - automatic dependent surveillance
- INS/IRS - inertial navigation system/inertial reference system

**Notes:**
1. Include low altitude, off-shore service and remote areas.
2. Until such time as satellite specifications communication is available
3. To be used where barometric navigation performance altimetry is not functional capability
4. VOR/DME will be progressively system withdrawn
5. NDB will be progressively withdrawn
6. The need for primary is reduced.

1. Communication System

At present, communications between aircraft and ground control centres are effected through high-frequency radio systems over land, oceans, and remote regions. Under the CNS/ATM system, communications between air and surface will reach a new dimension of being relayed to aircraft by satellites in space, which in turn could relay messages to ground control through a ground earth station (GES). This system permits communication not only by speech but by digital data link - an enormous advantage over the air traffic control system.¹

The aeronautical communications system, under the new CNS/ATM system, will extensively use digital modulation techniques to generate high efficiency in information flow and optimum use of automation. The need for voice communication still remains, yet the introduction of data communication speeds up the exchange of information between all parties connected to a single network.² This communication capability reduces flight deck workload, provides air traffic managers with information to improve routing over oceanic areas, and expedites addressing and reporting system (ACARS/AIR COM) coverage for worldwide aircraft communications.³

In the future communication system proposed by the FANS, all air traffic [ground-to-air] communications outside the airport terminal and high-density airspace beyond the reach of satellites are ensured by


connecting the ATC centre [on the ground] to a satellite ground earth station (GES), from which the signal is transmitted to the satellite. The satellite in turn relays the signal to the AES on board the aircraft. The AES transmits it back to the satellite, which relays the signal to ATC centres via the GES. In this process the satellites can provide uninterrupted communication throughout the globe because of wide coverage.4

The aeronautical telecommunications network (ATN) will provide data interchange facilities, including the ground data links, between ATS and other centres. The satellite communications system will ultimately eliminate the need for high-frequency (HF) voice, although HF may continue to be used over polar and other specific areas for economic reasons and until the satellite service is extended to those areas. Most communications will be in the form of data. Data communications will allow transmitted information to become more concise, accurate and efficient with no risk of misinterpretation. The medium of data communications can be of three types - satellite data link, secondary surveillance radar (SSR) mode and data link, and very highly frequency (VHF) data link - their use depending on conditions within the flight information region (FIR).5

The benefits of the new communications system are:
(a) the link between ground and airborne systems will be more direct and efficient, resulting in improved ATM system;

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(b) the handling and transfer of data among operators, aircraft and
ATS providers will improve;
(c) channel congestion will be reduced;
(d) errors due to faulty communications will be reduced and safety
enhanced;
(e) the new system will provide inter-operability across applications,
with minimum avionics required;
(f) the reduced workload will result from the ICAO's standardised
ATN; and
(g) the existing expensive ground-based systems can gradually be
phased out.

2. Air Navigation

Air navigation can be defined as "the art of directing the aircraft
from one place to another". In early days navigation was performed by
a visual observation of the land flown over. With the emergence of the
FANS, aircraft navigation has become safer and more accurate through
the use of navigation satellites orbiting around the Earth. The FANS
committee developed the concept of required navigation performance
capability (RNPC) as the minimum level of performance to be
demonstrated for navigation aids, and the user is left with a choice of
equipment. The RNPC concept supports the development of more
flexible route systems, and air navigation environments. The FANS

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6 Ibid.

7 See Navigation for the 21st Century (Ssurry, UK, undated), pp. 3-11.
committee has been confident, however, that the existing long- and short-range position determination aids finally give way to the GNSS, such as the GPS, or GLONASS. 8

The global navigation satellite system (GNSS) 9 is now being deployed through navigation satellites of the US global positioning system (GPS), and the Russian Federation's global orbiting navigation satellite system (GLONASS). 10 They promise significant benefits with worldwide civil aviation applications. The GNSS signals common approaches providing for standardized equipment, and their use will allow for a global, highly accurate, reliable navigation system.

The GNSS will provide significant improvements in the conventional radio navigation installation. It is more accurate than the system currently in service. It also provides a universal reference time. The GNSS system's navigation data can be integrated with the data of various on-board sensors, inertials, and aerodynamic parameters to provide quality service to the most advanced aircraft. The GNSS system, combined with air-ground data transmission systems, will provide excellent base for ADS in the entire airspace. The progress initiated by the GNSS system and the future possibility of eliminating ground navigation installations will significantly bolster the regularity, efficiency and economy of air transport. The GNSS has the potential to

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enhance safety too.\textsuperscript{11} This is beneficial both economically and operationally, especially in those parts of the world with no existing land-based navigation systems.\textsuperscript{12}

The GNSS, besides providing route navigation globally, is also expected to play a role in landing phases of the flights. The microwave landing system (MLS) will be the standard precision approach and landing aid, but satellite systems are expected eventually to achieve such level of accuracy as needed for non-precision approaches. In the case of multiple systems of the GNSS, the RNPC allows for numerous satellites a navigation system, which is used by one aircraft. The GNSS service providers should, says the FANS committee, work together to achieve maximum inter-operability. This could simplify avionics and reduce costs for the operators. It could also help one system complement another and act as a back-up in the event of a failure, or blockade.\textsuperscript{13}

The benefits of the new navigation system are:

(a) The GNSS will provide high integrity, accuracy to worldwide navigation service for the en route terminal and precision phases of flight and possibly for near category and precision approach at landing operations.

(b) Aircraft will be able to navigate in airspace in any part of the world while passing a single set of navigation avionics.

\textsuperscript{11}Guidelines for the introduction and operational use of GNSS. ICAO circular 267, AN/159, 1996, p. 1.

\textsuperscript{12}See Dr T.G. Anodia and J.E. Turner, n. 79, p. 13.

\textsuperscript{13}Report of the DOE n. 14, p. 10. Also see M.C. Altink-Pouw, "Perceived Obstacles to GNSS Institutional Arrangements can be Overcome in the Near Future", ICAO Journal, December 1993, pp. 19-20.
(c) The provider state will save the costs, as existing ground-based navigation aids are no longer reduced.

(d) Three- or four-dimensional navigation accuracy will improve.

(e) The new system can be used in conjunction with other systems, such as inter-trail navigation systems, to support the RNP.

(f) The new system will allow any runway to be used for non-precision approach operations and perhaps also for near-category and precision approaches, so helping achieve improvements at limited costs throughout the world.  

3. Surveillance

Surveillance is the basic necessity for air traffic controllers to monitor safe aircraft operation, manage airspace efficiently, and assist the pilot in flight navigation. Three tools are available for safe aircraft navigation: the airborne collision avoidance system (ACAS), automatic dependent surveillance (ADS), and the secondary surveillance radar mode (SS-Mod).  

The ACAS provides back-up to the ATS by alerting flight crew to potential collisions. The system is contained entirely on board the aircraft and is not dependent on any ground-based system. The purpose of the ADS is to support the automatic surveillance of appropriately equipped aircraft with complete transparency to the controller and pilot in communication mechanisms. Aircraft, aided with the ADS, automatically links up to the ATC centre, where the aircraft position will

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14See ICAO CNS/ATM, n. 86, p. 11.

15See FANS Manual, n. 53, p. 15.
appear on an electronic display, thereby providing positive control on aircraft beyond the line-of-sight. The aircraft separation distance can be safely reduced, and congestion threat on many routes relieved. An important feature of the ADS is that the downlinked data will be of considerable benefit to surveillance, and provides much more information than the present radar system.\textsuperscript{16}

For surveillance, secondary surveillance radar (SSR) will continue to be widely employed, with its protectiveness enhanced by the monopulse technique. In its Mode-'S' form with selective address and data capability, it is very useful for surveillance and monitoring. The SSR is limited to the line-of-sight, however, and the introduction of digital data links via satellite and accurate on-board navigation system will together offer what is known as the ADS, extending the SSR class coverage to oceans and other remote areas.\textsuperscript{17}

The future surveillance system will be characterised by the use of the ADS. The ADS has grown from a comparatively simple concept of providing aircraft position outside radar cover to a data link application, which enables vast information to be exchanged between the ground flight data processing systems and the aircraft avionics.\textsuperscript{18} The benefits of the new surveillance system will enhance flight safety and surveillance capability over oceanic and non-radar areas. By increasing ATC flexibility, it reduces delays and diversions from preferred flightpaths and cuts the flight operation costs. The Mode "S", in combination with the

\textsuperscript{16}Ibid.

\textsuperscript{17}Report of the DOE, n. 14, p. 10.

ADS, will facilitate a uniform surveillance service worldwide. The provider states gain cost saving through a phased elimination of the ground system.\textsuperscript{19}

In short, the future CNS system can be described thus:

(a) The existing ground-to-ground AFTN - utilizing telephones, teleprinters, and the air-to-ground HF VHF voice communications - will be replaced with ground-to-ground data communications, utilizing the ATN with VHF Mode-"S" and satellite sub-networks which provide air-to-ground data communication links.\textsuperscript{20}

(b) The existing ground-based NDB VHF omni-directional range (VOR) and DME navigational aids will be replaced with the GNSS. The current ILS approach and landing aid will be replaced with the MLS.\textsuperscript{21}

(c) In areas where there is a radar coverage it is expected that the primary radar will continue and the SSR will be replaced with Mode -"S"- an improved version of the SSR, which overcomes the interference limitations of the former, provides selective aircraft addressing, and a cost-effective ground-air-ground data link. In areas where there are currently no surveillance facilities, the ADS will be used, in which aircraft automatically report their


position as established by the on-board navigational system over data link.\textsuperscript{22}

D. Future Air Traffic Management (ATM)

The air traffic management (ATM) is a generic term, covering air traffic services (ATS), airspace management (ASM), and air traffic flow management (ATFM). The general objective of the ATM is to enable aircraft operators to meet their planned times of departure and arrival and adhere to their preferred flight profiles with minimum constraints and no safety risks.\textsuperscript{23} The ATM relies on the availability of a CNS system to provide information on the individual aircraft position and intends to match the traffic with the available controller capacity.\textsuperscript{24}

With the global air traffic rising at an unprecedented pace, the central tenet of the air traffic management community - safe and expeditious handling of air traffic - becomes ever more demanding. Commercial airlines increasingly insist on better services at lower unit costs from the ATS providers. Safety will never be compromised by commercial pressures, so the inevitable result is the delay in airline operators. A recent analysis suggests that delays resulting from on-ground holding, indirect routing, and inefficient flight levels could cost the airline industry as much as £4 billion (US$ 6 billion) a year by the next millennium.\textsuperscript{25}

\textsuperscript{22}See Chris White, n. 101, p. 86.

\textsuperscript{23}Colin Hume, "Developments in Air Traffic Management", \textit{Air Traffic Technology International} 1997, 8-13, at p. 8.

\textsuperscript{24}FANS Manual, n. 53, p. 5.

\textsuperscript{25}Cliffy Fry, "The Future Air Traffic Service Provision", \textit{Air Traffic Technology International} 1997, pp. 94-97, at p. 94.
The ATC has witnessed far-reaching changes since the introduction of new technologies and concepts, all commensurate with the growth of air traffic density. Communications, navigation and surveillance (CNS) - the three principal elements of the ATC - have to be used in an integrated manner to serve the global needs of air traffic in a safe, regular and efficient manner. These technological changes stress the need for better ATM.

The ATM system will outgrow its modernization drive currently under way, and its decisions will be based on user needs and technological opportunities in the 21st century. The flexibility facilitated by the new CNS system will allow for the introduction of automation capabilities from the simplest to the most advanced as required by individual states, yet it will go global in uniformity.26 The new system has been designed -

(a) to meet or increase the existing level of safety;
(b) to accommodate a full range of aircraft types and airborne capabilities;
(c) to improve the provision of information to users, including weather conditions, traffic situation and availability of facilities;
(d) to increase system capacity and fully utilize resources as required to meet air traffic pressures;
(e) to minimise airborne delays and holding - coupled with the adjustment of flight-track schedules - to achieve efficient traffic flows, airspace and airport use;
(f) to provide for dynamic accommodation for users' preferred three- and four- dimensional flight trajectories;

(g) to improve navigation and landing capabilities in support of advanced approach and departure procedures;

(h) to organize airspace in accordance with ATM provisions and procedures; and

(i) to create a single continuum of airspace, where boundaries are transparent to users.27

The future oceanic ATM operations will make an extensive use of the ADS, satellite data like communications, the GNSS aviation weather system, and ATM automation, including the integration of ATM automation and flight management computer operations via data links. This new capability will permit flexible routing and dynamic modification to aircraft routes in response to changing weather conditions. The increased airport capacity and improved safety will be the major objectives of the future ATM system. The design of the future system will contribute to this goal by utilizing procedures and technologies, which allow a higher traffic turnout; it will fully utilize scarce capacity resources, and restructure the traffic turnout so as to maximize efficiency in approach and departure operations.28

In sum, with the implementation of the new ATM system the airlines hope to gain total freedom for pilots to select or change routes for flight safety and efficiency. This goal, known as "Free Flight", will ensure the most economic, fastest or direct route yet to be flown over for each individual flight.29


28See ICAO Doc 9623, FANS II/4, AB.26 and 27.

29See generally pamphlet on FANS published by IATA, 1997.
Table - II
Overall ICAO CNS/ATM System Benefits: A High Level View

<table>
<thead>
<tr>
<th>Communications ground</th>
<th>Navigation</th>
<th>Surveillance</th>
</tr>
</thead>
<tbody>
<tr>
<td>More direct and efficient air round links</td>
<td>High integrity, high accuracy world-wide navigation</td>
<td>Enhanced flight safety. Extension of air-traffic services to non-radar areas</td>
</tr>
<tr>
<td>Improved data handling</td>
<td>Improved four dimensional navigation accuracy</td>
<td>Reduced separation minima in non-radar environment</td>
</tr>
<tr>
<td>Reduced channel congestion</td>
<td>Cost saving from elimination of ground-based navigation aids</td>
<td>Reduced flight operating costs</td>
</tr>
<tr>
<td>Reduced communication errors</td>
<td>Better runway utilization</td>
<td>Reduced delays Accommodation of more direct/preferred flight paths</td>
</tr>
<tr>
<td>Interoperability across applications.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced work load</td>
<td></td>
<td>Higher degree of controller responsiveness to flight profile changes</td>
</tr>
</tbody>
</table>

Air Traffic Management

- Enhanced safety
- Increased system capacity, optimized use and airport capacity
- Reduced delays
- Cost saving
- More efficient use of air space, greater flexibility reduced separations
- More dynamic flight planning, better accommodation of optimum flight profiles
- More accurate data
- Reduced error rates
- More accurate navigation
- Enhanced surveillance capability
- Reduced controller workload.

IV Application of Space Technology in Civil Aviation: Emerging Legal Issues

The ICAO established the future air navigation system (FANS) committee in 1983, aimed at employing satellite and advanced computer technology for the enhancement of international air navigation. This was formally endorsed by states and international organizations at the 10th Air Navigation Conference in 1991, and approved by the ICAO Council and the 29th session of the ICAO Assembly as the ICAO CNS/ATM system. Its implementation will not only revolutionize avionics but will influence the structure and content of legal regulations on civil aviation. The system comprises four elements: communications, navigation, surveillance, and air traffic management. The new CNS system will, it is recognized, meet future requirements and enhance worldwide air traffic management. This technological development implies an expansion of the corpus of the air law, more so, the legal regime designated to regulate the technical aspects of international civil aviation. With the air law's expansion comes the necessity to review underlying assumptions and legal principles of the CNS system.

Governments and potential users of this system are concerned about the costs - both of operation and transition, control and reliability of the system and the fate of the existing and envisioned ground-based navigation aids. The ICAO has dealt with legal and institutional issues of satellite navigation as part of its drive for global implementation, beginning with the first FANS committee in 1983. The ICAO Council


first included satellite navigation in the work programme of the FANS committee in 1988. The committee's agenda has since evolved into "consideration with regard to global navigation satellite systems (GNSS) of the establishment of a legal framework". It is at the top of the committee's priorities.32

This chapter makes some preliminary observations on the application of the new satellite-based CNS/ATM system. The CNS/ATM system is largely based on the GPS and GLONASS of the US and Russian Federation respectively, developed free of cost. But then who is liable to the system's malfunctioning? What law should govern satellite-based air navigation? What are the legal approaches to be readdressed in consequence thereof? What are the legal implications of international chaos and national security? Who should pay for the ongoing monitoring and maintenance of the system? What are the implications of foreign governments relying on this system?

The protection of a state's rights to full and excessive sovereignty over its airspace is another problem. The question may be easily resolved by states with large territories and access to space technology, but not by small states which may not exercise sovereignty due to their likely dependence on the former or former-controlled CNS/ATM system. The ICAO's promise that the CNS system will not affect sovereignty in any way is not based on logic - or empirical evidence. The prospects of an outright commercialisation of the CNS/ATM versus international obligations on the sharing of space technology

32See paper presented by USA on "Legal and Institutional Aspects of Global Satellites Navigation Services" (GNSS) to the 33rd Conference of Directors General of Civil Aviation, Asia and Pacific Region, New Delhi, 27-31 October 1997, at p. 2.
forms another core legal issue.\textsuperscript{33}

The important features of the CNS/ATM system are space satellites, radio frequency spectrum, and aircraft. The traditional air law does not enjoin rules governing space operations much less cover the use of the radio frequency spectrum. They come under the purview of the space and telecommunications laws. In determining the applicable legal order, conflict may arise between the air law acknowledging complete and exclusive sovereignty over airspace, the space law which includes the principle of navigation freedom in outer space, and the satellite communications law which again involves the use of outer space and is regulated by the International Telecommunications Union. This may, therefore, force a search of various laws for an appropriate approach to legal problems arising in the wake of the ICAO's CNS/ATM system.\textsuperscript{34}

This study summarily examines the relevant aspects of the space, telecommunications and air laws. They include the states' obligation to provide air navigation and universal accessibility to the CNS/ATM system, preserving the rights of the states, the ICAO's responsibility for SARPS, the legal regimes of the air and space laws, the determination of liability issues, and the institutional framework of the CNS/ATM.

A. The Legal Regime of Airspace and its Regulations

Of the two principal methods of creating an international law, custom and treaty, the first method has been less prominent in the


\textsuperscript{34}See Henaku, n. 112, p. 147.
regulation of human activities in airspace and outer space. Some writers, however, deem the principle of airspace sovereignty to have evolved as a new custom.35 But when air navigation first became a reality, four different theories were put forward on the legal regime of airspace.36 This battle of theories lasted only for a short time. It soon became manifest that the sovereignty over airspace was considered because of the inseparability of airspace and surface areas.37

In a century since aviation began, there were innumerable efforts to shape the legal regime of airspace. This is also closely linked to the legal status of aircraft, its nationality, etc. The nature of air sovereignty is not in any way different from territorial sovereignty. In both cases, the states are entitled to exercise their legal powers and carry out coercive acts to end other states' intrusion unless it is permitted by virtue of a customary or conventional law.38 There is still one aspect of air sovereignty to consider: what is its spatial extent?

First, the horizontal extent of air sovereignty: both the Paris Convention and the Chicago Convention contain articles defining the territory over which a state can claim air sovereignty, such as "land areas and adjacent territorial waters". On the basis of the states' practice, so it is concluded, a universal consensus exists, recognizing this rule as a

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36See (1) Free Air Theory, (2) complete sovereignty theory, (3) absolute sovereignty up to certain height, and above that level the air is free to all alike, (4) A state has sovereign rights in the suberjacent air space subject to right of free passage of all foreign non-military aircraft.

37See Goedhuis, n. 116, p. 257.

38Ibid.
general international law independent of any convention.\textsuperscript{39} On the vertical extent of air sovereignty, however, such consensus is lacking. Both conventions are silent on this aspect because when these conventions were adopted, the vertical extent of air sovereignty was not deemed to carry any practical importance.\textsuperscript{40}

After the Second World War and even before the advent of astronautics, several theories were proposed on the height of air sovereignty. Since 1957 when the first Sputnik was put into orbit around the Earth, the world community has renounced the rights of sovereignty over outer space; several of these theories thus do not have any more practical value.\textsuperscript{41}

The legal regime established by the Chicago Convention has two distinct aspects of aviation - economic and technical - for the purpose of regulation. Although having its basis in the first two chapters of the Chicago Convention, the structure of economic regulation is basically outside of it, i.e. in bilateral agreements based on the Bermuda Agreement. The technical side of aviation covers the provision of facilities and services to establish meteorological conditions, the establishment of radio contact, determining aircraft position and aircraft certification, and flight personnel. Indeed, one could suggest, the substance of the Chicago Convention is on the tactical side of aircraft operations. The corpus of legal and regulatory norms governing air


\textsuperscript{40}Ibid.

\textsuperscript{41}Ibid.
navigation is to be found in the convention, it annexes as well as the procedures for air navigation services (PANS). 42

B. The Legal Regime of Outer Space

The situation prior to the launch of the first satellite in 1957 may best be described as a "legal vacuum". During the early Fifties, a number of publicists held that outer space was a "res extra commercium," the "common property of all mankind", and subject to the principle of free and equal use, but state practice was too desultory to deduce the development of any customary rule. The state practice was almost wholly restricted to high-altitude flights, atmospheric balloons, and rockets. Not only was the legal status of space beyond airspace unclear, its point of commencement was left undefined, creating considerable uncertainties over legal implications of flights in upper regions of the atmosphere. 45

The first clarification of the legal status of outer space was provided in the UN GA Resolution 1721 (XVI) of 20 December 1961, which affirmed the applicability of international law, the freedom principle, and the non-appreciation rule. A more extensive affirmation was subsequently contained in the Declaration of Legal Principles of 13 December 1963. It reiterated the aforementioned principles as legal


rules in an attempt to clarify the legal status of outer space in view of the rapidly progressing uses of space.\textsuperscript{46}

The Outer Space Treaty 1967 further developed these early principles, making them legally binding. Although, as with any international convention, the treaty only has legal effect between the parties, its basic principles on the status of outer space can be regarded as part of the customary international law.\textsuperscript{47}

With the launch of the first orbital satellite in 1957 by the former USSR, \textit{ad coelum} as an infinite vertical continuation of airspace had to be viewed from a different perception by scientists and lawyers.\textsuperscript{48} The first contention relates to the leading principle applicable to outer space: the outer space - including the Moon and celestial bodies - is free from exploration and use by all the states and is not subject to national appropriation by the claims of sovereignty - or any means of use or occupation.\textsuperscript{49} Do not these two principal rules of international law constitute, as contended by a Colombian delegate during discussion in the United Nations Committee on Peaceful Uses of Outer Space (UN-COPUOS) on 23 June 1977, norms of peremptory international law and are they not binding on the states which have not registered with the space treaty 1967? The question is crucial in view of the provision laid down in Article 16 of the treaty, according to which any state may give notice of its withdrawal one year after its entry to the treaty.\textsuperscript{50}

\textsuperscript{46}\textit{Ibid.}, p. 318.
\textsuperscript{47}See \textit{Ibid.}
\textsuperscript{49}See Article 2 of outer space treaty 1967.
\textsuperscript{50}See Goedhius, n. 120, p. 380.
Immediately after the launch of the first spacecraft, it appeared as if the world would have to go through a period of state claim to sovereignty over parts of outer space, but a rapidly growing conviction emerged that though, with technical developments, it certainly should not be considered impossible for a state to exercise sovereignty over lower parts of outer space, the enormous potentialities of space activities could never be achieved by allowing sovereignty claims over this new medium. By denying the legality of such claims, it was realized, the interests of the world community would be best served.\textsuperscript{51}

The second issue sparking strong controversies concerns the extent to which the space treaty has restricted the discretionary powers of the states in exercising their freedom of exploration and use of outer space. On the one hand, a number of states and publicists have asserted that the rules of the treaty go beyond the familiar framework of ideas by which international restrictions until the conquest of outer space were governed, and that the treaty establishes the entire outer space as a common heritage of mankind.\textsuperscript{52}

On the other hand, eight equatorial states, in a declaration adopted in Bogota on 3 December 1976, stated that the international community was now calling into question all the terms of international space law which, according to them, was drawn up at a time when developing countries could not count on scientific advisory terms, prepared by industrial powers for their own benefit.\textsuperscript{53}

\textsuperscript{51}Ibid.

\textsuperscript{52}Ibid.

\textsuperscript{53}Ibid., p. 381.
These general principles govern each activity in outer space. To augment these and apply them to space exploration, the legal sub-committee of UN-COPUOS has formulated legal principles applicable to specific cases. Not all space activities, it is admitted, are as yet the subject of detailed legal principles. The temptation should, however, not be to eliminate the satellite-based air navigation system being considered as an item of study by the legal sub-committee. Whether the ICAO CNS/ATM system will be placed on the agenda of the sub-committee in terms of providing legislative principles will depend on the characteristics of the system, and the redress of a significant lacuna in regulations which the sub-committee is most competent to tackle. 54

C. Problems in Application of Air Law and Space Law

The FANS implementation involves the use of ground facilities as well as satellites orbiting in outer space. The regulation of operations involving satellites for aeronautical mobile satellite communications and global positioning systems would be beyond the scope of the air law. Legal experts have provided the following definitions of the air and space laws.

"Air law is the set of national and international rules concerning aircraft, air navigation, aero-commercial transport and all legal relations, public or private, arising from domestic and international air navigation." 55 The space law is "meant to regulate relations between


states to determine their rights and duties resulting from all activities
directed towards outer space and within it - and to do so in the interest
of mankind as a whole, to offer protection to life, terrestrial and
non-terrestrial, whatever it may exist". 56

Kolossov enumerates the following principles for the
international air law:
(a) the recognition of complete and exclusive sovereignty of each
state over airspace above its territory;
(b) the recognition of aircraft nationality in accordance with its
registration;
(c) the operation of scheduled international air services over foreign
territories with the special permission or authorization of
respective states;
(d) the freedom to fly over the high seas; and
(e) the collaboration of the states with the aim of promotion or safety
of flight in international air navigation. 57

The space law, however, according to the UN Legal
sub-committee, is based on the following principles:
(a) the prohibition of national appropriation of outer space and
celestial bodies;
(b) equal rights for all states to free use of outer space throughout its
continuity;
(c) the freedom of scientific investigations into outer space;

56Ibid.
57Ibid., p. 333.
(d) the preservation of sovereign rights of the states over space objects which they have launched; and

(e) the collaboration of the states to render assistance to the crews of spaceships in the event of an emergency.\footnote{Ibid.}

The question of boundaries between free outer space and sovereign airspace was first raised immediately after the launch of Sputnik I and has since been on the agenda of COPUOS for almost 30 years. The lack of any universally accepted definition of the constitution of activities free from national control is problematic. Our experience gained from remote sensing and satellite espionage highlights the controversial issues over the use of satellites for terrestrial missions. In essence, the application of the space law to these satellites has been opposed by the states. The freedom of space navigation may be applied to these satellites if specific conditions on the nature, purpose and operation of the mission are satisfactorily fulfilled.\footnote{Carl Q. Christol, \textit{The Modern International Law of Outer Space} (New York, 1982), pp. 435-521.}

In this context, the eventual implementation of the FANS necessitates a review of the elements of space law and their application. Issues do exist over the status of the space segment operator and the scope of satellite utilization. Clearly, the issue of an applicable legal regime will be resolved by the states through the ICAO, and its principal organs.
D. Satellite Communications and Legal Regulations

The major elements of satellite communications - space exploration and exploitation - are radio and satellites. The performance of a launch vehicle, functions of a satellite and transmission of messages via satellites between two or more places on the surface of the Earth are, of course, impossible without proper radio links, which must be free of interference. The protection against interference is provided by the international telecommunications law. Satellites are placed in space as an aerospace medium and are thus governed by principles of the aerospace law. The fact that telecommunication satellites may be used for Earth-bound activities does not remove them from this regime.60

The extensive need for international telecommunications has given rise to an international machinery for the co-ordination and regulation of this activity. The International Telecommunications Union (ITU) is the oldest specialist agency of the UN to regulate this activity. The object of ITU regulations and thus the telecommunications law is the management of radio frequency utilization.61 The radio spectrum, if not expendable, is in its accessibility a limited natural resource. Its usage is, therefore, strictly controlled.62

The allocation, allotment and assignment of radio frequency as well as the elaboration of a plan to effect the rational use of a radio

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62 Article 33 of the Nairobi Convention 1982.
spectrum is within the powers of the ITU. According to Article 4 of the International Telecommunications Convention, the ITU's purpose is "to maintain and extend international co-operation for the improvement and rational use of telecommunications of all kinds". The management of the spectrum and orbit is by a two-stage process of apportionment and control. The resources are "allocated" to different services, including aeronautical, space research and broadcasting, in the three ITU regions through inter-state negotiation and co-operation. The allocation of services is the basis and structure for detailed "assignment" and registration within the territory of individual states. Not only are the states responsible for the assignment, but they retain the powers to make domestic legislation determining the conditions for the use of assigned frequencies.

E. State Obligation to Provide Air Navigation System

Under Article 28(a) of the Chicago Convention, each contracting state has undertaken insofar as it may find it practicable to provide air navigation facilities in accordance with standards and recommended practices established under Article 37, 54 and 90 of the convention. The obligation of the states to provide these air navigation systems is not absolute but relative and is limited in scope and nature. The obligation

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63See Lyall, n. 42, p. 261.

64See n. 137.

65The allocating fora are the Administrative conferences. There are two main administrative conferences (a) World Administrative Conference and (b) Regional administrative conferences. The three regions are: Region 1. Africa, Europe, the Middle East, Mongolia and the USSR; Region 2 - The America, the Caribbean and Greenland; Region 3 - Asia Pacific Basin other than Hawaii.

stipulated in the Chicago Convention is limited to the territory of the states. The states do not have any pre-existing legal obligation to provide any facilities and services on the basis of either agreed regional air navigational plans or formal international agreements. The provision of facilities or services is based on the free will of states concerned. Even within a sovereign territory, the obligation of a state to provide air navigation system is limited to the extent of practicability. The convention does not decree any specific facilities and services as mandatory.\textsuperscript{67}

If a collectivity of states enters into an international cross-regional agreement, however, the agreement itself could contain the necessary provisions to provide the required air navigation facilities. The states could then adopt agreement ensuring a satisfactory solution to all the states concerned on the provisions of aeronautical navigation systems by satellites in airspace, which the international cross-regional agreement governs. The contracting states would obviously have to bear in mind the efficiency, financing and operational aspects of the new system.\textsuperscript{68}

F. Universal Accessibility of the ICAO's CNS/ATM System

The new CNS/ATM serves the civil aviation community as a whole, and its accessibility is of utmost relevance and concern to the states. The states have discussed the rights of access to the new work

\textsuperscript{67}M. Milde, "Legal Aspects of Future Air navigation System", \textit{AASL}, vol. xii, 1987, pp. 87-98.

ever since the start of deliberations on the concept. The FANS II committee, through a series of meetings, has set guidelines which specify universal accessibility as an acceptable institutional arrangement. Such accessibility was provided for air navigation safety services in early stages, and the principle of universal accessibility has been extended to the entire CNS/ATM system during the 10th Air Navigation Conference.

The FANS II committee reported: "[This] guideline is one of the fundamental (principles), underlying the philosophy of ICAO as the specialized agency of the UN for civil aviation." Moreover, Article 15 of the Chicago Convention stipulates that uniform conditions must be applied to the use of airport and air navigation facilities by national and foreign aircraft, with user charges subject to equal treatment for national and foreign aircraft engaged in similar international operations.

In space exploration activities - such as satellite communications and remote sensing which require global coverage - universal accessibility is duly respected through a "non-discriminatory distribution of and access to their product and services". In satellite communications, international organizations have been established to promote and facilitate satellite services to every state. Intelsat and Inmarsat function on the basis of non-discriminatory rights of access

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69 Special Committee for the monitoring and coordination of Development and Transition Planning for the FANS, ICAO Doc. 9623, FANS (ii)/4, 1993, at 8-1.


71 Ibid., p. 405.
consistent with Article 1 of the Outer Space Treaty. These organizations attempt to ensure universality through financing mechanisms, which offer similar services to all the states at reasonable rates regardless of the dense traffic area of a state.\textsuperscript{72}

Undoubtedly, any institutional arrangement supporting the CNS/ATM must guarantee network access to all the states involved in civil aviation.

G. Preserving the Sovereign Rights of States

Article 1 of the Chicago Convention stipulates that every state has complete and exclusive sovereignty over airspace above its territory. The restricted freedom of civil, non-scheduled flights apart, no international flights may operate over or into the territory of a state without its clearance. Under the Chicago Convention, the states have the rights and responsibility to regulate and control the provision, operation, and management of air navigation services within their territories. That a key aspect of the GNSS - the space segment - is generated by a satellite owned and operated by an agency different from the national civil aviation authority will not change such responsibility.\textsuperscript{73}

Each state enjoys the right to restrict international flights by various means: the establishment of prohibited zones, temporary restrictions on flights, designation of routes even for first and second freedom rights, defence interests over air space etc. The territorial principle governs the application of rules and regulations for flights and aircraft manoeuvres in a state. They include the admission to or

\textsuperscript{72}Ibid.

\textsuperscript{73}See 33rd DGs Conference, n. 113, p. 5.
departure from its territory of aircraft engaged in international air navigation. Each state has a right to designate routes to be followed within its territory by international air services, or airports any such service may use.\textsuperscript{74}

The FANS II committee has adopted the principle of territorial sovereignty as one of its guidelines for the provision of the AMSS at its second meeting. At its fourth meeting it acknowledged that the principle should be applied to all aspects of the CNS/ATM system. The "draft statement of overall ICAO policy on CNS/ATM systems, implementation and operation" - prepared by the ICAO secretary-general - expands such sovereignty and responsibility to include the co-ordination and control of communications. Hence, the guideline 1-4 specifies that the manner in which the responsibility of the states could be exercised in future must be considered in the light of the complexity of modern satellite systems often shared by the nations. A state may exercise control over its airspace through certification for AMSS service providers [their services comply with ICAO standards and recommended practices], and the requirement of non-interference with regulatory rights and responsibilities in the field of ATN.\textsuperscript{75}

Representatives at the FANS II committee's fourth meeting agreed that the international acceptability of the entire system rested on the equitable distribution of ownership, control and operation of the GNSS system among interested parties, especially the states and ATS authorities. The transcripts of the meeting indicate that the most important of the three factors to be distributed is the control of the GNSS.

\textsuperscript{74}See Hong and Shin, n. 151, p. 406.

\textsuperscript{75}Ibid.
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75Ibid.
Evidently, user states are interested in the degree of influence the ATS authority enjoys over standards, procedures, financing arrangements as well as the continuity, availability and quality of the essential services provided.  

The building of a seamless global CNS/ATM system requires the states to cede access to their airspace sovereignty because they can only reap the full benefits of the system through a co-operative framework for its implementation. The states have already ceded some measure of their airspace sovereignty, however, by acceding to the Chicago Convention and its substantial change of rights and obligations. Indeed, the contracting states agree presumptively to conform to the SARPs unless they see differences with the organization.  

H. ICAO Responsibility for SARPs

The system of international standards and recommended practices (SARPs), based on the Chicago Convention's technical annexes, supplemented by manuals and guidelines and subject to frequent updating, has been very successful in ensuring the safe operation of international civil aviation. Predictably, the implementation and operation of the CNS/ATM system must not impede the ICAO's competence in this realm. Article 37 of the Chicago Convention mandates the ICAO to adopt and amend from time to time the SARPs dealing inter alia with the communications system and air navigation aids so as to ensure the highest degree of uniformity. The FANS II

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76 Ibid., p. 407.
77 See 33rd DGs Conference, n. 113, p. 6.
78 See A. Hussain, n. 149, p. 47.
committee acknowledges this benefit to the civil aviation community, and unveiled at its fourth meeting a recommendation - the "timely production of procedures, specifications and standards and recommended practice".

Although much is being done to develop the SARPs for safety and non-safety communications, legal problems continue to persist. Moreover, the standards on aeronautical telecommunications, set to be included in the Annex 10 of the Chicago Convention, face the threat of deviation. This would greatly endanger the whole basis of Article 37, which seeks to promote uniformity in air navigation. The entire concept of future aeronautical CNS by satellite depends on the safety, regularity and efficiency of the system, which could be seriously undermined if the contracting states do not comply with the standards provided in the Annex 10. There is no sufficient legal basis for the ICAO in Articles 37 and 44, or the Annex 10 of the Chicago Convention, to force the states to use the new system.79 A new institutional framework has, therefore, to be considered.

In the ICAO CNS/ATM system, the SARPs would be of particular importance due to the complexity of technologies involved. All AMSS functions (ATS, AOC, AAC and APC) must be provided, for instance, by a given satellite in any region of the world to avoid the difficulties of installing multiple systems aboard an aircraft.80

79 Ibid.
80 See Hong and Shin, n. 151, p. 408.
1. Determination of Liabilities

The CNS/ATM system presupposes a multiplicity of participants - system operators, service providers and users, air traffic control authorities, etc., and such diverse array of actors obviously give rise to liability issues. The important features of the CNS/ATM system are space satellites, the radio frequency spectrum, and aircraft. The system involves the air, space and telecommunications laws, carrying different legal regimes. The settlement of liability claims in different spheres will prove a major problem for the future CNS/ATM system.

The basic air law rules governing liability claims for damage are stated in (a) the Warsaw Convention 1929, its other instruments, and (b) the Rome Convention 1952, and its Montreal Protocol 1978. The space law on liability consists of (a) the Space Treaty of 1967, and (b) the Liability Convention of 1972.

The liabilities in question fall into two theoretical categories: the liability resulting from the breach of a contract between two parties, and that arising from damage caused to a third party with the contractual arrangement of the parties. The third party liability issues can be resolved by domestic regulations, international conventions, the Rome Convention 1952, or the Convention on the International Liability for Damage Caused by Space Objects 1972; but a major concern exists over the former category.

Article 23 of the Rome Convention is applicable to damage caused to a third party on the territory of a contracting state by an aircraft registered in another contracting state. The 1978 Montreal Protocol has added a provision, stating that the convention is also applicable when damage is caused by an aircraft, whatever its
registration, whose operator has the principal place of business, or permanent residence, in another contracting state. 81

Unlike the Rome Convention, the liability convention does not impose territorial or geographical limits in its applicability. Nevertheless, some points remain unsolved, such as the claims of damage caused by space activities on the surface of the Moon, or celestial bodies. The only exceptions expressly recorded in the convention are that "the provisions of the convention do not apply to damage caused by a space object of a launching state to (a) nationals of that launching state, and (b) foreign nationals while participating in the operation of that space object".

The 1967 Outer Space Treaty's Articles VI and VII generally provide that nations are liable to damage caused by objects placed in space by them, or their non-governmental agencies. The applicability of Article VII seems focused on direct physical damage resulting from the launch of a spacecraft, and Article VI lays down important groundwork binding future international corporations like Inmarsat or Intelsat to the treaty obligations. The liability convention specifically sets out liability claims to those who place objects in space. The liability convention accordingly is more of an avenue for international claims. The convention makes a launching state absolutely liable to pay compensation for damage caused by its space objects on the surface of the Earth, or aircraft in flight. Interestingly, the launching state, otherwise absolutely liable, is to an extent exonerated if it can show that the damage has been caused by the gross negligence of the claimant, or its natural or juridical persons. 82

81 Diedericks, Verschoor, n. 136, p. 345.
82 Ibid.
Whereas the existing set of domestic and international norms govern the cases of air carrier's liability and product liability, the ICAO's CNS/ATM system brings new, as yet unresolved issues of liability to the forefront. The potential liability of space segment operators and CNS/ATM providers - data communications, navigation and information, for instance - has not been established. The multiplicity of nations should avoid any confusion over each party's liabilities.83

There is, it might be noted, no separate liability regime for any existing navigation aid. In any case, the study of air traffic control liability issue has been on the agenda of the ICAO's Legal Committee for many years, though it has a relatively low priority. Under the existing multilateral treaties, there is no direct mechanism by which a nation or party could hold the US/Russia liable to damage caused by incorrect signals.

J. Other Issues

The global nature of the CNS/ATM concept calls for more innovation and creativity than was needed in the past for air navigation systems in use so far. The new system should also take into consideration some emerging new issues including commercial interests of states; globalization of technologies; protection of sovereignty; defence and security interests of territorial states; prohibited areas; social service obligations of states; exercise of and control over freedom of the air; provisions of new technology in bilateral agreements; determination of routes and flight schedules; transfer of these new technologies to third world countries; and liability of international arrangements, etc.

83See Hong and Shin, n. 151, p. 409.
The new system remains a gigantic international undertaking - involving large capital injection, centralized control of vital elements, the possible unification of global airspace, and above all, consensus among the nations of the world of its universal acceptability. Perhaps the biggest challenge of ICAO and the international civil aviation world is to agree upon an integrated system that could be used worldwide and to formulate institutional, procedural and administrative regimes that would bind this system together.84

K. The Institutional Framework of CNS/ATM System

The new global CNS/ATM system has raised legal issues, requiring appropriate institutional arrangements to protect the rights of aviation administrators, international organizations, service providers, aircraft operators, consumers, and developing countries. The reason behind this is the new navigation system - potentially a single system based on the use of satellite technology - exceeds the boundaries of FIRs. With such system in place, national authorities won't necessarily provide services available in their airspace, but arrange for them to be provided by other states and entities. The new system could make ATS authorities dependent on third parties (i.e. other states and international organizations) and leave them without direct influence on service reliability of continuity and safety levels in airspace.85


85See Micke C. Altink-Pouw, "Perceived Obstacles to GNSS Institutional Arrangements can be Overcome in Near Future", ICAO Journal, December 1993, pp. 19 and 20, at p. 19.
Another most complex institutional issue deals with the implementation of the GNSS utilising GPS/GLONASS as the primary element because these are the systems provided by a single state for purposes other than civil aviation. Although the provider states have declared that position determination signals will be provided for a significant period without charge to users, some states are concerned that adequate priority and availability could not be given to civil aviation requirements in times of conflict.86

The FANS committee has been working since its inception to provide a suitable institutional framework in this regard. The FANS phase I committee, at its second meeting in 1985, concluded that the institutional management of global air navigation system deserved early attention.87 The committee's third meeting in 1986 reviewed information on international institutions and management aspects of the future CNS system.88

The terms of reference of the FANS phase II directed the committee *inter alia* to make recommendations for acceptable institutional arrangements on funding, ownership and management of global air navigation. The committee formed the working group I to address these issues. During the first two meetings on the FANS phase II, the committee developed Aeronautical-Mobile Satellite System (AMSS) institutional guidelines, AMSS scenarios, implementation options, contracts, check lists, and a CNS/ATM cost-benefit analysis. The guidelines, based on the opinions expressed by the states and


87ICAO Doc. FANS(1)/2, Report 1985, paras 61-65.

88ICAO Doc. FANS(1)/3, WP/32, September 1986.
experts in different fields, were recommended for approval by the legal committee at its 28th session in May 1992. After their approval by the ICAO legal committee, the FANS committee classified the guidelines into two types: those in the realm of the CNS/ATM and those applying directly to the AMSS and GNSS.\textsuperscript{89} The third meeting of the FANS phase II, held in Montreal from 30 March to 15 April 1992, assigned the following programme to the working group I for institutional arrangements:

(a) further development of a long-term strategy for the GNSS;
(b) a study into various options for funding and cost recovery in the GNSS;
(c) the establishment of working group I, a sub-group to study institutional issues of the ATN;
(d) the continued examination of the ICAO's role in the implementation of the CNS/ATN system; and
(e) investigation into ways and means of augmenting the ICAO's role in the ITU's frequency co-ordination process.\textsuperscript{90}

The ATN's sub-group was established to pursue the institutional arrangements. The first meeting of the ATN sub-group was held in Montreal from 19-23 October 1992. The terms of reference were reviewed and, it was noted, there were other items which could be considered: ownership, corporate control, capital financing and user charges, standardization and standards, regulation by the states, liability,

\textsuperscript{89}See Hong and Shin, n. 151, p. 403, 1994, p. 403.

\textsuperscript{90}See ICAO, Doc. 9623, FANS(ii)/4, 6-1.
relationship to commercial facilities, and implementation options. The meeting zeroed in on the following institutional issues:

(a) policy and regulatory issues;
(b) implementation issues;
(c) strategic co-ordination issues; and
(d) tactical management issues.

The meeting also identified five key issues to be dealt in preparation for the fourth meeting of the FANS II Committee:

(a) GNSS strategy to achieve early service benefits;
(b) the early development of ATN standards and recommended practices, identification of institutional issues, qualification and certification of ATN components;
(c) the co-ordination of AMSS implementation between user airlines and civil aviation administrations;
(d) standard methods for a cost-benefit analysis; and
(e) The ICAO's role and supporting activities for the progress of global CNS/ATM systems in the post-FANS era.

The fourth meeting identified the following key issues, with discussions proceeding on this basis:

(a) the early introduction of the GNSS using GPS/GLONASS;

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91Ibid., 6-3.
92Ibid.
93Ibid., 6-5.
(b) the development of a GNSS implementation strategy for medium- and long-term use;

(c) the clarification of the elements of GNSS ownership, control, agreements, contracts, and regulations;

(d) the institutional co-ordination of GNSS augmentation systems;

(e) the endorsement of the ATN guidelines and scenarios;

(f) the acceptance of ARINC specification 622 on migration path to the ATN, and

(g) documentation supporting acceptable performance and efficient use of AMSS facilities.

The Chicago Convention described the relationship involving the governments, the international community and the operators. The SARPs provide a mechanism for policymaking. The current civil litigation and claims systems handle liability issues with some efficiency. The market will determine the GNSS's acceptance and to what extent other redundant systems can be decommissioned. Multilateral mechanisms may arise to build a follow-up to the GPS and GLONASS as initial signal providers. Finally, the ICAO Legal Committee will work to give shape and meaning to institutional arrangements, but the main work of implementing the CNS/ATM will continue to consist of technical efforts in the ICAO and policy planning in the member states.
V. Application Of Satellite Technology And Airspace Management In India

A. New Aviation Technologies and Problem of Third World Countries

Rapid advances in science and technology have great potential to benefit mankind. Paradoxically, industrialized nations continue to dominate science and technology, undertaking nearly 95% of all research and development. The Third World, on the contrary, despite representing 70% of the world population, has only 5% of the global research and development under its control.94

Professor U.R. Rao, of India, in his speech to the COPUOS on 18 June 1992, said the greatest problem the world had faced yet was chronic hunger. The developing countries -- they occupy less than 55 per cent of the world geographical area -- suffered, Professor Rao argued, from serious shortages of resources and capital, lack of trained manpower, widespread illiteracy, low agricultural output, poor communications infrastructure, industrial backwardness, and exponential population growth. Recurring floods, drought and earthquakes, mismanagement of basic land and water resources, and increasing desertification and deforestation had further eroded the very survival of developing societies.95 They were facing, he said, a grim future, which could, of course, be alleviated by the application of space technology.


Modern aviation involves a worldwide system of sophisticated computers, radars, and communications technology, in addition to the expansion of airports. The reality, of course, poses a particular challenge to the small and developing nations, hard pressed to catch up with the latest technology.\textsuperscript{96} The expanding technologies of civil aviation, besides the deregulation and privatisation of the aviation industry, have caused serious economic and financial problems to the third world. These problems include state ownership or government interference in the decisionmaking of airline managements, shortage of capital required to buy modern and fuel-efficient aircraft, high fuel prices, inadequate airport and aircraft maintenance facilities, and lack of well-trained management staff and specialists to cope with modern technologies.\textsuperscript{97}

In most developing countries, the inefficiency of transport services can be attributed not merely to the lack of adequate funds, but to the scarcity of qualified and well-trained staff. These nations, despite the availability of scarce funds, indeed lack trained personnel to instal, operate and repair upgraded systems. There are not enough staff to operate the civil aviation infrastructure much less maintain it. The trained personnel are often so preoccupied that they cannot be relieved of duty to take advanced training. Even when governments train them at huge costs, they are lured to lucrative jobs in advanced countries. Some governments - including India - have sought to end this drain of trained staff by requiring them to sign agreements for advanced training


\textsuperscript{97}A.D. Groeneweg, "More efforts should be directed towards improving aviation infrastructure in Developing Countries", \textit{ICAO Journal}, December 1996, p. 22.
only if they remain in government service for a fixed number of years. This approach, though sound in theory, has not proved practically effective because many staff flout the agreements.98

A recent study by the ICAO estimates that the world will need to invest more than US$1,000 million (at 1991 prices) over the next 20 years for airline fleet replacement and expansion as part of airport infrastructure. The investment will amount to about US$800 billion for about 1,100 new aircraft, and between $250 and $350 billion for new and upgraded airport infrastructure and airways facilities over the next two decades. The ICAO moreover estimates that the developing countries' investment in aircraft over the next 20 years will be about 2.7 times higher than the financing requirements of the previous 20 years.99

The participation of the developing countries' airlines in international air transport is also affected inter alia by arbitrary taxes and fares, excessive fees and user charges, and access to convenient slots and airports. The well-established airlines are continuously seeking new ways and means of consolidating their stakes on the market through total or partial mergers, buyouts, joint market agreements, and co-operative ventures. The new restructuring of the aviation industry thus will have an adverse impact on the developing countries.100

B. Airspace Management in India

Airspace management is an intricate process involving the

98 See Philippe Rochat, n. 177, p. 56.
99 See Investment Requirements for Aircraft Fleets and Route Facility Infrastructure to the Year 2010. ICAO Circular 236/AT/95, p. 17.
100 See Outlook for Air Transport to the Year 2003. See ICAO Circular 252/AT/103, pp. 21-23.
establishment of ATS routes, airways, controlled airspace, etc., supported duly by adequate communications, navigation and surveillance facilities, and air traffic management units. The escalation in fuel costs and an overall surge in operational expenses have forced an awareness on airline operators about the efficient global airspace management.\textsuperscript{101} The adoption of relevant ICAO standards and recommended practices, or the formulation of state standards, for the purpose helps implement an effective airspace management system.

Many measures are required to establish airspace management. They require that the airspace should be defined in terms of lateral and vertical limits, and that different types of services be provided within those limits. The rules and regulations governing the operation of flights within, across and into such airspace have to be framed and published. ATS routes operating aircraft from one aerodrome to another should be established and radio navigational aids essential to aircraft guidance installed so as to enable a flight to stay within the specified limits of established air corridors. A unit or number of units must be set up to provide air traffic control and flight information services, search and rescue services, etc., and these units must be manned by adequately qualified and trained personnel. Since the operation of international flights involves flights through the national airspace of several states and the high seas, it is but natural that rules and regulations governing such operations should have global application.\textsuperscript{102}

\textsuperscript{101}See M.S.G.K. Warrier, "Air Space Management - Need for Coordination", R.P. Anand et al., eds, Recent Developments in Civil Aviation in India (New Delhi, 1987), pp. 211-14 at p. 211.

The situation of Indian airspace is significant for the world air map. The ICAO's air traffic services have allocated to India a very large airspace at 60 degrees east longitude of the western boundary and 94 degrees east longitude on the eastern limit, extending from the Himalayas in the north to 10 degrees latitude (south of the Equator) in the south for the provision of air traffic services. The air traffic in this region is very enormous and situated on busy trunk routes connecting Western Europe to Australia, Singapore, and Japan. The air route also connects West Asia through Pakistan, Afghanistan to India and beyond towards the east, connecting Malaysia, Hong Kong, Singapore, etc. The night curfew imposed in the east and the west makes air traffic in Indian airspace busy during nights. The day traffic is largely domestic. India, a member of the ICAO, has a duty to provide air navigation services to all aircraft flying through its airspace.

India occupies a strategic position vis-a-vis international air traffic between the west and the east. The most prominent of busy international ATS routes are: R 219 from Mumbai to Sharja with an average of over 300 flights a day; B-466 from Mumbai to Kuala Lumpur via Chennai with over a 150 flights operating on this route; B-457 from Belgaum to Oman established as a bypass route to reduce congestion on R-219 within the Mumbai terminal area and thus permit almost unrestricted climb and descent to departing and arriving flights in addition to improving the availability of optimum cruising levels to flights; G-450 from Calcutta to Mogodish via Mumbai; R-461 from Mumbai to Colombo; G-8 from Mumbai to Ankara via Karachi and

103 Aircraft Manual India (Revised Edition 1995), Section RAC.
Tehran; R-468 from Mumbai to Bangkok; R-452 from Delhi to Tehran and Jeddah; and R-460 from Delhi to Rangoon via Calcutta.\(^{105}\)

In order to ensure that specified ATS routes are available for the operation of domestic flights between a large number of domestic and international aerodromes, over 60 such routes have been established within Indian airspace so far. Some of them no doubt link more than two aerodromes, stretching from one corner of the country to another. The important domestic ATS routes are: W-15 from Mumbai to Thiruvananthapuram; W-19 from Delhi to Chennai; W-13 from Mumbai to Ahmedabad; W-10 from Mumbai to Indore and Bhopal; W-56 from Mumbai to Bangalore via Belgaum; W-21 from Calcutta to Chennai; and W-61 from Mumbai to Rajkot and Jamnagar.\(^{106}\)

C. Application of Satellite Technology in Indian Civil Aviation

Air traffic controls in India are currently based on conventional ground-based CNS aids - comprising VHF/HF ground-to-air communication-navigational aids like non-directional beacons (NDBs), very high-frequency omni ranges (VORs), distance measuring equipment (DME), instrument landing systems (ILS), and radars for \textit{en route} and terminal surveillance and control. It is to be noted, however, that despite huge outlays made to cover the entire airspace with these aids, poor time response, poor quality in communications, range limitations and inefficient airspace utilization have primarily constricted these aids.


\(^{106}\)Ibid.
This necessitates the consideration of satellite technology to supplement/complement the existing system, if not to replace the latter, in order to provide smooth transition and mitigate these limitations. In view of the nature of India's airspace, this will provide not only the surveillance of the total area but better control over air traffic, particularly oceanic areas, thus reducing route mileage and accommodating greater traffic densities.107

India has been following international developments in satellite technology for civil aviation with a view to adopting satellite technology. An inter-agency steering committee on radio determination satellite service (RDSS) was set up, and a system known as SARST introduced in the country in 1989 in collaboration with the SARSAT club. With the active involvement of the Indian Space Research Organisation (ISRO), a plan is being launched to implement the wide area augmentation system (WAAS) for Indian airspace. The plan envisages that one or two satellites of Insat-3 series could carry a navigation payload. The ranging stations will be established by ISRO, and the Airports Authority of India (AAI) provides an optimum network of range and integrity monitoring stations. The European Space Agency, engaged in setting up a similar network for Europe, has also been approached for mutual co-operation in this effort.108

India has been actively participating in the ICAO's FANS committee since its inception, which is working to evolve technical and operational aspects of satellite applications for the CNS. The

10833rd DGA Conference, "Implementation of CNS/ATM programme in India", n.113, p. 5.
commitment to the FANS, CNS/ATM systems, and air traffic modernization must, therefore, deepen to meet the soaring demand for air transport services in India; and the AAI has nevertheless, drawn up a detailed plan for the development of its infrastructure. India, at the 10th Air Navigation Conference in Montreal in September 1991, endorsed the FANS concept to implement satellite technology for CNS/ATM in civil aviation in a phased manner. India's position at the conference was to approve a switch from the existing terrestrial-based CNS system to the satellite-based CNS system. The Government of India has been contemplating introducing the future CNS system in a timeframe developed by the ICAO.

Since the adoption of the ICAO's CNS/ATM global implementation plan in October 1993, planning has commenced in India with to develop a national CNS/ATM blueprint. Much work progressed in preliminary stages to identify needs and evaluate technology options and costs. The long-term vision of the ATM system and operational concepts have been the driving force in the choice of technologies proposed for development in Indian airspace. A phased approach has been adopted in the implementation of the future CNS system to mitigate risks and ensure the early availability of new technologies. The transition has been planned through the augmentation and better use of the existing facilities, followed by initial CNS/ATM functionalities which could, when upgraded and integrated, provide full CNS/ATM capabilities in progression to a free flight scenario.¹⁰⁹

¹⁰⁹Ibid.
The AAI, in its push for communication, navigational and surveillance infrastructure technologies, has drawn up a detailed plan for 2010. The preparation of the plan is guided by the ICAO's CNS/ATM global planning in conjunction with Asia-Pacific regional planning. The main objective of the AAI's CNS/ATM plan is to provide foundation for an integrated, long-term development of global CNS/ATM systems aimed at achieving seamless operations.110

The AAI has embarked on the upgradation of conventional navigation and surveillance facilities to manage the current and future air traffic growth. The ongoing projects involve the augmentation of the instrument landing system (from 29 to 34), very high-frequency omni range (55 to 63), and high-power distance measuring equipment (41 to 59). The state-of-the-art airport surveillance radar (ASR), and secondary radar with Mode-S capability are being installed in Hyderabad, Thiruvananthapuram, Ahmedabad, and Guwahati for the first time. The installation of these radars will enhance flight safety and fuel saving by aircraft.111

The ATS are being modernized at Mumbai and Delhi international airports to match with the best technology found anywhere in the world. The project involves the automation of the ATC systems using essential navigation aids, primary/secondary radars, and computers. The handling capacity of both these airports would increase and expand from the current average of eight to 10 flights an hour to around 40 flights an hour with the establishment of ASR-MSSR

110Ibid.
111"AAI : Meeting the Challenges", Indian Express (New Delhi), (Special issue on Civil Aviation), 15 December 1995.
at these airports. Raython, a worldwide supplier of ATM automation and radar equipment, is conducting ADS/FANS trials for the AAI as part of the ATS/modernization. The contract for the modernization of air traffic services - Mumbai-Delhi (MATS-BD), Delhi-Mumbai international airports - will include the FANS I and ADS functions. The objective of these trials, including both ADS and CPDLC operations, is to define requirements, train operators, optimize HMI aspects, and develop operational procedures. The ADS trials of work station will be based on hardware from the actual delivered automation system. The addition of this capability to the Delhi-Mumbai automation system will provide a critical extension of the evolving FANS I routes from the Bay of Bengal to Europe, helping to reduce air traffic congestion and increase safety in Indian airspace.

The existing land-based system does not offer extended coverage to the oceanic airspace of the Bay of Bengal and the Arabian Sea, so satellite-based ADS systems are proposed. One such stand-alone CNS/ATM system has already been installed at Calcutta airport. Integrated ADS/FDPS operational systems are scheduled for commissioning at Chennai and Calcutta airports. Further seamless ADS operation AIDC is also planned. The ADS facility will also be installed at Delhi and Mumbai airports by March 1999.

112See The Hindu (New Delhi), 5 June 1995.


114See 33rd DGs Conference n. 113, p. 7.
VI. Conclusion

The idea of using space technology in civil aviation dates back to 1940s, yet it received an impetus only in the late 1950s with the dawn of space age. In the 1960s and 1970s numerous successful attempts were made by the ICAO and other international organizations like Inmarsat, Intelsat, the ITU, and the WMO, and satellite technology was utilized fruitfully for communications, navigation, surveillance, air traffic control, airspace management, etc. Its shortcomings, however, started showing up in the 1980s due to unprecedented growth in air traffic and cargo, emergence of hitech aircraft, and liberalization of the aviation industry. These factors impelled the ICAO to identify and assess new concepts and technology, which will serve aviation globally well into the 21st century.

The ICAO's future satellite-based CNS/ATM system is the key to worldwide improvements in communication navigation, surveillance and air traffic management. The major thrust of change is the shift from ground-based to satellite-based systems, individual to global orientation, and analogue to digital technology. Airborne GPS and GLONASS, combined with satellite communications, could substantially reduce route distance, cut down operational costs, improve accuracy, coverage, safety and reliability, and flight management. The new technology benefits the airlines, pilots, controllers, and the entire aerospace industry. It has the ability to provide on-board reservation, access to various information services, telephone networks, and expanded cabin service to the consumer. The new technology will also enable passengers to transmit personal computer information through a worldwide public telephone data network.
With the implementation of the CNS/ATM system, the impact of space satellites will not only be felt on the technical side of air navigation but on its legal framework. It implies the active intrusion of space and telecommunications laws into aviation regulation. Thus an appropriate legal framework has to be found to regulate the new system. Institutional competence, regulatory objectives of the law and the role played by the CNS/ATM system dictate that the space and telecommunications laws should serve to complement the air law in regulating the new system. Thus the search for solutions should not be limited to the air law only.

India is a member of both the ICAO and FANS committees. It has been following the developments and assessing the prospects of satellite technology applications in civil aviation. It is implementing the new technology to achieve a transition from the existing terrestrial-based CNS system to the satellite-based CNS system in an evolutionary manner with suitable institutional arrangements, ensuring the reliability and integrity of satellite service. It cannot be denied, however, that in the beginning the developed countries will benefit in a major way by the introduction of this new technology to the neglect of the developing countries. The developing countries have far too many problems - lack of finance, high fuel prices, inadequate infrastructural facilities, limited staff, and poor technical knowhow - to implement this new technology. The situation may improve with more co-operation between the states and international organizations [in expertise and resources] on the one hand, and the developing countries on the other.