Map Asia 2004 Beijing, China

COMMUNICATION NAVIGATION SURVEILLANCE / AIR TRAFFIC MANAGEMENT (CNS / ATM) BEYOND 2012

Arjun Singh, Airport Authority of India

Introduction

The aviation industry plays a major role in world economic activity and remains one of the fastest growing sectors of the world economy. The need for change in the current CNS/ATM is due to two principal factors: Due to inherent limitations in the current system, it will not be able to cope-up with the growing demand of air traffic; and the need for global consistency in the providing air traffic services (ATS) while progressing towards a seamless CNS/ATM system. To maintain vitality of Civil Aviation, it has to be ensured that efficient, safe, secure and environmentally sustainable air navigation is available at the global, regional and national levels. This requires the implementations of a CNS/ ATM system that allows maximum use of enhanced capabilities provided by technical advances. In the technical advancement, the Global navigation satellite system (GNSS) has played the major role to change the scenario of the aviation industry and some of the forthcoming technology is being developed based on GPS technology for accurate positioning information which support the non- precision approach (NPA) and precision approach (PA) in all phases of flight.

Emerging New Concepts on CNS/ATM:

The following new emerging concepts may prove as performance measurement gauge for CNS /ATM system:

i. **Required Total System Performance (RTSP) concept:** It is sum total of several components, such as airspace, flight operation and facilities/services provided. The required communication performance (RCP) and required surveillance performance (RSP) concept, which are being developed together with, required navigation performance (RNP) would be the intended basis for RTSP.

ii. **Required Communication Performance (RCP) concept:** It refers to a series of communication performance requirements defined in terms of capability, availability, error averaging, traffic delay etc. A given airspace, any communication system or combination of the systems that complies with the specified parameters can be considered operationally acceptable.

iii. Required Navigation Performance (RNP) concept: It is classified according to the flight path limits measured in nautical miles (NM) within which the aircraft should remain. Aircraft should be capable of maintaining that navigation precision with 95% probability. As a result, lower RNP values are equivalent to narrow limits near the boundaries of the terminal area.

iv. Required Surveillance Performance (RSP) Concept: It defines the surveillance requirements according to the airspace involved. The surveillance system must provide the updated aircraft position in order to ensure a safe separation. In low- traffic oceanic / remote airspace, position information should be updated every 12 seconds. In high-traffic airspace, position information should be updated every 4 seconds. The surveillance system should allow users to select the preferred en-route flight path and conform fully to emergency procedures, contribute to search and rescue operations, and to allow for the application of separation in a defined airspace.

v. Free Flight/Autonomous Flight:

It is developed in the United States and originally conceived to give aircrafts more maneuvering capacity, with the support of available new technologies. It also emphasized the need for users to decide their own schedules, routes, and altitudes, thus reducing delays and cost involved.

1.0 COMMUNICATION SYSTEM:

In future, voice communication will be used for critical messages, such as vectoring to avoid traffic and landing clearance at airports with heavy traffic. It will serve as back up for data link. VHF analogue radios available today are not compatible with upcoming new technology. The VHF Data Link (VDL) operation requires a VHF digital radio (VDR). VDL is essential for ATN implementation and consequently, for greater use of ATS data links. The availability of airborne equipment manufactured in series, including digital radios, will make it possible to equip a larger number of aircraft. The VDL formats specify a protocol for delivering data packets between airborne equipment and ground systems similar to that used in the aircraft communication addressing and reporting system (ACARS). The difference is that the VDL provides a capacity 10 times greater than the equivalent of 25 KHz VHF channel.

VDL Mode 1: The use of VHF analogue radios for data exchange was started by air lines in the late 70s. Current air borne radios have been used to transmit data between operators and their aircrafts by means of special ground-based stations and interconnection networks. The so-called ACARS system has been developed and has grown considerably, with limited use for ATC communication. This mode has been especially designed to use ACARS modulation equipment and radio. ACARS and VDL mode-1 is a low speed bit oriented data transfer system. It uses carrier sense multiple access (CSMA) methodology. The new development has overtaken VDL mode-1 and is no longer in use.

VDL Mode -2: It is improved version of the VDL- Mode 1 and also uses same technology, but is not capable of handling voice communication. Average data transmission is 31.5 kbps. It employs a globally dedicated common signaling channel of 136.975 MHz. Limited commercial service are available at this time, as aircraft operators and service providers are able to introduce new equipment.

VDL Mode 3: It is an integrated digital data and communication system that makes it possible to use four radio channels on a carrier (with a 25 KHz spacing). It uses a data link technology called TDMA. The data capability provides a mobile sub network i.e. compliant to aeronautic traffic network (ATN). It is presently is not available for operational use.

VDL Mode 4 : It also has navigation and surveillance capabilities and uses a data link technology called self-organizing time division multiple access (STDMA). In this mode station, stations transmit their geographical position together with data message in time slots that are dynamically modified at frequent intervals.

Before starting a transmission using the STDMA technique, the aircraft keeps listening watch on the frequency to be used and establish a track and a table of time slots of all other aircrafts. An algorithm in the aircraft transceiver selects a free slot or takes the slot of the most distant aircraft. This modulation system allows distant stations to transmit in the same slot with a minimum of interference. STDMA does not have voice communication capability. In this mode aircraft is not involved in any manual frequency tuning for any station change. Even so, reception of the geographic position of other aircraft gives a surveillance capability, which is candidate technology for ADS-B operations.

1.1 Data Link:

Data link is the basic component of communication between air traffic controller (ATC) units and aircraft. Data links were initially used only for ACARS communications but new equipments are compatible with ATN communications, which will improve the efficiency and compatibility of aeronautical VHF data channels. There are two types of ATS data links: one for the exchange of text message and the other for more complex and computer processed message for future air navigation system (FANS) uses, which employs ACARS data links.

i) **MODE-S data link**: It allows for an air-ground data link whose use is particularly indicated for airspace with traffic of high density. It can also operate in a mixed environment, in which aircrafts are equipped with transponders of different data link capabilities to fly.

ii) **HF data link (HFDL):** The feasibility of using HF data links for ATC communication has been demonstrated The propagation anomalies rarely affect the entire HF frequency band, it is possible with carefully sited system of well connected ground stations with a number of adequate frequencies available in the HF band, to find best frequency for transmission of data packages anywhere and at any time. HF data link is also an excellent stand by system for aeronautical mobile satellite system (AMSS) in oceanic / remote areas. In this mode aircraft can contact three or more HFDL ground station constantly and its hub can become ATN routers.

iii) **Controller-Pilot Data Link Communication (CPDLC)**: It is the means of communication between the controller and the pilot that uses data links for ATC communication. In the area where CNS/ATM routes are built and where airspaces exist, that are outside HF communication range, CPDLC is the primary means of communication supplemented by HF and voice satellite links. Messages may be composed through individual utilization or a combination of upto five message elements for clearance, pre-departure clearance, and message related to ATC. The CPDLC will resolve number of flaws in the existing system e.g. it will provide an automatic data entry capabilities, which will permit ground systems and airborne flight management computes (FMC) to enter critical information, such as the flight routes etc. This will cut down on errors caused by manual data entry. It will also permit a significant reduction in transmission time, thus reducing the congestions and will eliminate misunderstanding due to a deficient quality of the voice received, propagation problems, dialects and the possibility of having instant access to previous voice transmission recording.

In future the CPDLC may be the primary means of communication, all aircraft should be also be advised of appropriate voice communication frequencies. Aircraft communication via CPDLC should only be done with the appropriate ATC unit for it route segment, otherwise request may get rejected due to absence of corresponding flight plan. The pilot initiates the CPDLC procedure by sending a contract message containing the four-letter ICAO site designator of the ATC unit. The latter will respond with an acknowledgement message. When an aircraft enters into airspace where CPDLC is used, the pilot has to send a contract message between 15 and 45 minutes before entering. An automated ATS system will not consider log-on attempts if the flight number or registration used for contract are not exactly the same as those indicated in the flight plan. Under normal conditions, the relevant ATC unit initiates the CPDLC disconnect sequence, sending an uplink **end of service** message. In response to this the airborne equipment sends a downlink **disconnect** message. Now next ATC unit can exchange the CPDLC message with the aircraft.

1.2 Data Links between ATS Units (ADIC)

The ADIC offers the means for exchanging data during the reporting, co-ordination, and transfer of control phases. ADIC use will largely reduce the need for voice co-ordination. ADIC message format and procedures are designed for use through any ground-ground circuit, including the AFTN and the future ATN. The means of communication for transmission of AIDC messages can be AFTN, ATN and Dedicated data network.

1.3 Aeronautical Mobile Satellite Services (AMSS)

The radar surveillance system and VHF communication equipment are limited to line-of-sight, they are not usable for surveillance and communication over oceanic or desert regions; further, they require many means of support, such as electric power and maintenance. In addition, HF communication is not fully acceptable because it is unsafe, of medium quality and requires too much technical support. Satellite communication on the other hand can provide high-quality voice and data communication services instantaneously, irrespective of the type of air space involved.

The AMSS provides digital voice and data services using geo-stationary satellites to aeronautical users and operates in the mobile satellites service portions of L-band from 1545 to 1555 MHz and from 1646.5 to 1656.5 MHz. AMSS is also designed to be a sub-network of the ATN and can support ACARS messages. The digital voice component of AMSS is designed to interface with terrestrial public switched telephone network (PSTN) and to provide high quality telephone service both for aeronautical passenger communications (APC), ATS & Aeronautical operational control (AOC). Geo-stationary communication satellite is designed especially for mobile communication offers near-global coverage for both voice and data communication channels.

1.4 Aeronautical Telecommunication Network (ATN)

The various communication sub-networks (AMSS, VHF data, Mode S data link etc) will be interconnected through ATN. The satellite assisted air navigation system concept supported by ICAO allows for more efficient use of the CNS in assisting the migration towards an ATC that is fully integrated with the ATM concept. In computer data interoperation terminology, the necessary infrastructure for supporting the interconnection of automated ATM system is called inter-network. An inter-network involves the interconnection of computers with gateways or routers through actual sub-networks. This make possible to build a virtually homogenous data network in a common environment from both the administrative and technical viewpoints.

The ATN has been defined as an inter-network architecture shown in Fig-1 that allows for the interoperation of the ground, air-ground and avionics data sub-networks through the adoption of common interface and protocol services based on the International Standardization Organization (ISO) open system inter-connection (OSI) reference model. The ATN is designed in such a way that it can offer communication services to different groups of users such as: ATS, AOC, aeronautical administrative communication (AAC) and passenger aeronautical communication (PAC).

In designing the ATN it is essential to understand how data link communication can interconnect with end systems, both airborne and ground based. It is therefore necessary to define the operational utilization of data messages. Although as stated above before, different system user groups can be identified, priority should be given mainly to ATS service users. Use of data communications for ATS purposes can vary significantly.

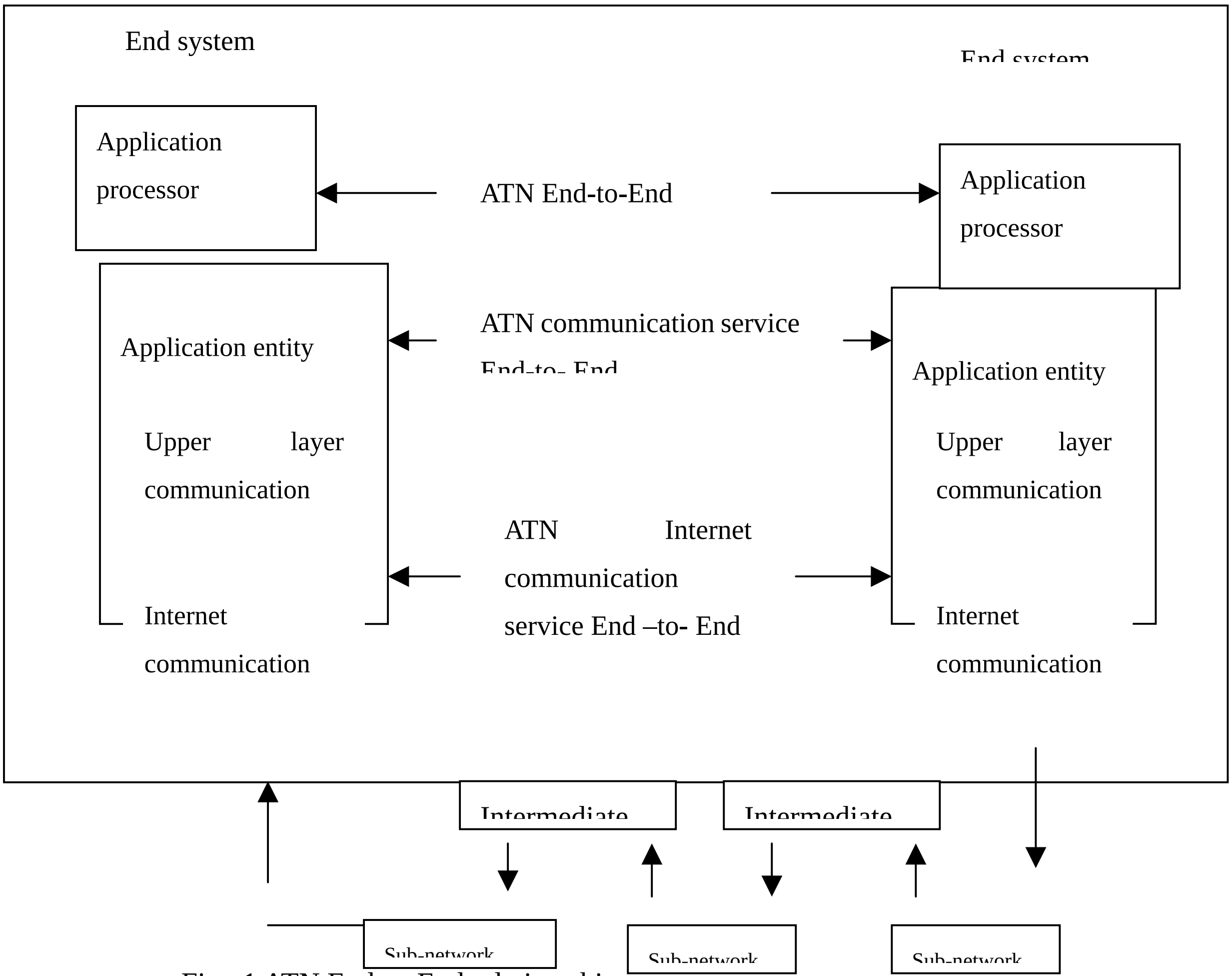

Fig –1 ATN End-to-End relation ship

Figure – 1 ATN end-to-end relationship

2.0 NAVIGATION:

Future navigation technology will definitely improve the accuracy of position determination and to provide better predictions of future position to enable aircraft to fly more accurate and well-defined profiles. Improvement in position accuracy is also a prerequisite for the introduction of reduced separation minima. The GNSS is the solution for seam less navigation.

2.1 Global Navigation Satellites System (GNSS)

The term GNSS is generic name used by ICAO to define any world-wide positioning and time-determining system that includes one or more satellite constellations, aircraft receivers and various integrity monitoring systems including the required augmentation system for meeting operational performance requirements. The core constellation of the GNSS is GPS, GLONASS and Galileo (in future).

2.1.a Global Positioning System (GPS): The GPS is a satellite-based radio navigation system that provides its users with high precision position and time information over the entire globe. The space segment is composed of 24 satellites with a useful life of approximately 7.5 years, arranged in 6 orbits of four satellites each at an altitude of 20,200Km. The system is divided into three segment i.e user segment, ground segment and space segment. The user segment consists of the antenna and the processor receiver for receiving and processing the navigation solutions used to provide it with the precision position and time. The GPS satellites are positioned in very precise and predictable orbits. The GPS satellites orbit the earth every 11 Hrs 58 Minutes and pass over some of the monitoring station at least twice a day. These stations are equipped to calculate satellite positions with precision and to uplink the corrected information to them. GPS satellites send information to the receiver of their position with respect to the center of the earth, together with the time signal.

The airborne receiver uses this information to calculate a position with respect to the surface of the earth, which will be presented to the user in terms of latitude and longitude. The GPS satellites use 1984 geodetic coordinate system (WGS-84) i.e. this coordinate system was adopted by US in 1984.

2.1.b Global Orbiting Navigation Satellite System (GLONASS)

The Russian Federation has implemented the GLONASS, its concept quite similar to the GPS

with different signal processing techniques. It provides for space signals to be sent to properly equipped users for precision determination of position, speed and time. The space segment consists of 24 satellites orbiting at an altitude of 19,100 Km with an orbit period of 11Hrs and 15 minutes. They are distributed into 3 orbits of 8 satellites each with an operational life of 3 years (5 years improved version GLONASS-M)

The ground segment fulfils satellites monitoring and control functions at same time it selects the data to be modulated in the encoded signals sent for navigation purposes. This segment includes the master station monitoring and information delivery stations. The measurement data from each monitoring station are processed at the master station and used to compute the navigation data down linked to satellites by relay stations. The operation of the system requires precise synchronization of satellites clocks with the time of the GLONASS system.

The user segment automatically receives navigation signals from at least four satellites and measures their speed. Simultaneously, it selects and processes all input data and calculates 3 coordinates, 3 speed components and the precise time. The geodetic coordinate system used in the system is called Earth Parameters 90 (PE-90).

2.1.c Galileo:

Galileo is European's contribution to the next generation Global Navigation Satellite System (GNSS) intended to provide the European Nations with greater independence by delivering a civil controlled satellite based navigation system. Implementation of Galileo is expected to stimulate growth in the use of GNSS technology in intermodal transport systems thereby improving mobility safety and quality of life whilst also stimulating economic growth in the areas of receiver manufactures and application development. When considering the possibility of a failure of GPS to maintain a service, the implications for commercial customer in the fields such as telecom, location based services and financial community are clearly not acceptable. For these reasons and in consideration of the potential impacts on European business, the European Commission (EC) and the European Space Agency (ESA) has embarked on the definition phase of Galileo.

The current base line for Galileo calls for a constellation of around 30 middle Earth orbiting (MEO) satellites. The option of including some GEOS in the constellation is not rule out and indeed. Some interesting options could become available if GEOS are used to complement the system. The option of delivering a search and rescue service is also being analyzed for both technical and economic viability.

2.1.d GPS –L5:

As part of GPS modernization process many civil user group have advocated the need for second and third civil GPS signal. The proposed signals are a C/A code signal at the L2 frequency, starting on

Block IIR-M satellite Vehicle (SVs) and a new signal in an existing Aeronautical Radio Navigation Services band at 1176.45 MHz called L5, starting with Block IIF SVs. The signal at L5 will occupy a new bandwidth of at least 24 MHz.

2.1.e Errors: Like all other conventional navigation systems, the GPS is subject to errors that can degrade the precision of the system. The errors are Ionospheric error, Troposheric error, Selective Availability, Satellite clock error, Receiver clock error, Multi path error, Receiver error, Satellites Ephemeris error and Geometrical error

The most significant error occurs when the satellites signal goes through the earth atmosphere. This is a layer of electrically charged particles located approximately between 130 and 190 Km above the surface of the earth. As the GPS signal travels through the ionosphere, it is slowed down in a proportion that varies according to time of days, solar activity and series of the other elements. Ionospheric delays may be forecast and an average correction applied to the GPS position. Another error is caused by water vapour in the atmosphere which delays the GPS signal and also contributes to degrade the position of the system.

Lastly the error existing in the system can be significantly increased, depending upon the geometry of the satellites used to determine a position. When the position dilution of precision (PDOP) is a factor in errors of between 30 and 300 meters can occur, depending upon receiver type, relative satellite position and extent of other errors.

Note: *DOP factors are expressed how geometry affects to yield position accuracy & scale ranging accuracy. The optimum geometry for four satellites is achieved when three satellites are equally spaced on the horizon and one satellite directly on overhead. The geometry can be said to "dilute" the range domain accuracy by the DOP factors.*

3.0 GEODETIC REFERENCE:

There are many geodetic reference datum's in use throughout the world providing reference for the charting of particular area. Each datum has been produced by fitting a particular mathematical earth model (ellipsoid) to the true shape of the earth grid (Geoid) in such a way as to minimize the difference between the ellipsoid and the geoid over the area of the interest. Most ellipsoids in the use were derived in the last center and were normally referenced to a local observatory. These different datum's and ellipsoids produce different latitude and longitude grids and hence different sets of geographical coordinates. Implementation of CNS/ATM systems require a global geodetic frame of reference to avoid errors in geographic coordinates that might be caused by the location of references in more than one datum.

3.1 World Geodetic System –1984 (WGS-84)

The WGS-84 was developed to provide for more precision and continuing updating of

geodetic gravitational data also to offer means for interrelating positions based on various geodetic systems or datum through a system of coordinates that consider a single earth center as its fixed system. The WGS-84 represents the model of geocentric, geodetic and gravitational earth that uses data and technology available as of 1984. Such system allows the user to relate geographic data, such as coordinates obtained from a source based on a local datum, with another source. The WGS-84 is an ideal system for global navigation applications such as international air operations. In a static survey modality, the precision of geodetic latitude and longitude and geodic height of WGS-84 is within ± one meter.

3.2 Navigation System Performance Requirements: Navigation system performance requirements are defined in ICAO's manual on RNP (DOC 9613) for single aircraft and for the total system that includes the Signal-In –Space (SIS) the airborne equipment and the ability of the aircraft to fly the desired trajectory. All the navigation aids must fulfill four basic performance requirements in order to be certified i.e. continuity, availability, integrity and accuracy.

- **i) Continuity:** It is the ability of the entire system to carry out its function without interruption during planned operating period.
- **ii) Availability**: It is the ability of the system to transmit signals of the required quality most of the time. This is a critical requirement in landing guidance and for this reason stand by equipment is added to ground-based aids.
- **iii) Integrity:** It is the ability of the navigational aid (s) to warn the pilot that it has failed or giving incorrect message.
- **iv) Accuracy:** It is the ability of the navigational aid(s) is to guide the path of an aircraft within pre-defined tolerances.

The GPS component of the GNSS has a precision of 100 meters on the horizontal plane 95% of the time. The signals available for civil users are degraded signal-in-space (SIS) due security reason. It is estimated that GLONASS signal can be manipulated in a similar fashion. It is available as intended for civil users. It should also be borne in mind that a satellite fix in space is an ellipsoid in which the vertical axis of error is almost 50% larger than the horizontal axis error.

3.3 Navigation System: There are three type of navigation system.

- i. **Supplementary Navigation System**: The navigation system must meet the precision and integrity requirements but not the availability and continuity requirement.
- ii. **Primary Navigation System**: The navigation system that must meet the precision and integrity requirements on approval for a given operation of flight phase but not the availability and continuity. Safety is achieved by limiting flights to specific periods of time and establishing

certain procedural restrictions.

iii. **Sole Means Navigation System**: The navigation system is approved for a given operation or flight phase which must meet, the four navigation system performance requirements i.e. continuity, availability, integrity and precision for that operation of flight phase

3.4 Augmentations:

The GPS fails to provide continuity, availability, integrity and accuracy to allow for its use as the sole means of navigation for all phases of flight. In order to meet operational requirements, augmentation must be applied to basic GPS signals to eliminates the errors. Three basic categories of augmentation have been proposed i.e. Air-borne-based augmentation system (ABAS), Ground-based augmentation system (GBAS) and Satellite–based augmentation system (SBAS). The brief of the augmentation systems are given below.

3.4.a Air-borne based augmentation system (ABAS): It contains two types.

a) **Receiver autonomous integrity monitoring (RAIM):** this technique can be used if there are more than 4 satellites with the appropriate geometry within the range of receiver; with 5 satellites, 5 independent positions can be computed. If these do not match, the receiver infers that one or more of the satellites are supplying incorrect information and a warning light turn ON on equipment panel. If there are six or more satellites within range, more independent position positions can be calculated and receiver will be able to identify the defective satellites and exclude it from positioning calculation. A process known as barometric aiding may assist the RAIM technique. Aircraft barometric altitude information is taken from the GPS receiver, which can simulate a satellites placed directly over the user.

b) **Aircraft Autonomous integrity monitoring (AAIM)**: in this method on-board augmentation can be used. An Inertial Navigation System (INS) can replace the GNSS at times when their antennas are shielded (during maneuvering of aircraft) or when numbers of satellites within range of the receiver are inadequate.

3.4.b Ground- Based Augmentation System (GBAS):

This system is used to enhance the continuity, availability, integrity and precision of GNSS signals within a reduced geographic area. It consists of a ground monitoring station whose locations known with precision. This station evaluates the information received from GNSS satellites, detects clock and other errors and sends a correction signal to airborne receivers through a VHF data links. Precision of the order of 5 meters can be achieved with ground-based augmentation systems, which makes them suitable for Cat-II/III instrument approaches. The advantages of the GBAS lie in the fact, that it can serve all airport runways within a range of 25 nautical miles (NM) from the ground monitoring station.

3.4.c Satellite Based Augmentation System (SBAS)

The GBAS will not be able to provide coverage for all phases of flights because of its range limitations. An effective means of overcoming this limitation has been devised, using Geo-stationary earth orbiting satellites (GEOS) to transmit messages to correct GNSS signals on a wide geographic area. There are five SBAS service providers in the world i.e. Wide Area Augmentation System (WAAS) - USA, European Geo-stationary Navigation Over-Lay Service (EGNOS) – European Community, Multifunctional transport satellite Augmentation system (MSAS) – Japan, GPS and Geo Augmentation Navigation (GAGAN)- India, Ground Regional Augmentation System (GRAS) – Australia.

3.4.c.1 Wide Area Augmentation System (WAAS) (USA)

WAAS is designed and under implementation by US as an augmentation to GPS which includes integrity broadcasts, differential corrections and additional ranging signals. It provides the accuracy, integrity, availability and continuity required to support all phases of flight through CAT-I precision approach (PA). WAAS consists of one integrated system providing all SBAS functionality. The delivery schedule will be accomplished in three phases by delivering an initial operating system and then upgrading the system through preplanned product improvements. Phase–I WAAS will also provide the initial operating system which consists of two WAAS master stations (WMS's), 25 WAAS Reference Stations (WRS,s) leased GEOSs and ground uplinks to achieve a primary en-route guidance through non-precision approach (NPA) capability, as well as enable GPS /WAAS to be used as a supplemental navigational-aid for CAT-I PA's. Shortly after the completion of contract of Phase–I, the FAA will commission the WAAS for operational use in the US national air space (NAS). WAAS has been commissioned in the year 2003 for limited use as a sole means of navigation.

3.4.c.2 European Geo-Stationary Navigation Overlay System (EGNOS) (EUROPE)

EGNOS is the joint venture of European institutions and space industries to show their strong commitment in the development and system operations of satellite navigation.. European's EGNOS ensures international cooperation as well as European independence. The European Tripartite Group comprising the European Space Agency (ESA), the European Community, EUROCONTROL and the European organization for safety of air navigation, manages EGNOS.

In view of the operational implementation to come, the following seven major European air traffic service providers are on the way to form a legal entity. They are the EGNOS operator and infrastructure group (EOIG), France DGCA, German DFS, Italian ENAV, NAV-EP

of Portugal, Spanish AENA, Swiss control of Switzerland and NAST of United Kingdom. In addition the CNES (French Space Agency), the Norwegian Mapping Authority and major European air traffic management service providers actively contribute to the development and the future operation of EGNOS. All of them are working under collaborator framework of the EGNOS program. The EGNOS service augments the GPS and GLONASS signals. The two satellite systems send a positioning signal to the user. The ranging and monitoring stations network acquire, firstly the ranging signal generated by two constellations, GEOS and secondly generate the required atmospheric data.

3.4.c.3 Multi Functional Transport Satellites (MTSAT) Satellite - Based Augmentation System (MSAS) (JAPAN)

The MTSAT Satellite-Based Augmentation System (MSAS) is the wide area augmentation system being developed by Japan Civil Aviation Bureau (JCAB) for civil Aviation. This space-based augmentation system will provide en-route information through PA navigation services for all the aircraft within Japan airspace. The MSAS employs a ranging function to generate GPS like signals and enable aircraft to use MTSAT as a 25th GPS satellite. The MSAS is similar in function to the WAAS (US). Information on real-time conditions of the GPS constellations transmitted to each aircraft via the integrity function of MSAS provides satellites location, while the differential corrections function provides ranging error data to each aircraft. MSAS uses advanced technologies such as satellites orbit ranging, ionospheric and tropospheric delay estimation to ensure the reliability of these functions.

3.4.c.4 GPS /GLONASS And Geo-Stationary Augmented Navigation (GAGAN) (INDIA)

GAGAN system uses two-core constellation of medium orbiting satellites i.e. GPS and GLONASS. The positioning services offered by these two constellations for civilian use including civil aviation fall short of accuracy, integrity, availability and continuity requirements of air navigation services. Indian air space, coming in between Europe on the West and Japan on the East, occupies a very critical position and hence there is a need to have a system to bridge the gap between the coverage of EGNOS and MSAS and to facilitate seamless navigation of the aircraft from East to West and vice versa. GAGAN will provide the coverage over Indian airspace to the users. Indian augmentation with Indian payloads on GSAT-4 satellites, which are controlled by India, will offer some amount of control and flexibility on the position accuracies available to strategic users. India will be able to play an important role in providing seamless SBAS in the world. In years to come, India may well become a SBAS service provider to the neighboring countries in Asia-Pacific region. The national plan envisages implementation of a full operational capability SBAS in three phase and will be operational in the year 2008.

3.4.c.5 Ground Regional Augmentation System (GRAS):

The Ground-based regional augmentation system (GRAS) is a system providing GNSS augmentation service by which the user receives information directly from ground-based transmitters, allowing continuous reception of the service over a large geographical area of approximately 370 Km (200NM). The ground component may be interconnected in a network. GRAS supports GNSS (GPS, GLONASS, and GALILEO) operations in the all phases of the flight including en-route, terminal and instrument approach with vertical guidance (APV) operations. GRAS should be viewed as complementary to SBAS (such as EGNOS, WAAS, GAGAN and MSAS) and GBAS. GRAS is made up of multiple ground station with overlapping coverage. However the service provider will have to ensure that the topology of the ground infrastructures meets the operational requirements. The use of the locally valid augmentation makes it possible to use a subset of the GBAS message elements. A GRAS solution must include an auto-tuning functionality for seamless use of different ground station as the flight progresses.

4.0 SURVEILLANCE:

Surveillance is the eye of the ATC. For effective ATC to be possible, people or systems on the ground must know the position of the aircraft on a continuous basis and be able to estimate their future position. Surveillance provides the controller with the information necessary to insure specified separation between aircraft, to manage the airspace efficiently and to assist the pilot in the navigation. The surveillance systems presently in use can be divided into two main types: dependent surveillance **and** independent surveillance**. In dependent surveillance systems, the aircraft position is determined on board and then transmitted to ATC. As far independent surveillance such as primary radar is a system that measures aircraft position from the ground. The current surveillance is based on either voice position reporting or radar, which measures range and azimuth of aircraft from the ground station. The secondary surveillance radar augmented with Mode-S when traffic conditions so warrant will continue to be used, especially in high traffic density airspaces. In other places, where coverage of SSR is not possible, such as oceanic airspaces and remote areas over the earth, surveillance will be provided using automatic dependence surveillance (ADS).**

4.1 Automatic Dependent Surveillance (ADS)

In this, the aircraft automatically transmits, via data links, its identification and 3-D position to the ATC unit. It allows controllers to observe on a pseudo-radar display, the position of aircraft and possible deviations from the assigned flight paths. The design of the ADS should allow the implementation without disrupting ATS. It should also be sufficiently flexible to adaptability to local requirement and ATS special requirements, expandability, integration with new technology, provide sufficient safety and switch over to other forms of ATS in case of failure or degradation. It should also have the capability to provide a minimum service to all duly equipped aircraft and become finally part of ATS infrastructure that derives full advantage of the ADS.

4.1.a Automatic Dependent Surveillance ADS-A (Addressed)

This system operates only in the air-ground mode and at the request of the ATC unit. It is the controller who determines which reports are necessary for controlling each aircraft. The basic principle is given as: Communication contracts must first be established between airborne equipment and ground systems before being able to receive any ADS report. The controller determines which report is necessary to control each aircraft in the flight segments under the control of a given ATC unit. The issuance of basic ADS report at periodic intervals is defined by the ground system with one or more blocks of additional data containing specific information. ADS report may contain geographically defined points, such as waypoints and intermediate points, in addition to reports triggered by specific occurrence. Certain types of airborne equipments have the capability to maintain contracts with four or five ATC unit simultaneously. These aircraft will also send automatic position reports, in keeping with ADS contracts made by ground system. At given time or distance before reaching the boundaries of the FIR, which can vary depending on the ground system. The latter will immediately prepare and transmit ADS reports addressed to the grounds system in keeping with the pre-established contracts. In some system, the controller has the capability to replace the ADS contracts if necessary. The ground system will issue the appropriate message to start the modification of exiting contracts.

Automated ground systems can use the ADS position reports and other data groups from the ADS message to provide automated flight tracking in accordance with flight plan. Most automated ground system compares the aircraft position reported by the ADS with the position foreseen by the ground system, taken from the flight plan. The ground system will prepare and show the controller the appropriate message in the event that the ADS report does not match the position foresee by the ground system. This monitoring capability makes it possible to verify whether the flight is proceeding according to flight plan. Further more, aircrafts are equipped with FAN-1A capable of doing their own monitoring and of making an automatic report in case of significant flight variations, when so required by an appropriate occurrence contract. The ground system will include, together with the request for an ADS occurrence contract, the value that triggered these reports.

4.1.b Automatic Dependent Surveillance Contracts (ADS-C) :

There are three types of contract, each of them operating independently of the others. They are periodic contract, occurrence contracts & demand contracts. A request for a periodic contract defines the contract requirements to be included in the reports and reporting frequency. Through an uplink, an ATS unit initiates the periodic report request. This request allows an ATS unit to include the optional data groups in the basic ADS reports, also specifying the frequency of inclusion. The controller can modify the periodic reporting average up and down in order to accommodate special situations, such as traffic density. Information about the minimum reporting averages recommended for each type of aircraft can be obtained from the manufacturer's manual. Only one periodic contract can be established. if another is to be established , then the previous contract will be replaced . This periodic contract will remain in force until modified or cancelled.

The occurrence contract specify a report request to be sent by the aircraft if certain occurrence takes place e.g. variation in ascent or decent regime, lateral deviation in flight path, change in altitude, change in reporting point. Only one occurrence contract may be established each time between the aircraft and the ground system even so, the contract may contemplate different type of the occurrence. The demand contracts request is a single request from the ground system for the airborne equipment to send an ADS report containing the data specified in the request. A demand contact may be requested by the ground system at any time. A request for such contract will not affect any other that exists.

The emergency mode is activated or cancelled by the pilot only. Once activated, the emergency mode connects the aircraft with all ground systems that have established periodic or occurrence contracts with it. When pilot cancels the emergency mode, the on board equipment will send a cancellation message to each ground station that received this message.

4.2 Automatic Dependence Surveillance- Broadcast (ADS-B)

ADS-B is a new aeronautical surveillance concept by virtue of which the aircraft transmits its position through data link. The position information is received by near-by aircraft, which enables all users to be informed about their own position and the position of all other nearby traffic. The position information may be displayed in the cockpit of aircraft thus equipped to allow for new possibility of detecting traffic. Ground vehicle and facilities can also be equipped to receive and transmit position data, making it possible to monitor all types of traffic through two-way data links. In addition to position data, other data like aircraft identification and speed (obtained from GNSS receiver) may be also transmitted. ADS-B will play important role in the cockpit environment, and it will keep the pilot informed about all the traffic vicinity of the airports. The cockpit display is used to show the position and intentions of all aircrafts within a 200-NM radius. This equipment is called cockpit display of traffic position (CDTI) or traffic situation display (TSD).

However ADS-B allows keeping a visual display of all surrounding traffic. On the ground, the ADS-B will offer ATC new surveillance capabilities at a fraction of the cost of a conventional SSR. An ADS-B ground station is a transmitter / receiver station without the complex

and costly rotary antenna radar systems. An ADS-B ground station does not need to make high-precision measurements of the aircraft position, thus reducing the cost of the ground equipment considerably. The ADS-B concept is independent of the type of link used for data transmission. The information can be relayed by VHF or satellites or SSR mode-S. Therefore ADS-B will be an advanced and relatively low cost-system that will provide high quality flight surveillance information, Low cost, flexibility in surveillance reporting, more precise data capability to support new application,, identical surveillance information to the all users, surveillance available for all phases of flight. The ADS-B will also send a message to ground control unit within a radius of 95 NM around the transmitting aircraft.

ADS messages contain the data like position, time, track, ground speed , vertical situation, magnetic heading, Mac number (speed of the aircraft), next route reporting point, estimated altitude at next reporting point, second to the next reporting point, upper wind direction, upper wind velocity and temperature. Moreover ATC using ADS information must have the capability to automate the function like flight data validation, automatic tracking, and direction of potential conflict, conflict resolution and display of relevant processed data.

5.0 AIR TRAFFIC MANAGEMENT (ATM):

ATM is the aggregation of airborne functions and ground-based functions required to ensure the safe and efficient movement of aircraft during all phases of operation. ATM also is used to describe airspace and air traffic management activities that are carried out jointly by aeronautical authorities concerned with the planning and organization for the effective use of airspace and its movements within their regions of responsibility. The ATM operational concept must have a visionary scope and be referred to the concept of endurance of flight, shared separation assurance and situational awareness in the cockpits. The general objective of the ATM is to allow aircraft operators to comply with the estimated times of departure and arrival and to follow preferred flight profiles with a minimum of limitations and without jeopardizing agreed level of safety. ATM consists of an air and a ground component, both closely integrated through well-defined procedures and interfaces. The ground component is made up of air space management (ASM), air traffic flow measurement (ATFM) and Air traffic services (ATS).

5.1 Air Space Management (ASM):

Its purpose is to maximize use of available airspace within a given airspace structure. In designing the future airspace structure, its boundaries and divisions should not impede the effective use of automated conflict detection and resolution technique or the use of the advanced avionics equipment with which modern aircraft are equipped. The purpose of dividing the airspace into sector is to develop an optimum configuration, combined with use of other appropriate

methods for enhancing ATC capabilities. When using the airspace, close co-ordination and supervision are essential in order to meet the contrasting and legitimate requirements of all users and minimize any restriction on operations.

5.2 Air Traffic Flow Measurement (ATFM):

Although ATM is designed to accommodate the maximum traffic demand and can be expanded to respond to predicted growth, it should be borne in mind that it may not be possible to meet excessive maximum air traffic demands. For that reason, ATM has a coordinated sub-system called ATFM. In order to develop, the data on probable future demand forecasts, based on available background, are collated with the development foreseen by airports and airlines, aircraft manufacturer's order books and macroeconomic trend forecasts of the domestic and other State economics. The ATFM function is to balance traffic demand and ATC capacity. The task of AFTM focuses on a general picture of traffic and on the planning strategy required to ensure efficient use of airport and airspaces in specific area that are prone to "**bottlenecks**". ATS units must provide the AFTM with information about traffic management capability. The AFTM should also have access to the airline flight database to obtain up-to-date information about long and short time programming. Common databases are needed to provide a consistent AFTM service. Finally, AFTM units should plan for the introduction and start-up of automated systems.

5.3 Air Traffic Service (ATS):

The implementation of CNS elements improves ATS services, incorporating advanced technology into existing or basic function instead of merely replacing them. Consideration should be given to using the operational functions and new elements of the system in parallel with the existing ones for a limited period of time, in order to evaluate their operational application and familiarize pilots and controllers with the new procedures. Automated aids will be introduced, such as a conflict prediction and resolution advisory capability. Standards, and recommended practices (SARPs) and procedures to be introduced should facilitate the operation of aircraft with different equipment in the same ATS environment.

5.4 Free Flight/Autonomous Flight:

The concept of free flight/ autonomous flight developed in the United States and originally conceived to give aircraft more maneuvering capacity, with the support of available new technologies. It also emphasizes the need for users to decide of their own upon their schedules, routes, and altitudes, thus reducing delays and costs. The most important thing is the principle of maintaining a safe separation between aircraft. This principle is based upon two strips of airspace, known as protection strips and the alert strips, whose dimensions are determined by the aircraft speed, performance, and CNS equipment. The protected zone of the one closet to the aircraft can never overlap with the protected zone of another aircraft. The alert zone extends beyond the protected zone and the aircraft can maneuver freely until its alert zone touched by another aircraft. If this happens, the controller can give one or both pilots heading vectoring or other restrictions in order to ensure the separation. Eventually, most of the orders will be sent by data link, which will be integrated into an air-ground communication network. Furthermore, airborne computers and GPS satellite will enable pilots, assisted by controllers, to use cockpit displays of traffic (CDTI) to select the best separation options.

6.0 Conclusions:

The benefits of the communication system are the links between ground and airborne automated systems will be more direct and effective. Improved data processing and transfer between operators, aircraft and ATS providers will alleviate the congestion of voice channel, reduce the possibility of making mistakes and allow for a more efficient link between ground and airborne systems.

The benefits of the new navigation system is the availability of an improved guidance and position capability in any part of the world will enhance operation efficiency, reducing flight time and the fuel required through navigation. The availability of the NPA for runways lacking ground navigation aids or that are served by unreliable navigation aids: will reduce delays, alternates, over flights and cancellations due to bad weather. The availability of a GNSS-supported PA through GBAS or SBAS coupled with airborne ones will also offer advantages over exiting equipment. The capability of providing approach guidance for more airports could attract from those where delays due to congestion are common. By reducing such delays, operators will save flight time and fuel. Eventually use of the GNSS for all phases will result saving for operator due to the reduction of airborne equipment types. It will also reduce maintenance and capital costs. Advance integration techniques with inertial reference systems (IRS) will make possible to operator with more precise approach i.e. CAT-II & III. The availability of satellite navigation will enable the gradual deactivation and phasing out of conventional ground aids which will provide significant saving to the service provider.

The benefits of the new surveillance system are with use of ADS. ADS applied in airspace without radar coverage will evolve to a point where services will be furnished that are very similar to those provided by radar control, including aircraft position display on a ground screen. ADS use leads to a reduction of separation minima used in non-radar airspaces. The exiting regulatory separation over oceanic airspace may be reduces by one-half, thus doubling the capacity of the oceanic routes. ADS uses also adds operational flexibility to ATC for controllers are able to

respond better to user flight preferences.

The benefits of the free flight option is improved safety through advanced conflict detection and resolution technique, More flexibility for managing flight operations and better prediction of airspace conditions and their effects on such operation, better tools for decision making by pilots, air traffic controller, and flight dispatchers, saving from reduced fuel consumption and lower aircraft operating costs, reduced use of flow control, environmental improvements due to reduction in exhaust emissions in en-route flights, approaches at airports, more precise position and time and possibility of sharing information between pilots and controllers.

References:

1. International Civil Aviation Organization, *Global Air Navigation Plan for CNS/ATM systems (Doc9750)*
2. International Civil Aviation Organization, Fifth meeting of the Aeronautical Mobile Communications Panel (AMCP), working paper No.-6 " *Report on Assessment of CNS Digital Link*".
3. International Civil Aviation Organization, *Manual on testing of Radio Navigation aids (Doc 8071).*
4. International Civil Aviation Organization, *Guidelines for the introduction and operational use of Global Navigation Satellite System (Circular 267)*
5. International Civil Aviation Organization, *Eleventh Air Conference (September/ October 2003) working paper no.188, draft report of committee B on Agenda Item 6.*
6. International Civil Aviation Organization, *ADS and ATS Data link Applications (Circular256)*
7. International Civil Aviation Organization, *Draft Airborne Separation Assistance system* circular.
8. *Seamless Sky* by H.V Sudarsan Published by "Ashgate Publishing limited, England".