

**MANUAL FOR  
AERONAUTICAL MOBILE SATELLITE (ROUTE) SERVICE  
Part 1**

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# **1 INTRODUCTION**

## **1.1 Objective**

The objectives of this part of the manual are to provide an overview of the Aeronautical Mobile Satellite (Route) Service (AMS(R)S) and offer guidance on the consideration of satellite networks as a platform for AMS(R)S communications for the safety and regularity of flight. This manual is to be considered in conjunction with ICAO Standards and Recommended Practices (SARPs) as contained in Annex 10, Volume III, Part I, Chapter 4 and subsequent sections of this document which provide implementation guidance for specific satellite systems.

## **1.2 Scope**

This part contains a general description of aeronautical mobile satellite communications including information on applications, user requirements, potential operational benefits, and standardization activities undertaken by ICAO and aviation industry bodies. Information on institutional guidelines related to AMS(R)S services, the Standards and Recommended Practices (SARPs), and AMS(R)S spectrum issues are also included.

## **1.3 Historical**

In the 1960s, the civil aviation community began careful studies of the practicability of satellite communications providing long distance communications, primarily as a replacement for high frequency (HF) communications over oceanic and remote areas. Early experimentation focused on the use of the very high frequency (VHF) spectrum (118 to 136 MHz).

Using the NASA ATS 3 experimental satellite, the aviation community demonstrated the feasibility of VHF satellite based communications in aviation. In 1968, ICAO established a panel of experts to explore the Application of Space Techniques Relating to Aviation (ASTRA). This panel studied the technical characteristics of an aeronautical satellite system. At that time, the aviation community considered that an initial, low capacity, satellite system could provide early relief to satisfy in particular the requirements for oceanic communications and would permit transition to a higher capacity satellite at a later stage as technology developed. These satellite systems were to operate in frequency bands, allocated on an exclusive basis to the aeronautical mobile satellite (route) service. Use of the bands for public correspondence (e.g. passenger communications) was not excluded.

During 1971 - 1973 and 1974 - 1975, several experiments were accomplished with the ATS 5 and ATS 6 satellites respectively. These tests demonstrated that at that time, it was feasible to use available technology for providing satellite communications to aircraft in the 1.5 / 1.6 GHz bands. A KC-135 aircraft was used to test the effect of direct path and multipath propagation with different antennae. Ranging and digital data demonstration tests were also performed. Aircraft tests were performed at various altitudes, elevation angles to the satellite and at various headings and speeds.

An international aeronautical satellite programme (AEROSAT) was planned in the early 1970s. AEROSAT was a programme to jointly plan, construct and manage a dedicated aeronautical experimental satellite system sponsored by Canada, the United States, and the European Space Agency (ESA) representing several European nations, under a memorandum of understanding signed in August 1974. Its objective was to develop and launch several satellites to perform a variety of experiments to determine preferred system characteristics of an operational system. The satellites were to be launched in the late 1970s. However the satellite cost grew much larger than anticipated and a downturn in world wide economic conditions, along with the lack of the expected traffic growth, caused the airlines to withdraw their support.

From 1978 to 1982, the Aviation Review Committee (ARC) managed a broad alternative system improvements study aimed at oceanic and remote overland areas, with the participation of more than twenty States and international organizations. The ARC identified the potential of automatic dependent surveillance (ADS) and air ground satellite data link communications based on a space segment shared with other (non-aeronautical) communication services.

In November 1983, following the ARC conclusions and recommendations, the ICAO Council established the Special Committee on Future Air Navigation Systems (FANS) to "study technical, operational, institutional and economic questions, including cost/benefit effects relating to future potential air navigation systems". FANS tasks included studying the application of satellite technology in aviation. In 1988, the FANS Committee concluded its work and recommended to ICAO the adoption of the global communication, navigation and surveillance/air traffic management (CNS/ATM) systems concept, largely based on satellite technology. The concept was consequently endorsed by the Tenth Air Navigation Conference in 1991.

The systems concept was further developed and refined by the Phase II of the FANS Committee which concluded its work in 1993. Its work included a study of the necessary institutional arrangements, development of a global co-ordinated implementation plan, an assessment of ongoing of research and development activities, and development guidelines for air traffic management (ATM) evolution. Noting the fact that implementation activities had already begun, the name "global CNS/ATM systems concept" was changed to "CNS/ATM systems".

The future air navigation system was mainly based on:

- a) a global navigation satellite system (GNSS) to allow aircraft en route to determine their present position world wide, based on signals transmitted by satellites;
- b) an aeronautical mobile satellite service (AMSS) interoperable with SSR Mode S data link and VHF data link, in the framework of the aeronautical telecommunication network (ATN); and
- c) ground-based ATM systems, including airspace management, flow management and air traffic services (ATS).

Satellite systems were planned to firstly be used in large areas with low density of air traffic such as remote and oceanic areas. In areas with higher air traffic density (e.g. terminal areas) compatible terrestrial based systems were part of the CNS/ATM.

This document, which is an updated and enhanced version of the “Global Co-ordinated Plan for Transition to the ICAO CNS/ATM Systems” contained in the Report of the Fourth Meeting of the Special Committee for the Monitoring and Co-ordination of Development and Transition Planning for the Future Air Navigation System (FANS Phase II) (Doc 9623), has been produced to include recently developed concepts and systems.

In its “Global Co-ordinated Plan for Transition to the ICAO CNS/ATM Systems” as contained in the report of the fourth meeting of the Special Committee for the Monitoring and Co-ordination of Development and Transition Planning for the Future Air Navigation System (FANS Phase II) (Doc 9623), the FANS Committee recognized that satellite technology had a unique potential to satisfy many present and future CNS needs. A key part of future system improvement would be the introduction of air-ground digital data communication services (data link firstly, and then voice) which could provide substantial benefits in ATS efficiency and capacity, satisfying the need for improved air traffic safety as well. Important system considerations included world wide interoperability, access by all classes of aeronautical users, the need to accommodate evolutionary system growth in terms of functional capability and capacity, consideration of different requirements in different areas, and the potential for taking advantage of satellite service capabilities offered by different service providers. Therefore, the committee defined the minimum necessary level of communication systems standardization to achieve the mentioned objectives and recommended the subsequent architecture in the FANS/4 Report.

Following Recommendation 7/1 (Development of SARPs and guidance material for aeronautical mobile satellite (R) service) from FANS/3, the Air Navigation Commission established in 1988 the Aeronautical Mobile Satellite Service Panel (AMSSP), to develop the SARPs and related guidance material based on the CNS/ATM developed by FANS.

The fourth meeting of the Aeronautical Mobile Communications Panel (AMCP/4, 1996) noted the near-future availability of non-geostationary-satellite systems (which were expected to provide mobile satellite communication services) as well as the potential for application of such services to a broad segment of the aviation community. The meeting considered the need to undertake a feasibility study of the potential of these systems for the provision of AMS(R)S. AMCP/5 (1998) concluded that the use of non-geostationary-satellite systems for AMS(R)S was feasible. Following AMCP/5 Recommendation 5/1, the panel developed specific draft SARPs and guidance material for such satellite systems. In 2003, the Aeronautical Communication Panel (ACP) which was created after a merging between the AMCP and the Aeronautical Telecommunications Network Panel (ATNP), started to review and combine the AMSS SARPs (specific to geostationary satellite systems such as Inmarsat and MTSAT) and the next-generation satellite systems SARPs. This work was completed in 2005 at the first meeting of the ACP Working Group of the Whole.

Amendment 82 to Annex 10, as adopted by Council in 2007, introduced for the first time generic SARPs for AMS(R)S which are independent of the technology employed within a satellite communications system, cover performance requirements for data and voice operations, and accommodate low-Earth orbit (LEO), medium Earth-orbit (MEO) and geostationary orbit (GSO) constellations. The SARPs and guidance material for AMS(R)S were structured as directed by Assembly Resolution A35-14, Appendix A. Technical specifications were divided into a “core”

SARPs element, complemented by additional material, as published in this manual, and by references to documents developed by recognized standards-making bodies (e.g. International Telecommunication Union (ITU) and RTCA).

## **2 SERVICES, USER REQUIREMENTS AND OPERATIONAL BENEFITS**

### **2.1 Satellite communication services**

#### **2.1.1 General**

Air traffic scenarios in various parts of the world widely differ and are likely to do so in the future. Global Air Traffic Management (ATM) systems must therefore be able to deal with diverse air traffic densities and different aircraft types, with vastly different performances and equipment fit; these variations, however, should not lead to undue diversity and potential incompatibility in avionics and ground segments.

In general, as new communication, navigation and surveillance systems provide for closer interaction between the ground and airborne systems before and during flight, air traffic management may allow for more flexible and efficient use of airspace and thus enhance air traffic safety and capacity.

Aeronautical communication services are classified as:

- a) Safety and regularity communications, AMS(R)S, requiring high integrity and rapid response:
  - 1) safety-related communications carried out by the air traffic services (ATS) for air traffic control (ATC), flight information and alerting; and
  - 2) communications carried out by aircraft operators, which also affect air transport safety, regularity and efficiency (aeronautical operational control communications (AOC)); and
  
- b) non-safety related communications:
  - 1) private correspondence of aeronautical operators (aeronautical administrative communications (AAC)); and
  - 2) public correspondence (aeronautical passenger communications (APC)).

##### **2.1.1.1 Data communication**

Since the earliest days of air traffic control, air-ground communication between the flight crew and the air traffic controller of the aircraft operator has been conducted through speech over radiotelephony on either HF or VHF. When radiotelephony channels become congested or, in the case of HF radio-telephone channels during HF propagation disturbances, voice communication availability and reliability can decrease to a point where flight safety and efficiency may be affected.

Despite the introduction of Secondary Surveillance Radar (SSR) and VHF digital link (VDL), both of which include limited air-to-ground data transfer and provides controller workload relief, the burden of voice communication on the air traffic controller and the pilot is still high. Moreover, large areas of the world are beyond the coverage of SSR and VHF. In those remote and oceanic areas, both tactical communication and position reports are being exchanged over HF circuits with variable quality.

Experience has shown that alleviation of the shortcomings in the voice communication systems is limited by factors on the ground. In particular, the saturation of manual air traffic control capabilities creates strong pressure for automated assistance in air traffic services, and because of this, increasing levels of automation are being incorporated in aircraft systems. Achieving full potential benefits of automation requires an increased information flow between the aircraft and ground systems. Moreover, a digital data link is an essential element of an advanced automated air traffic control environment.

It is currently envisaged that future air traffic management systems (on the ground and in the aircraft) make increased use of various physical links (e.g., HF data link, VHF data link and satellite data link) to allow for the (automatic) transmission of data from the aircraft to the ground and vice versa. Efficient use of this data lends towards a more universal value of its supporting services. It therefore is to the advantage of service providers and users to support international standardization of these data links and their applications.

Many useful safety and efficiency related applications can be implemented using air-ground data links. In order to be used for safety related services, an air-ground data link must have high integrity.

#### **2.1.1.2 Voice communication**

Whereas increased automation of data exchange between air and ground systems is expected, the use of voice communication will remain imperative. Emergency and non-routine problems, as well as urgent communications between pilot and air traffic controller, make voice communications a continuing requirement.

Aeronautical mobile services in continental areas continue to use VHF for line-of-sight voice communications. Oceanic and other remote areas at present rely on HF voice communications, which may imply the need for communication operators relaying communications between pilots and controllers.

A viable solution to overcome the limitations in current ATS and AOC voice communications, particularly in remote and oceanic areas, is the application of satellite-based communication systems.

#### **2.1.2 Air traffic services (ATS)**

An important application of satellite technology to civil aviation is the provision of communication services for ATS purposes, particularly in remote and oceanic areas, covering, *inter alia*, flight information service, alerting service and air traffic control service including area,

approach and aerodrome control services. The use of satellite systems for the delivery of services provides significant advances in benefits to air traffic services over those provided by HF and VHF. The enhancements offered by satellite-provided ATS are in both cost-savings and service quality. For example, whereas HF services can be unreliable due to propagation conditions and limited bandwidth, and VHF communication systems do not have extended coverage, satellite services can overcome most of these limitations.. Moreover, satellite services are global in nature and may include coverage of both the North and South Poles. The provision of air traffic services (ATS) in oceanic airspace differs in many aspects from that provided over land areas. Oceanic flights are conducted in airspace where no sovereign rights are exercised and where normally, in that airspace, more than one State is concerned with the provision of ATS. Therefore the planning of ATS for such operations is basically a matter of international concern. The development and implementation of the ICAO air navigation plans and the provision of ATS for such areas is entrusted by ICAO to designated States based on regional air navigation agreements.

Additional information is contained in the *Manual of Air Traffic Services Data Link Applications* (Doc 9694).

#### **2.1.2.1 Air traffic control services (ATC)**

The main objectives of the air traffic control services are to prevent collisions between aircraft and between aircraft and obstructions in the manoeuvring area and to expedite and maintain an orderly flow of air traffic. These objectives can be achieved by applying separation between aircraft and by issuing clearances to individual flights as close as possible to their stated intentions, taking into account the actual state of airspace utilization and within the general framework of measures for the control of air traffic flow when applicable.

Flight planning plays an important role in operations over oceanic airspace. Theoretically, the flight path from departure aerodrome to destination, along a great circle, would give the minimum distance track. However, wind speeds and directions and other meteorological aspects such as temperature, areas of clear air turbulence, etc., affect flight times and flight safety and therefore the optimum flight paths vary considerably from day to day. Additionally, the free choice of the desired flight path may be restricted by the need to maintain a particular flight level, Mach number or a specific track in an organized track system.

The fuel cost is a dominant part of the total cost of flight operations and is especially significant for long-distance flights. ATC can assist in fuel conservation and gas emission reduction by accepting a pilot's request for a change of his current flight plan (if the traffic situation permits) which is normally a result of a change in the operational factors affecting the efficiency of his flight.

#### **2.1.2.2 Flight information services (FIS)**

Flight information services provide flight crews with compiled meteorological and operational flight information specifically relevant to the departure, approach and landing phases of flight.

### **2.1.2.3 Alerting services**

The objective of the alerting service is to enable flight crews to notify appropriate organizations regarding aircraft in need of search and rescue aid and to assist such organizations as required.

### **2.1.2.4 Automated dependent surveillance (ADS)**

The introduction of satellite communication technology, together with sufficiently accurate and reliable aircraft navigation, e.g., by Global Navigation Satellite System (GNSS), present ample opportunity to provide better surveillance services mostly in areas where such services lack efficiency - in particular over oceanic areas and other areas where the current systems (i.e., radars) prove difficult, uneconomic, or even impossible to implement.

ADS is an application whereby the information generated by an aircraft on board navigation system is automatically relayed from the aircraft, via satellite data link, to the air traffic services and displayed to the air traffic controller on a display similar to radar. The aircraft position report and other associated data can be derived automatically, and in almost real-time, by the air traffic control system, thus improving its safety and performance efficiency. Ground-to-air messages also will be required to control the ADS information flow.

### **2.1.2.5 Controller pilot data link communication (CPDLC)**

One of the keys to the future air traffic management system lies with the two-way exchange of data, both between aircraft and the ATC system and between ATC systems. CPDLC is a means of communication between controller and pilot, using data link for ATC communications.

The CPDLC application provides the ATS facility with data link communications services. Sending a message by CPDLC consists of selecting the addressee, selecting and completing, if necessary, the appropriate message from a displayed menu or by other means which allow fast and efficient message selection, and executing the transmission. The messages defined herein include clearances, expected clearances, requests, reports and related ATC information. A “free-text” capability is also provided to exchange information not conforming to defined formats. Receiving the message will normally take place by display and/or printing of the message.

CPDLC will remedy a number of shortcomings of voice communication, such as voice channel congestion, misunderstanding due to bad voice quality and/or misinterpretation, and corruption of the signal due to simultaneous transmissions.

### **2.1.2.6 Automated downlink of airborne parameter services**

The automated downlink of information available in the aircraft will support safety services. Such service may, for example, help detect inconsistencies between ATC-used flight plans and the one flight plan activated in the aircraft’s flight management system (FMS). Enhancement to existing surveillance functions on the ground can be facilitated by downlinking of specific tactical flight information such as current indicated heading, air speed, vertical rate of climb or descent, and wind vector.

### **2.1.3 Aeronautical operational control communications (AOC)**

Aeronautical operational control is a safety service and defined in Annex 6 — *Operation of Aircraft*. Operational control provides for the right and duty of the aircraft operator to exercise authority over the initiation, continuation, diversion or termination of a flight in the interest of the safety of the aircraft and the regularity and efficiency of flight.

Operational control communications accommodate airline dispatch and flight operations department functions but may also interface with other airline departments such as engineering, maintenance and scheduling, in exercising or coordinating related functions.

Current experience with AOC has shown that a significant amount of messages are exchanged using data communications. AOC voice, however, will continue to be required. Based on expected increases in air traffic, AOC data communications will further grow as the result of both the increase in number of messages per aircraft and size and characteristics of the message content. AMS(R)S can assist in performing functions such as:

- Exceptional situation handling (aircraft/flight emergencies etc.);
- Flight planning;
- Weather information;
- Airport/airways operational information;
- Flight crew scheduling;
- Aircraft engine monitoring;
- In-flight maintenance problem reporting and solving; and
- Aircraft schedule.

Such AOC functions may operate via air-ground voice and data communications either through the cockpit crew or directly with airborne sensors or systems.

### **2.1.4 Non-safety services**

Non-safety services include aeronautical administrative communication (AAC) and passenger correspondence (APC). Non-safety communication services may be authorized by administrations in certain frequency bands allocated to the AMS(R)S as long as they cease immediately, if necessary, to permit transmission of messages for safety and regularity of flights (i.e., ATS and AOC, according to priorities 1 to 6 of Article 51 of the ITU Radio Regulations).

## **2.2 User requirements**

Air-ground satellite data communication plays a key role in the functional improvement of existing and new ATM functions, particularly in remote and oceanic areas.

In order to fulfil these operational requirements, these ATM functions require a certain level of quality of communication services. This level is specified in the communication, technical and operational characteristics required by the SARPs.

Satellite voice communications continue to be used, particularly in non-routine and emergency situations, and offer improved voice quality over HF-voice.

ATM-related communications (voice and data) are given high priority in transit through the satellite system and the ATN, as appropriate. The satellite system architecture supports ATS needs for handling both data and voice.

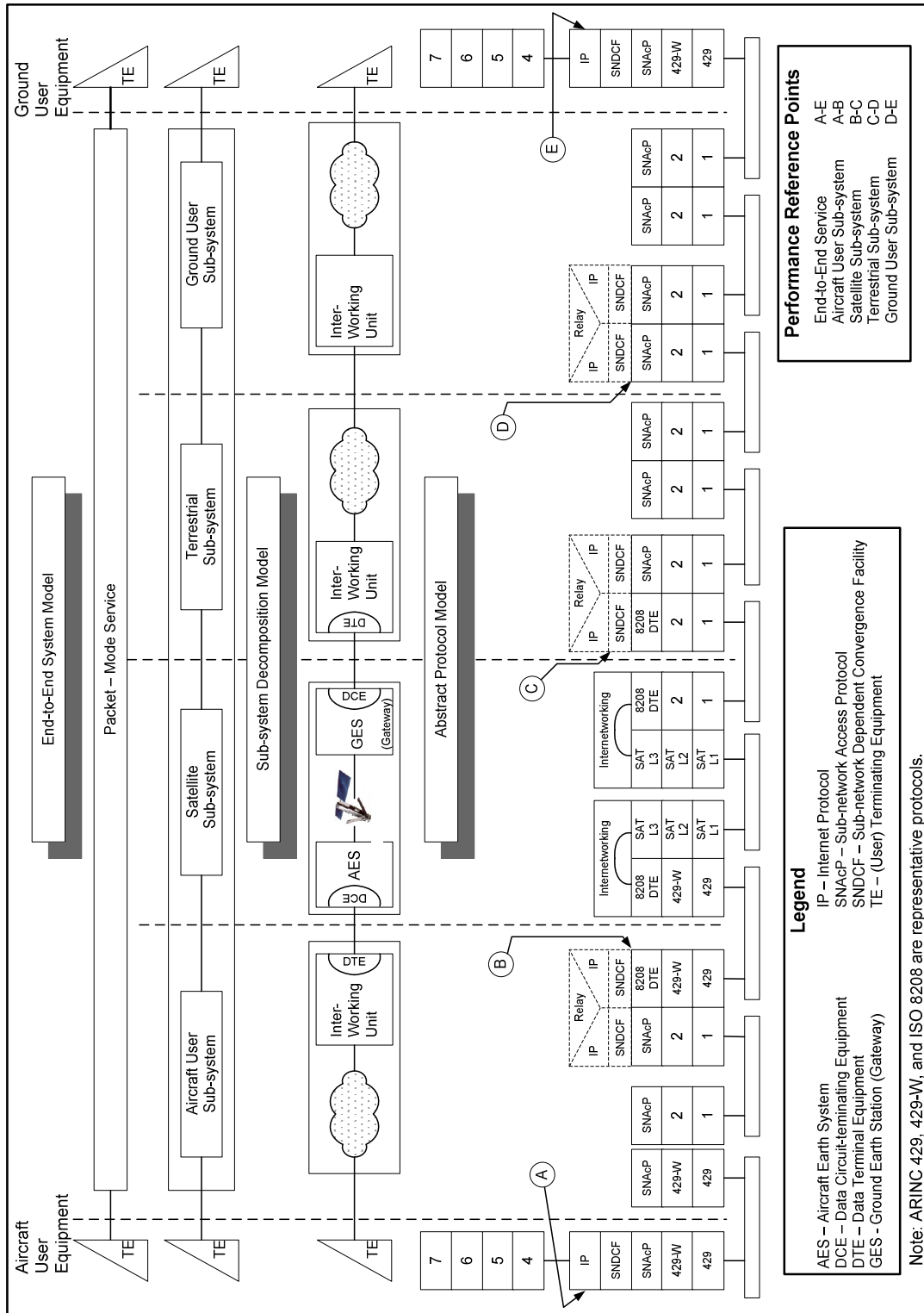
AMS(R)S requirements are to be derived from these characteristics, in terms of service reliability, availability, etc., to achieve the required standards of service. Primary service requirements for AMS(R)S are highlighted in the following subparagraphs.

### **2.2.1 Performance criteria for end-to-end applications**

The aeronautical satellite communication system will support the categories of AMS(R)S communications according to the appropriate performance, integrity and availability criteria, taking into account a gradual increase in communication needs. Systems which allow for step-by-step and evolutionary implementation and growth are desirable.

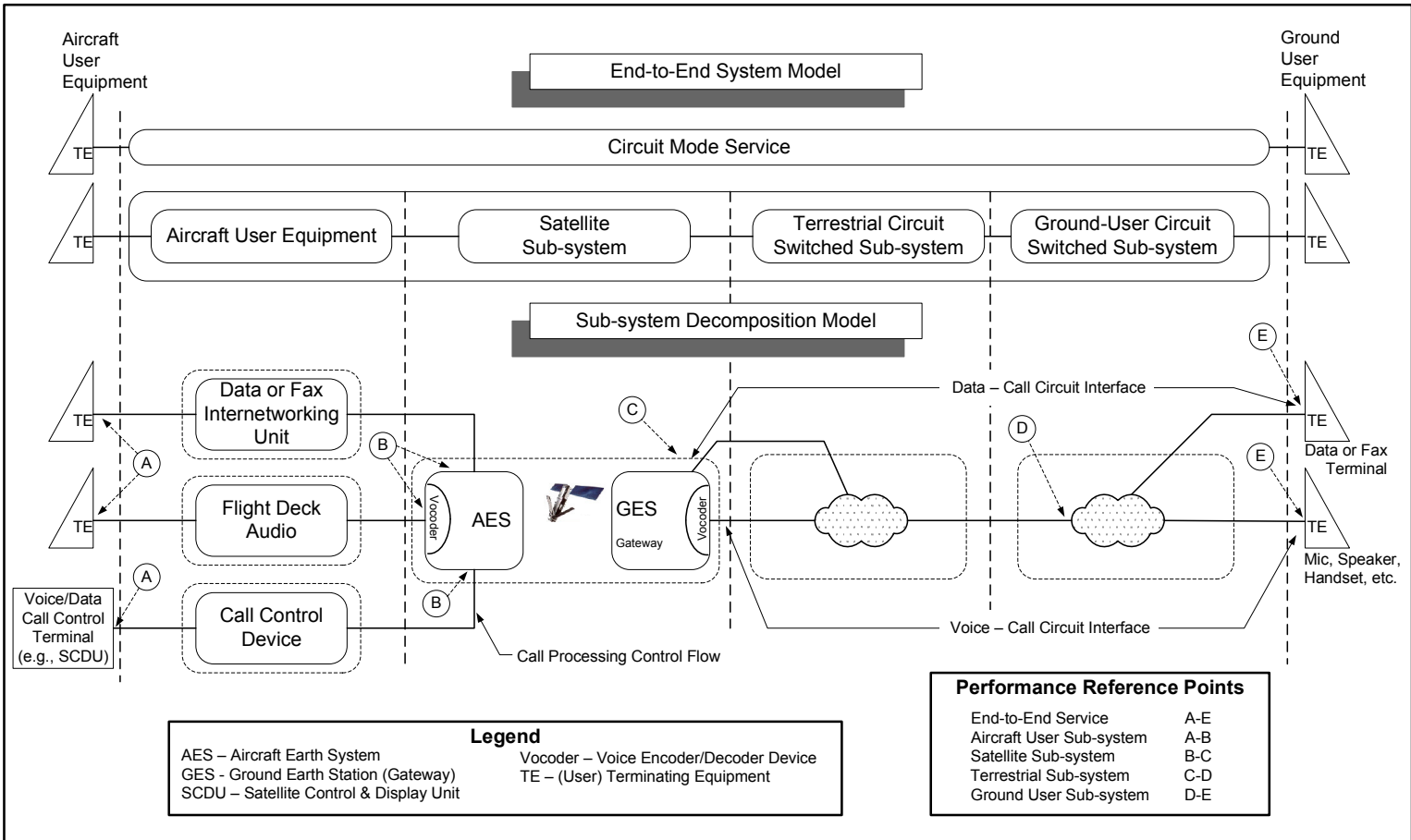
AMS(R)S system performance parameters as defined in SARPs, are provided for the ATN satellite subnetwork (see Figure 2-1 between points B and D for Packet mode and Figure 2-2a between points B and C for circuit mode services). Additional information on ATN end-to-end performance between user terminals is contained in the *Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN) using ISO/OSI standards and protocols* (Doc 9880).

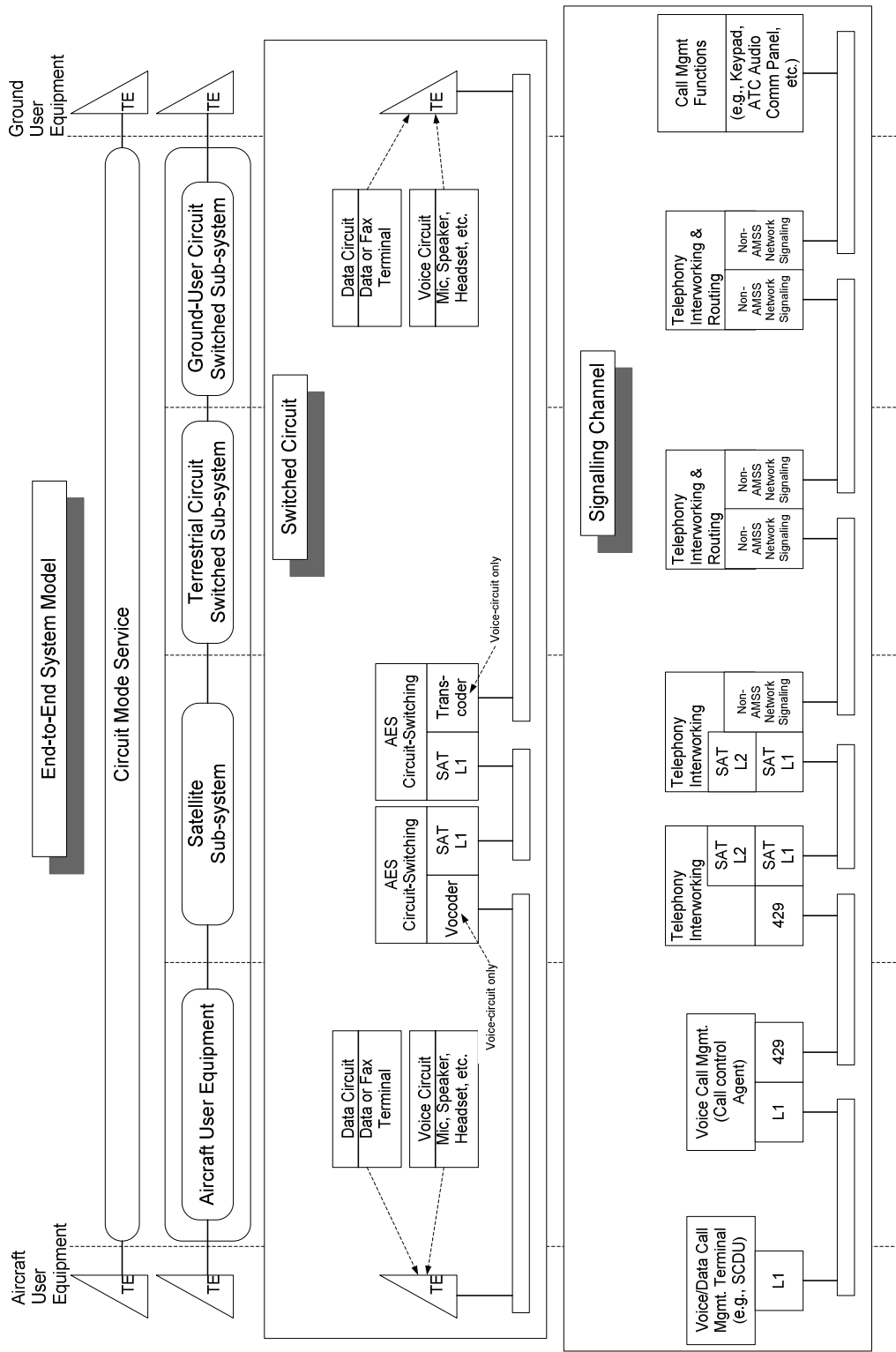
AMS(R)S data services are based primarily on the use of packet data communications. The Packet mode structure of the system and its four subsystems is shown in Figure 2-1. The AMS(R)S Circuit mode service primarily serves voice but also supports continuous data and facsimile services where these services are needed and appropriate. The system structure for Circuit mode services is depicted in Figures 2-2a and Figure 2-2b.



Packet-Mode Services System Structure  
Figure 2-1

Circuit-Mode Services System Structure-Part A  
Figure 2-2a





Circuit-Mode Services System Structure-Part B  
Figure 2-2b

Note: 429 is only a representative protocol

Measures of the service quality of the end-to-end system including the AMS(R)S subnetwork are detailed in the following subparagraphs.

#### **2.2.1.1 Minimum available throughput**

Throughput is defined as the amount of user data (per time unit) which can be transferred over the available links between the AES and the GES. The message transfer frequency (i.e., number of ADS reports per time unit), together with message length (i.e., number of bits in the ADS report) and the protocol overhead, determines the required throughput for ADS messages.

#### **2.2.1.2 Maximum data transit delay**

The satellite data transit delay for packet data communications is defined as the time between sending and receiving a message within the satellite system, using the AMS(R)S. In addition, ATN data transit delays (when the message is further sent through the ground-based ATN) need to be considered. Maximum data transit delay requirements are derived from the required communication performance parameters, or RCP, (i.e., time between generating and sending airborne data and receiving the data for processing on the ground).

#### **2.2.2 Priority**

Each AMS(R)S communication transaction is assigned a priority. This priority is dependent on the information type and is assigned by the associated user application in accordance with the internationally defined priorities in Annex 10.

The ATN sequences messages in order of priority. The AMS(R)S will provide a sequencing mechanism that complies with the priority assigned to a message.

#### **2.2.3 Reliability/integrity**

The AMS(R)S will have the integrity and reliability required for provision of safety communication. Users must be able to pass their messages reliably, regardless of the position or situation of the aircraft, with rapid access and minor transmission delay, but at an economic rate.

Reliability is defined as the probability that a satellite subnetwork will actually deliver the intended message within a set amount of time. The failure to deliver a message may result either from a complete breakdown of an essential component or because of detected errors which are unrecoverable.

Integrity is defined as the probability a message will be received without undetected errors.

It is necessary to establish performance standards for reliability, continuity, and integrity of service for the space segment, ground stations, and associated facilities. This will require application of ICAO SARPs and certification.

The consequences of loss of a satellite in an aeronautical air-ground communication system would be severe unless an adequately rapid changeover to back-up facilities could be achieved.

However, the past history of communication satellites has shown that, once operating in orbit, satellites are extremely reliable. Both satellite and ground equipment changeover will be required to occur within a very short time, depending on the critical nature of the safety service being supported. This implies that a mature system may require either hot standby redundancy of both space segment and earth station or alternative strategies relating to both space and earth segment facilities and equipment. Such strategies would need to ensure that the loss of one satellite would cause minimum disturbance to communication traffic and allow timely restoration of full services.

GES mean time between failures (MTBF) will be high and mean time to repair (MTTR) will be low, employing hot stand-by and uninterruptible power supplies (UPS) to ensure AMS(R)S continuity. Moreover system performance will be further enhanced due to the availability of technical support, e.g., logistics and maintenance staff.

The AES will also be able to cope adequately with a satellite failure, for example, by rapid acquisition of the signal from an alternate satellite or by tracking the signals from more than one satellite at all times.

Requirements for changeover time will be related to such parameters as the needed surveillance update rate in those cases where, for example, the communication system is supporting ADS.

As with all the avionics, the AES will be designed so that MTBF is as long as possible whereas the MTTR is as short as possible. These two requirements will apply to essential airborne units such as the satellite data unit, communication management unit, beam steering unit and the antenna sub-system. This may be achieved by main/hot standby configuration of the critical units stated above, as well as automated changeover mechanisms within each unit.

#### **2.2.4 Protection**

Protection is defined as the degree to which unauthorized parties are prevented from interfering with data transfer over the satellite sub-network.

For safety communications, the AMS(R)S, at the minimum, will provide protection against modification, addition or deletion of user data.

Measures need to be provided to grant protection from intentional and other harmful interference resulting from malfunction of aircraft earth stations (AES), ground earth stations (GES),- also referred to as Gateways - satellites, or from sources outside the system.

As an additional level of protection, critical services provided from an interfered satellite could be transferred to another satellite, if necessary by pre-empting lower priority services. Frequency management will be carried out automatically from ground control.

System performance monitoring in real time will be necessary at appropriate locations. Additionally, some protection from intentional jamming will be achieved with spot beam systems as the effect will be limited to the beam containing the interfering signal with minimal effect on adjacent beams.

### **2.2.5 Minimum area of connectivity**

Operationally required connectivity determines the designated operational coverage area and may influence the location of GESs. In general, satellite systems are intended to provide long distance connectivity in areas which, for technical and/or economical reasons, cannot be serviced by terrestrial aeronautical air/ground communication systems.

In particular, connectivity is required between aircraft flying in oceanic airspace and oceanic area control centres. Additionally, remote areas require connectivity through satellite systems with area control centres (ACC). Connectivity requirements can, when technology permits, include other airspace, including continental airspace with high density air traffic and area control centres.

### **2.2.6 Costs and benefits**

The initial cost of AES equipment varies widely depending on the class of service provided, e.g., core capability, data rate and voice capability. Moreover, aircraft operators have an interest in keeping cost and quantity of onboard equipment to a minimum. Any onboard equipment requirements should appropriately weigh costs and benefits ensuring that the minimum communications service standards are met and taking into account the desire for minimizing cost.

### **2.2.7 Interoperability**

The AMS(R)S must be compatible and interoperable with external aircraft and ground systems and also must co-exist with other aviation data links in order to achieve significant cost and operational benefits. Prerequisites for interoperability are:

- a) the definition of standard protocols at the network interface layer; and
- b) a global addressing plan.

To achieve this interoperability, ICAO has defined a particular network protocol architecture through which various networks, including AMS(R)S, Mode S and VDL, can communicate. This is known as the aeronautical telecommunications network (ATN). Details are available in the *Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN)* (Doc 9880).

## **2.3 Operational scenarios and anticipated benefits**

### **2.3.1 General**

The application of AMS(R)S in oceanic and remote areas should provide improved communications, surveillance and procedures. This will lead to improved safety, increased airspace efficiency including a potential for reduced separation, improved meteorological information, and reduced flight time, based on the use of more efficient flight profiles.

A reduction of longitudinal and lateral separation between aircraft requires enhanced communications/navigation/surveillance (CNS) capabilities in air traffic systems and on board of those aircraft. Enhanced CNS systems provide controllers with automated tools such as conflict

prediction and reporting to assist in separation assurance and with tools to better monitor flight plan conformance. Enhanced communication and surveillance systems also enable controllers and pilots to better communicate and manage weather deviations and contingency situations such as aircraft turn-backs and diversions.

Flight planning plays an important role in operations over oceanic airspace. Theoretically, the flight path from departure aerodrome to destination, along a great circle, would give the minimum distance track. However, wind speeds and directions and other meteorological aspects such as temperature, areas of clear air turbulence, etc., affect flight times and therefore the optimum flight paths vary considerably from day to day. Additionally, the free choice of the desired flight path may be restricted by the need to maintain a particular flight level, Mach number or a specific track in an organized track system.

The fuel cost is a dominant part of the total cost of flight operations and is especially significant for long-distance flights. ATC can assist in fuel conservation and gas emissions reduction by accepting a pilot's request for a change of his current flight plan (if the traffic situation permits) which is normally a result of a change in the operational factors affecting the efficiency of his flight.

For aircraft equipped with automated dependent surveillance (ADS), it allows to automatically report the aircraft's current position, based on information generated by an on-board navigation system, via satellite data link, to the air traffic services. Automated air traffic management systems together with graphical situational displays along with the ability to interface with controller pilot data link communication (CPDLC) air traffic controllers will be in a position to control traffic in oceanic and remote areas almost real time. These will change the way controller in these areas work by moving them from a flight data strip and mental traffic picture to real time "viewing" of traffic.

If there is any controller instruction/clearance to be passed on, the controller can use CPDLC to relay information such as climb, descent, maintain a particular mach speed etc into the cockpit. The total transaction time using satellite communication may be significantly less compared to using HF.

### **2.3.2 High air traffic density oceanic areas**

Currently, in certain parts of the world, controllers in oceanic airspace rely on infrequent position reports that are manually read by the pilot from the airborne navigation equipment. The position reports are then transmitted on a communications medium (HF radio) to a receiving operator. The communications operator transcribes a teletype message from the voice report and sends it to the oceanic area control centre. Finally the teletype message is printed at the oceanic area control centre and manually delivered to the controller.

At present, these manually based operations are expected to be fully automated with the use of AMS(R)S. Due to the gradual progress in the airborne equipment, space segment, and ground segment (i.e., the transition from the low speed data link to the high speed data link and the gradual increase of satellite communication equipage), ATC systems are expected to evolve.

The AMS(R)S in oceanic areas with high air traffic density will provide capability for rapid access communications between the ground and the aircraft for both data and voice. This system will be able to accommodate ADS.

The evolution of ATM resulting from AMS(R)S (data and voice communications environment) is characterized by the improvement of traffic monitoring (surveillance accuracy); trajectory prediction; and conflict search and resolution, including short term conflict alert and will permit improvement of existing flight planning procedures.

Consequently, a reduction of longitudinal and lateral separation, an increase of tactical conflict resolution and better accommodation of optimal routes are expected.

### **2.3.3 Low air traffic density oceanic/continental en-route areas**

AMS(R)S in oceanic and continental en route areas with low air traffic density shall provide the capability of rapid access communications between the ground and aircraft for both data and voice. The satellite communication service will be able to accommodate ADS.

The evolution of ATM resulting from AMS(R)S (data and voice communications environment) is characterized by the improvement of traffic monitoring (surveillance accuracy), trajectory prediction, conflict detection and resolution, and flight planning procedures. As a consequence, there will be an increase in tactical conflict resolution and improved accommodation of optimal routes.

### **2.3.4 High air traffic density continental en route areas**

AMS(R)S in high air traffic density continental en route areas will provide the capability of immediate access communications between the ground and aircraft for both data and voice and will coexist with the VHF voice and data service. AMS(R)S will be able to accommodate ADS but also, as a surveillance system, will coexist with the SSR Mode A, C and S.

The evolution of air traffic management will include increased accommodation of optimum routes, accommodation of 3D navigation (improved definition of vertical profiles), 3D planning capability based on actual aircraft performance, advanced data communications exchange capability between ATC centres, trajectory prediction for flexible routing, improved conflict search and computer generated resolution advisory, improved short term conflict alert and resolution, air/ground data link communication capability, and improved trajectory prediction based on actual aircraft performance. All of this could be enhanced to accommodate 4D capabilities (where time is the fourth dimension of air navigation, negotiated between air and ground).

### **2.3.5 Terminal areas**

AMS(R)S may be applied to terminal areas with low density traffic to provide the capability for immediate access communications between ground and aircraft for both data and voice. It may coexist with VHF voice and data, as well as SSR services.

## **3 STANDARDIZATION ACTIVITIES**

### **3.1 General**

In addition to the definition of SARPs by ICAO, as described in paragraph 4.3 below, standardization activities by other bodies are taking place, as presented below. Documents which define technical aspects of the individual aeronautical satellite system (including the functional requirements of ground and aircraft earth stations) are developed and maintained by the satellite sub-system operator.

### **3.2 AEEC (ARINC) characteristics**

Airlines, air transport equipment manufacturers, and aviation service providers support the Airline Electronic Engineering Committee (AEEC) in developing systems and/or equipment to support industry standardization of common avionics signal characteristics, equipment mounting, and inter-equipment signal interfaces. ARINC 741, 761 and 781 are examples of system-level specifications that define, in detail, form, installation, and wiring and operational capability of the equipment and interchangeability. In addition, there are a number of specifications, such as ARINC 429, that define, in detail, standardized data bus, interface, or protocol requirements, which are used by system-level specifications, such as the aforementioned 741, 761 and 781. Avionics manufacturers and service providers shall make every attempt to subscribe to the pertinent standards and specifications in order to provide the highest degree of system and service commonality as possible.

### **3.3 Minimum operational performance standards (MOPS)**

MOPS are the standards by which the airworthiness and functional performance of avionics equipment and installed systems are determined in the United States of America. They are developed in the public domain by RTCA and then adopted by the U.S. Federal Aviation Administration (FAA) as basic technical standards for equipment certified under their Technical Standard Order (TSO) programme. MOPS are used by manufacturers for bench, installation and flight testing. Other States have similar equipment approval procedures, often based on the RTCA MOPS or similar standards produced by other organizations.

RTCA has developed DO-262, “Minimum Operational Performance Standards for Avionics Supporting Next Generation Satellite Systems.” Guidance on aeronautical mobile satellite service end-to-end system performance can be found in DO-215A.

### **3.4 Minimum aviation system performance standards (MASPS)**

RTCA also develops MASPS which specify characteristics useful to designers, installers, manufacturers, service providers and users of systems intended for operational use within a defined airspace. The MASPS describe the system (subsystems/functions) and provide information needed to understand the rationale for system characteristics, operational goals, requirements and typical applications. Definitions and assumptions essential to proper understanding of the MASPS are provided as well as minimum system test procedures to verify system performance compliance (e.g., end-to-end performance verification).

RTCA has developed minimum aviation system performance standards (MASPS) DO-270 for “AMS(R)S as used in Aeronautical Data Links.”

### **3.5 Satellite system access approval**

Satellite sub-system operators require ground and aircraft earth station equipment to perform in accordance with their system access standards. Thus, it will be necessary for equipment manufacturers to obtain system access approval from those system operators in whose systems they expect their equipment to function. With respect to aircraft earth stations, where components are procured from different manufacturers and installed on board an aircraft by an aircraft manufacturer or the owner, the burden of obtaining system access approval from satellite sub-system operators may fall on the aircraft manufacturer or owner.

### **3.6 Avionics and certification**

#### **3.6.1 Avionics**

Various avionics manufacturers are active in the field of the satellite AMS(R)S avionics. At the request of airlines, aircraft manufacturers who produce long range wide body aircraft are presently accepting options for satellite AMS(R)S installations on new aircraft.

#### **3.6.2 Airworthiness certification**

AMS(R)S aeronautical equipment cannot be operated unless certified as airworthy by the authorized agency of the State of its manufacture and, depending on treaty arrangements the State has with others, it must also be certified by the equivalent agencies of other States. The standards by which airworthiness is determined include RTCA MOPS, as noted above, and similar specifications produced by other international bodies such as EUROCAE or by the certification agencies themselves.

#### **3.6.3 Type acceptance**

With respect to radio transmission characteristics, type acceptance procedures are prepared by communications regulatory agencies, e.g., in the United States, the Federal Communications

Commission (FCC), and are conducted by manufacturers to assure that potential radiated interference is within specified limits. The technical characteristics of type acceptance are closely related to MOPS and their testing.

### **3.6.4 Licensing and permits**

The control and regulation of the radio equipment in aircraft is an important function in the operation of radio. Correct operation of equipment in approved frequency bands and on assigned, operational frequencies must be assured throughout an aircraft's flight on national or international journeys. Performance standards for both telecommunication and air safety requirements are the means used to achieve conformity with international rules.

Individual AES are, by their nature, airborne radio stations; therefore, are expected to require some form of licensing by national radio regulatory authorities. Operator (e.g. pilot) permits may also be required.

### **3.7 Terrestrial Sub-system Service Providers**

ICAO policy states that institutional arrangements should not prevent competition among different service providers. It is therefore inferred that the AMS(R)S would be offered to States, civil aviation administrations, airlines and others, by more than one service provider.

## **4 ICAO ACTIVITIES**

### **4.1 Institutional arrangements**

The institutional aspect of ATS communications by satellites is complex because State liability is concerned. The following guidelines were stressed by ICAO's Tenth Air Navigation Conference:

Guideline a): *Universal accessibility to air navigation safety services must be available without discrimination.*

This guideline is one of the fundamental principles underlying the philosophy of ICAO as the specialized agency of the United Nations for civil aviation. The application of the future Communications, Navigation and Surveillance (CNS) systems must not change this guideline, and, at this stage, it appears that it will not create new problems in this regard.

Guideline b): *The rights and responsibilities of States to control operations of aircraft within their sovereign airspace must not be compromised.*

This guideline is a fundamental tenet of international civil aviation philosophy, but it raises questions concerning the ability to utilize the "universal" capability of aircraft inherent in the application of modern technology. Satellite technology, in particular, makes it possible to improve the efficient utilization of airspace and the economic operation of international flights

across political boundaries. One of the foremost challenges of the future is likely to be to find practical ways to utilize these potential improvements without imposing unacceptable conditions regarding the sovereignty of national airspace. For example, where a State provides ATS communications through another State's ground earth station (GES) and other facilities, arrangements should avoid subordination of that State's ATS service.

*Guideline c): Arrangements must preserve, facilitate and not inhibit ICAO responsibility for the establishment of appropriate Standards, Recommended Practices and procedures in accordance with Article 37 of the Convention on International Civil Aviation.*

Article 37 of the Convention on International Civil Aviation recognizes the specialized safety needs of aircraft operations and designates ICAO as the body responsible for the adoption and application of air navigation safety Standards embodied in technical Annexes to the Convention. ICAO has long recognized the desirability, particularly for economic reasons, of aligning its technical Standards as closely as possible with similar specifications being developed by other international standardization bodies but has always retained its authority to diverge from other similar international technical standards should the need arise. The reasons for the inclusion of Article 37 in the Convention still exist, and ICAO is vigilant in carrying out its mandate in this area of activity.

*Guideline d): Arrangements must ensure the ability to protect safety communications from harmful interference.*

As the electromagnetic spectrum becomes more intensely used, the incidence of harmful interference to aircraft safety services has increased alarmingly, and it would appear prudent to assume that this trend will continue, and probably accelerate in the future. In modern satellite technology, and particularly on questions concerning use of the electromagnetic spectrum, there are strong pressures to ensure that non aviation users conform to critical specifications dictated by the safety requirements of the civil aviation community. The most effective place to deal with harmful interference is at its source, and ICAO has been doing its best to ensure that acceptable levels are established for spurious emissions allowable from activities in the electromagnetic spectrum of a growing number of users. The future CNS system will utilize previously unexploited parts of the electromagnetic spectrum, and may be susceptible to new forms of harmful interference, so that continuing efforts in coordination, research, application and regulatory enforcement will be required to retain established safety criteria. Arrangements should ensure that continuous oversight and control of the area's spectrum use is conducted so that harmful interference can be quickly detected and corrected.

*Guideline e): Arrangements must be adequately flexible to accommodate presently defined services and a range of future services.*

As in the introduction of any new system, users require assurance that there will be no degradation of existing services. Possibilities for additional services need to be introduced, and

such additions need to be implemented with minimum disruption to existing systems. Furthermore, institutional and organizational arrangements must also ensure the required flexibility. Safety message priority must be assured.

Guideline f): *Arrangements must facilitate the certification by States of those service providers whose services comply with ICAO Standards, Recommended Practices and procedures for the aeronautical mobile satellite (R) service (AMS(R)S).*

The certification process should ensure that services provided meet the appropriate ICAO SARPs, as well as any State requirements, such as financial responsibility, competence and capacity.

Guideline g): *Institutional arrangements should not prevent competition among different service providers that comply with ICAO SARPs.*

This guideline seeks to encourage competition in the provision of aeronautical mobile satellite service. In some areas, however, ATS administrations may wish to select and regulate the satellite system to be used, for reasons such as the existence of contracts with service providers, or special interfaces with service providers that operate through a particular satellite system.

Guideline h): *ICAO's responsibility for co ordination and use of AMS(R)S spectrum allocations must continue to be recognized.*

Where ICAO plays a role in the coordination and use of radio frequency spectrum within the aeronautical community, the ITU is responsible for the international allocation, coordination, registration and protection of frequency assignments.

While there has been little difficulty in the past with regard to recognition of ICAO's responsibility *vis-à-vis* Annex 10 provisions, frequency allocations have become extremely complex in today's environment, and users are placing different interpretations on the meaning of "responsibility."

Guideline i): *Arrangements must recognize States' responsibility and authority to enforce safety regulations.*

In the complexity of modern satellite systems, particularly in cases of satellite systems sharing resources with other services, the manner in which States' responsibility could be exercised becomes also more complex.

Guideline j): *Arrangements must ensure guaranteed priority of aeronautical mobile-satellite safety communications over aeronautical non-safety and non-aeronautical mobile-satellite communications in accordance with ICAO SARPs.*

This guideline is generally acknowledged as a requirement, but the provisions of guaranteed priority for aeronautical safety communications in any satellite system must be demonstrated in practice and under all satellite conditions before acceptance. Relevant details are being studied in the Aeronautical Communications Panel (ACP).

Guideline k): *Arrangements must be in place so that service providers, operating in the same area, co-operate to ensure that space segment resources are made available to handle AMS(R)S service.*

As message traffic increases for both aeronautical safety and non-safety service, situations may arise where one service provider runs out of resources (e.g. satellite power, spectrum, etc.) to support AMS(R)S, however, another service provider(s), providing service in the same area could support AMS(R)S. Under these conditions arrangements should be developed so that resources are made available to handle the AMS(R)S traffic of the first service provider through co operative use of the resources.

Guideline l): *Arrangements should enable all AMSS functions (ATS, AOC, AAC and APC) to be provided through common avionics equipment in the aircraft.*

This guideline has special significance for the civil aviation industry because of the special problems (technical and economical) involved with multiple airborne satellite installations.

Guideline m): *Arrangements should make all four identified satellite services (ATS, AOC, AAC and APC) available through any given satellite in any region of the world.*

This guideline is in recognition of the difficulties of installing multiple systems aboard aircraft. An aircraft should, as a matter of principle, not be required to access more than one satellite to obtain all four identified AMSS functions, (ATS, AOC, AAC and APC).

Guideline n): *Adequate arrangements should be made for recovery in the event of a significant malfunction or catastrophic failure of the satellite system.*

Where a single satellite system provider offers a service in an area, a back-up capability must be available within that system in the event of a significant malfunction or catastrophic failure. In the special case where more than one satellite system provider offers identical, or near identical, and technically compatible services in the same area, co-operative institutional arrangements may facilitate back-up service in the event of a significant malfunction or catastrophic failure in one of the systems.

Guideline o): *Policies governing charges levied on users must not inhibit or compromise the use of satellite based service for safety messages.*

Because of the importance and the pre-eminence of safety messages in aeronautical mobile communications, their use must be in accordance with regulations and without regard to the cost of individual transmissions. In implementing this guideline, the specific Annex 10 definition of what constitutes a safety message must be conveyed to the service provider of the AMSS system.

Guideline p): *Existing governmental or inter governmental agencies, modified if necessary, should be used to the extent practicable.*

This guideline states the practical fact that new agencies need not be established if existing agencies in present or modified form can do the job satisfactorily.

Guideline q): *Arrangements should allow the introduction of satellite services on an evolutionary growth basis.*

One of the practical difficulties in introducing any new aeronautical service is the implementation of required equipment in aircraft. Therefore, any system which allows for step-by-step and evolutionary implementation and growth is highly desirable.

Guideline r): *Arrangements should provide for the determination of liabilities.*

The determination of liabilities among the various service providers of the AMSS system is a task requiring inputs from work being done by other groups in ICAO. This guideline has been listed here as a reminder that liability issues could have a bearing on institutional arrangements.

Guideline s): *Arrangements must retain ATS authority to co ordinate and maintain control, directly or indirectly, over aeronautical mobile satellite communications according to message priorities established in the ITU Radio Regulations.*

This guideline pertains to the requirement for the ATS authority to retain authority and control over aeronautical safety communications and notes the need for a rigid examination and adequate demonstration that this vital function can be retained both in respect of dedicated aeronautical satellite systems and in generic satellite systems.

#### **4.2 AMS(R)S spectrum issues**

Under its Constitution and Convention, the International Telecommunications Union (ITU) has recognition and authority as the international body for telecommunications. The Radio Regulations (RR) are the instrument through which this specialization is expressed in internationally agreed terms for radio matters. The ITU Radio Regulations lay down the framework for international spectrum management and contain the Table of Frequency Allocations, which is effectively the worldwide agreement on the deployment and conditions of use of all radio frequencies in the radio frequency spectrum.

Spectrum for the provision of AMS(R)S is made available through agreements reached at World Radiocommunication Conferences (WRC) of the (ITU). These agreements are embodied in the Radio Regulations. Articles 1, 5, 9, and 11 of these regulations address the availability and protection of the spectrum for AMS(R)S. Article 1 defines Safety Service and the Mobile Satellite Service (MSS), which includes the AMS(R)S.

MSS primary allocations are required to be used by satellite systems and networks to provide AMS(R)S (RR Article 5). These allocations generally are used to provide uplinks and downlinks in the range 1.5 – 1.6 GHz. This frequency range has been divided into a number of MSS allocations which are being used by geostationary and non-geostationary satellite systems. The allocations for these systems include footnotes which are considered part of the allocation and provide an indication that these bands may be used for AMS(R)S. They also specify the requirement for frequency coordination between the MSS systems and with other services operating in the same frequency bands.

Frequency coordination is carried out in accordance with the provisions of Article 9 of the RR. The purpose of this coordination is to ensure that harmful interference is neither caused nor received by the MSS systems concerned. When coordination is successfully completed, the MSS systems are registered with the ITU (RR Article 11) and included in the International Frequency List. When this status is achieved, the systems are entitled to receive protection which also ensures the protection of AMS(R)S.

Additional information is contained in the *Handbook on Radio Frequency Spectrum Requirements for Civil Aviation including Statement of Approved ICAO Policies* (Doc 9718).

### **4.3 Standards and Recommended Practices (SARPs)**

During the review of the report of the eighth meeting of the Aeronautical Mobile Communications Panel (AMCP/8), the predecessor of the Aeronautical Communications Panel (ACP), the Air Navigation Commission requested the ACP to develop proposals for the reorganization of the AMSS SARPs (Annex 10, Volume III, Part I, Chapter 4) into a section with “core” SARPs, to be retained in Annex 10, and a set of detailed technical specifications for AMS(R)S, as required. In pursuing this work, the “core” functionality of the AMSS SARPs and the next-generation satellite system (NGSS) draft SARPs, which were developed at the seventh meeting of the AMCP (AMCP/7), were integrated into a single set of AMS(R)S SARPs. These AMS(R)S SARPs have replaced the AMSS and the (draft) NGSS SARPs.

Relevant detailed technical specifications for AMS(R)S have been developed by the ACP and are contained in this manual. In this process, as much as possible, reference has been made to relevant material already available through organizations such as RTCA and EUROCAE.

The AMS(R)S SARPs have been incorporated in Annex 10, Amendment 82 and became applicable on 22 November 2007.

#### **4.4 Required communication performance (RCP)**

The emergence of several types of data links for the conduct of air-ground data interchange, as well as for the support of specific navigation, surveillance and other functions, has raised the concern that the air navigation system is becoming too complex. Obviously, it would have been ideal to have a single air-ground communications system capable of handling all communications, navigation and surveillance requirements in all types of airspace and for all phases of flight in a cost effective manner. However, as no such technological solution has yet been found to meet all operational requirements, the aviation community has to consider all available as well as emerging communications systems, though some may only perform a single function or only serve a limited area.

The availability of several communications systems does provide a degree of flexibility to planning and implementation in different types of airspace; however, the proliferation of subnetworks will add to the complexity of the operation of air-ground communications. One solution to this problem is to do away with the specification of individual systems and instead, translate all relevant operational requirements in a certain airspace and scenario into a series of communications performance parameters. The term required communications performance (RCP) therefore refers to a set of well-quantified communications performance requirements, such as capacity, availability, error rate, and transit delay. Once RCP has been specified for an operational scenario in a given airspace, any single communications system, or combination of systems meeting the set parameters, can be considered as operationally acceptable.

Guidance material on RCP is contained in the *Manual on required communication performance (RCP)* (Doc 9869).

#### **4.5 Aeronautical telecommunication network (ATN)**

The concept of an ATN which was developed through ICAO and other aeronautical organizations supported the interoperability between the different types of air ground data links, e.g. Mode S, VHF data link and AMS(R)S. For packet data service, the AMS(R)S was considered as a subnetwork of the ATN. The ATN concept allowed for connectivity between air/ground data link subnetworks and terrestrial subnetworks, so integrating all the different aeronautical communication subnetworks, including the aeronautical fixed telecommunication needs.

In the ATN concept, the network aspects of each subnetwork are independent of the application environment, and certain parts of the avionics can be shared between the different air ground subnetworks. In particular, as data link application services evolve with time, it is important that the subnetwork characteristics remain the same.

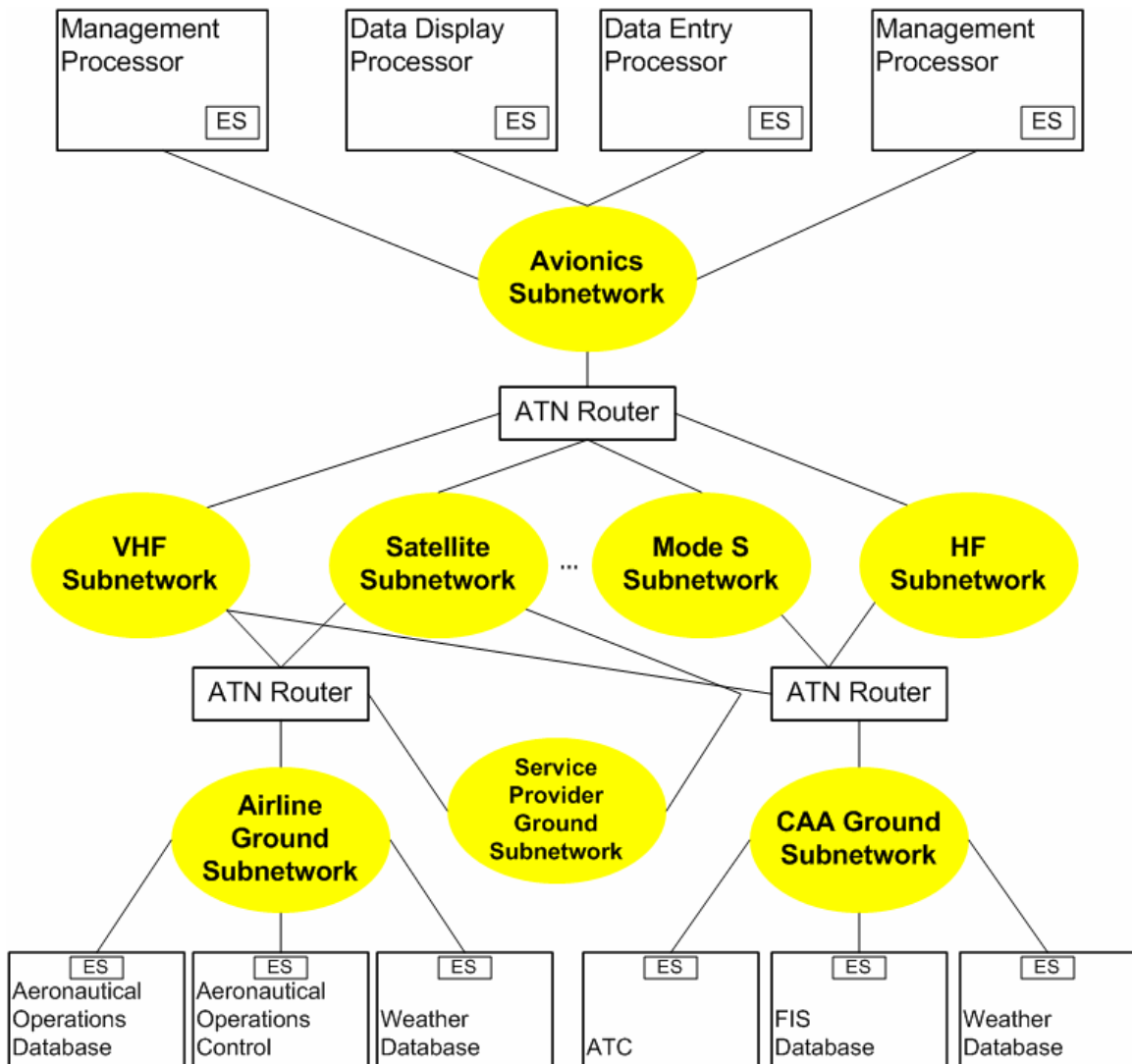
To achieve this interoperability between data links, the international aviation community had decided to adhere to the open system interconnection (OSI) reference model developed by the International Organization for Standardization (ISO). In February 1993, the Air Navigation Commission (ANC) established the Aeronautical Telecommunication Network Panel (ATNP) to develop Standards and Recommended Practices (SARPs), guidance material and other relevant

documents for the ATN. Work was predicated on the predominant networking technology of that time, the OSI/ISO protocol suite. Since then, significant changes had occurred in the technology arena and in the air traffic management. Technologically, the worldwide acceptance of the Internet Protocol Suite (IPS) as internetworking protocol had led industry away from providing OSI-based commercial products. This resulted in numerous ICAO contracting states and aeronautical technical organizations to review their planned implementation of the OSI/ISO protocols; this was also the genesis for the current ICAO activities to include IPS in ATN SARPs.

The ATN and its associated application processes have been specifically designed to provide, in a manner transparent to the end-user, a reliable end-to-end communications service over dissimilar networks in support of air traffic services. ATN can also carry other communications service types, such as AOC communications, AAC and APC. Some other features of the ATN:

- a) enhanced data security;
- b) based on internationally recognized data communications Standards;
- c) accommodates differing services (e.g. preferred air ground subnetwork);
- d) allows the integration of public/private networks; and
- e) makes efficient use of bandwidth, which is a limited resource in air-ground data links.

A diagram of the ATN architecture is given in Figure 4-1.



Overview of ATN Architecture

Figure 4-1

When a State or organization transitions to an ATN environment, consideration must be given to interfacing with systems of other States and organizations. Furthermore, the ground-to-air interface(s) will be to either an ATN aircraft or a FANS-1/A aircraft. An ATS unit which needs to exchange data with ATN aircraft should implement applications which are the ground-based peers of the aircraft applications. In addition, the ground ATN environment must be connected to the aircraft ATN environment via one or more mobile subnetworks. There are two possible ways to use a mobile subnetwork. The first is a direct connection from the ATS unit to the aircraft router. The second way is to use the air-ground router and mobile subnetwork of another organization. Communication with a FANS-1/A aircraft will be accomplished by an “accommodation software” in an ATS unit. All FANS-1/A accommodation-related work will be

done on the ground. Both ATN and FANS-1/A downlink messages will be processed without restriction, and uplink messages will arrive correctly at their intended destination (i.e. FANS-1/A to FANS-1/A aircraft and ATN to ATN aircraft). However, the FANS-1/A-only aircraft are not expected to be able to obtain the same operational services which will be offered to ATN aircraft.

Guidance material can be found in the *Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN) using ISO/OSI standards and protocols* (Doc 9880). This manual contains the detailed technical specifications for the ATN, based on relevant standards and protocols established by the International Organization for Standardization (ISO) and the Telecommunication Standardization Sector of the International Telecommunication Union (ITU-T) for Open Systems Interconnection (OSI). It contains information on air-ground and ground-ground applications, Internet communication services, including upper layer communications service, directory service, security services, systems management and identifier registration. Additional information may be found in *Comprehensive Aeronautical Telecommunication Network (ATN) Manual* (Doc 9739). The ATN is currently migrating towards Internet Protocol suite (IPS) standards.

An opportunity offered to enable early use of current technology by the application of ARINC Specifications 622 (*ATS Data Link Applications Over ACARS Air-Ground Network*) and 623 (*Character-Oriented Air Traffic Service Applications*) over character-based data communication systems such as Aircraft Communications Addressing and Reporting System (ACARS) will provide for significant benefits in ATM. Several States are proceeding with implementation of ATS ground facilities to meet and take early advantage of aircraft CNS packages, both of which are based on the ARINC Specifications 622 and 623. The implementation plans recognize that eventual transition to the ATN is an objective and that ARINC Specifications 622 and 623 are intermediate interim steps designed to gain early CNS/ATM benefits from existing technology.

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