# Democratic Socialist Republic of Sri Lanka

# Civil Aviation Authority of Sri Lanka

## Implementing Standards

(Issued under Sec. 120,Civil Aviation Act No. 14 of 2010)

# Title: Conformance to Annex-10-Aeronautical Telecommunications Vol. III (Part I) (Digital Data Communication Systems)

**Reference No**: IS-10-(iii)-1 **S.N**: 039 **Date**: 1st Februvary 2017

Pursuant to Sec 120 of the Civil Aviation Act No.14 of 2010, which is hereinafter referred to as the CA Act, Director General of Civil Aviation shall have the power to issue, whenever he considers it necessary or appropriate to do so, such Implementing Standards for the purpose of giving effect to any provision in the CA Act, any Regulations or Rules made thereunder including the Articles of the Convention on International Civil Aviation specified in the Schedule to the CA Act.

Accordingly, I, the undersigned being the Director General of Civil Aviation do hereby issue the Implementing Standards on **Digital Data Communication Systems** as mentioned in the Attachment hereto (Ref:Attachment No IS-10-(iii)-1-Att.) elaborating the requirements to be satisfied for the effective implementation of the International Standards and Recommended Practices on “Digital Data Communications Systems” contained in Annex 10 Volume 3 Part I “Aeronautical Telecommunications” to the Convention and the Air Navigation Regulations of 1955.

These Implementing Standard shall be applicable to Airport & Aviation Services (SL) Ltd.and shall come in to force with immediate effect and remain in force unless revoked.

Attention is also drawn to sec. 103 of the Act, which states inter alia that failure to comply with Implementing Standard is an offence.

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Enclosure: Attachment No IS-10-(iii)-1-Att

# Implementing Standards

# SLCAIS -039: Digital Data Communication Systems

## 1. GENERAL:

### 1.1 Introduction

A. Requirements contained in this document are based on the amendment 90 of ICAO Annex 10 –Volume III Part I "Digital Data Communication Systems".

B. The requirements contained in this document are applicable to Aeronautical Telecommunication Service Providers and Service providers of Aeronautical Aids for Communication Navigation and Surveillance (CNS) in Sri Lanka.

C. This document supersedes the Implementing Standard 039 Revision 00 issued by the Director General of Civil Aviation and IS 039 Revision 00 is shall be treated as null and void.

D. It may be amended from time to time and the amendments will be reflected with a vertical line on the right side of the text

# 1. CHAPTER 01 - DEFINITIONS

This chapter contains general definitions relevant to communication systems. Definitions specific to each of the systems included in this document are contained in the relevant chapters.

***Aeronautical administrative communications (AAC)*** – Communications necessary for the exchange of aeronautical administrative messages.

***Aeronautical operational control (AOC)*** – Communication required for the exercise of authority over the initiation, continuation, diversion or termination of flight for safety, regularity and efficiency reasons.

***Aeronautical telecommunication network (ATN)*** **–** A global internetwork architecture that allows ground, air-ground and avionic data subnetworks to exchange digital data for the safety of air navigation and for the regular, efficient and economic operation of air traffic services.

***Aircraft address*** **–** A unique combination of twenty-four bits available for assignment to an aircraft for the purpose of airground communications, navigation and surveillance.

***Aircraft earth station (AES)*** **–** A mobile earth station in the aeronautical mobile-satellite service located on board an aircraft (see also “GES”).

***Air traffic service*** **–** A generic term meaning variously, flight information service, alerting service, air atraffic advisory service, air traffic control service (area control service, approach control service or aerodrome control service).

***Automatic dependent surveillance — contract (ADS-C)*** **–** A means by which the terms of an ADS-C agreement will be exchanged between the ground system and the aircraft, via a data link, specifying under what conditions ADS-C reports would be initiated, and what data would be contained in the reports.

***Automatic terminal information service (ATIS)*** **–** The automatic provision of current, routine information to arriving and departing aircraft throughout 24 hours or a specified portion thereof. *Data link-automatic terminal information service (D-ATIS).* The provision of ATIS via data link. *Voice-automatic terminal information service (Voice-ATIS).* The provision of ATIS by means of continuous and repetitive voice broadcasts.

***Bit error rate (BER)*** **–** The number of bit errors in a sample divided by the total number of bits in the sample, generally averaged over many such samples.

***Carrier-to-multipath ratio (C/M)*** **–** The ratio of the carrier power received directly, i.e. without reflection, to the multipath power, i.e. carrier power received via reflection.

***Carrier-to-noise density ratio (C/No)*** **–** The ratio of the total carrier power to the average noise power in a 1 Hz bandwidth, usually expressed in dBHz.

***Channel rate*** **–** The rate at which bits are transmitted over the RF channel. These bits include those bits used for framing and error correction, as well as the information bits. For burst transmission, the channel rate refers to the instantaneous burst rate over the period of the burst.

***Channel rate accuracy* –** This is relative accuracy of the clock to which the tra

***Controller pilot data link communications (CPDLC)* –** A means of communication nsmitted channel bits are synchronized. For example, at a channel rate of 1.2 kbits/s, maximum error of one part in 106 implies the maximum allowed error in the clock is ±1.2 × 10-3 Hz.

***Circuit mode* –** A configuration of the communications network which gives the appearance to the application of a dedicated transmission path.
between controller and pilot, using data link for ATC communications.

***Data link flight information services (D-FIS)* –** The provision of FIS via data link.

***Doppler shift* –** The frequency shift observed at a receiver due to any relative motion between transmitter and receiver.

***End-to-end* –** Pertaining or relating to an entire communication path, typically from (1) the interface between the information source and the communication system at the transmitting end to (2) the interface between the communication system and the information user or processor or application at the receiving end.

***End-user* –** An ultimate source and/or consumer of information.
***Energy per symbol to noise density ratio (Es/No)* –** The ratio of the average energy transmitted per channel symbol to the average noise power in a 1 Hz bandwidth, usually expressed in dB. For A-BPSK and A-QPSK, one channel symbol refers to one channel bit.

***Equivalent isotropically radiated power (e.i.r.p.)* –** The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna *(absolute or isotropic gain).*

***Flight information service (FIS)* –** A service provided for the purpose of giving advice and information useful for the safe and efficient conduct of flights.

***Forward error correction (FEC)* –** The process of adding redundant information to the transmitted signal in a manner which allows correction, at the receiver, of errors incurred in the transmission.

***Gain-to-noise temperature rati* –** The ratio, usually expressed in dB/K, of the antenna gain to the noise at the receiver output of the antenna subsystem. The noise is expressed as the temperature that a 1 ohm resistor must be raised to produce the same noise power density.

***Ground earth station (GES)* –** An earth station in the fixed satellite service, or, in some cases, in the aeronautical mobile-satellite service, located at a specified fixed point on land to provide a feeder link for the aeronautical mobilesatellite service.

This definition is used in the ITU’s Radio Regulations under the term “aeronautical earth station”. The definition herein as “GES” for use in the SARPs is to clearly distinguish it from an aircraft earth station (AES), which is a mobile station on an aircraft.

***Mode S subnetwork*** – A means of performing an interchange of digital data through the use of secondary surveillance radar (SSR) Mode S interrogators and transponders in accordance with defined protocols.

***Point-to-point*** – Pertaining or relating to the interconnection of two devices, particularly end-user instruments. A communication path of service intended to connect two discrete end-users; as distinguished from broadcast or multipoint service.

***Slotted aloha*** – A random access strategy whereby multiple users access the same communications channel independently, but each communication must be confined to a fixed time slot. The same timing slot structure is known to all users, but there is no other coordination between the users.

***Time division multiple access (TDMA)*** – A multiple access scheme based on time-shared use of an RF channel employing: (1) discrete contiguous time slots as the fundamental shared resource; and (2) a set of operating protocols that allows users to interact with a master control station to mediate access to the channel.

***Time division multiplex (TDM)*** – A channel sharing strategy in which packets of information from the same source but with different destinations are sequenced in time on the same channel.

***Transit delay*** – In packet data systems, the elapsed time between a request to transmit an assembled data packet and an indication at the receiving end that the corresponding packet has been received and is ready to be used or forwarded.

***VHF digital link (VDL*** – A constituent mobile subnetwork of the aeronautical telecommunication network (ATN), operating in the aeronautical mobile VHF frequency band. In addition, the VDL may provide non-ATN functions such as, for instance, digitized voice.

## 2. CHAPTER 02 - AERONAUTICAL TELECOMMUNICATION NETWORK

Detailed technical specifications for ATN/OSI applications are contained in the Manual on Detailed Technical Specifications for the Aeronautical Telecommunication Network (ATN) using ISO/OSI standards and protocols (Doc 9880) and in the Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN) (Doc 9705).

Detailed technical specifications for ATN/IPS applications are contained in the Manual for the ATN using IPS standards and protocols (Doc 9896).

### 2.1 DEFINITIONS

***Application entity (AE)*** – An AE represents a set of ISO/OSI communication capabilities of a particular application process (see ISO/IEC 9545 for further details).

***ATN security services*** – A set of information security provisions allowing the receiving end system or intermediate system to unambiguously identify (i.e. authenticate) the source of the received information and to verify the integrity of that information.

***ATS interfacility data communication (AIDC)*** – Automated data exchange between air traffic services units in support of flight notification, flight coordination, transfer of control and transfer of communication.

***ATS message handling service (ATSMHS)*** – An ATN application consisting of procedures used to exchange ATS messages in store-and-forward mode over the ATN such that the conveyance of an ATS message is in general not correlated with the conveyance of another ATS message by the service provider.

***ATS message handling system (AMHS)*** – The set of computing and communication resources implemented by ATS organizations to provide the ATS message handling service.

***Authorized path*** – A communication path suitable for a given message category.

***Data link initiation capability (DLIC)*** – A data link application that provides the ability to exchange addresses, names and version numbers necessary to initiate data link applications (see Doc 4444).

***Directory service (DIR)*** – A service based on the ITU-T X.500 series of recommendations, providing access to and management of structured information relevant to the operation of the ATN and its users.

***Required communication performance (RCP)*** – A statement of the performance requirements for operational communication in support of specific ATM functions (see Manual on Required Communication Performance (RCP) (Doc 9869)).

## 2.2 INTRODUCTION

2.2.1 The ATN is specifically and exclusively intended to provide digital data communications services to air traffic service provider organizations and aircraft operating agencies in support of:

(a) Air traffic services communications (ATSC) with aircraft;

(b) Air traffic services communications between ATS units;

(c) Aeronautical operational control communications (AOC); and

(d) Aeronautical administrative communications (AAC).

## 2.3 GENERAL

The Standards in sections 2.4 to 2.8 define the minimum required protocols and services that will enable the global implementation of the aeronautical telecommunication network (ATN).

2.3.1 ATN communication services shall support ATN applications.

2.3.2 Requirements for implementation of the ATN shall be made on the basis of regional air navigation agreements. These agreements shall specify the area in which the communication standards for the ATN/OSI or the ATN/IPS are applicable.

## 2.4 GENERAL REQUIREMENTS

2.4.1 The ATN shall either use International Organization for Standardization (ISO) communication standards for open systems interconnection (OSI) or use the Internet Society (ISOC) communications standards for the Internet Protocol Suite (IPS).

ATN/IPS implementation is preferred for ground-ground networks. While ATN/OSI continues to be supported in air-ground networks, particularly when using VDL Mode 2, it is expected that future air-ground implementations will use the ATN/IPS.

Interoperability between interconnecting OSI/IPS networks is expected to be arranged prior toimplementation.

Guidance material on interoperability between ATN/OSI and ATN/IPS is contained in Doc 9896.

2.4.2 The AFTN/AMHS gateway shall ensure the interoperability of AFTN and stations and networks with the ATN.

2.4.3 An authorized path(s) shall be defined on the basis of a predefined routing policy.

2.4.4 The ATN shall transmit, relay and deliver messages in accordance with the priority classifications and without discrimination or undue delay.

2.4.5 The ATN shall provide means to define data communications that can be carried only over authorized paths for the traffic type and category specified by the user.

2.4.6 The ATN shall provide communication in accordance with the prescribed required communication performance (RCP).

*The* Manual on Required Communication Performance (RCP) *(Doc 9869) contains the necessary information on RCP*.

2.4.7 The ATN shall operate in accordance with the communication priorities defined in Table 2-1 and Table 2-2.

2.4.8 The ATN shall enable exchange of application information when one or more authorized paths exist.

2.4.9 The ATN shall notify the appropriate application processes when no authorized path exists.

2.4.10 The ATN shall make provisions for the efficient use of limited bandwidth subnetworks.

2.4.11 The ATN should enable an aircraft intermediate system (router) to connect to a ground intermediate system (router) via different subnetworks.

2.4.12 The ATN should enable an aircraft intermediate system (router) to connect to different ground intermediate systems (routers).

2.4.13 The ATN shall enable the exchange of address information between applications.

2.4.14 where the absolute time of day is used within the ATN, it shall be accurate to within 1 second of coordinated universal time (UTC).

The time accuracy value results in synchronization errors of up to two seconds.

## 2.5 ATN APPLICATIONS REQUIREMENTS

### 2.5.1 System applications

System applications provide services that are necessary for operation of the ATN.

2.5.1.1 The ATN shall support the data link initiation capability (DLIC) applications when air-ground data links are implemented.

The Manual of Air Traffic Services Data Link Applications (Doc 9694, Part I) defines the data link initiation capability (DLIC) application.

2.5.1.2 The ATN/OSI end-system shall support the following directory services (DIR) application functions when AMHS and/or security protocols are implemented:

a) directory information retrieval; and

b) directory information modification.

### 2.5.2 Air-ground applications

2.5.2.1 The ATN shall be capable of supporting one or more of the following applications:

a) ADS-C Tables 2-1 and 2-2 are located at the end of this chapter.

b) CPDLC; and

c) FIS (including ATIS and METAR).

*See the* Manual of Air Traffic Services Data Link Applications *(Doc 9694).*

### 2.5.3 Ground-ground applications

2.5.3.1 The ATN shall be capable of supporting the following applications:

a) ATS interfacility data communication (AIDC); and

b) ATS message handling services applications (ATSMHS).

*See the* Manual of Air Traffic Services Data Link Applications *(Doc 9694).*

## 2.6 ATN COMMUNICATIONS SERVICE REQUIREMENTS

2.6.1 ATN/IPS upper layer communications service

2.6.1.1 An ATN host shall be capable of supporting the ATN/IPS upper layers including an application layer.

2.6.2 ATN/OSI upper layer communications service

2.6.2.1 An ATN/OSI end-system (ES) shall be capable of supporting the OSI upper layer communications service (ULCS) including session, presentation and application layers.

2.6.3 ATN/IPS communications service

2.6.3.1 An ATN host shall be capable of supporting the ATN/IPS including the:

a) transport layer in accordance with RFC 793 (TCP) and RFC 768 (UDP); and

b) network layer in accordance with RFC 2460 (IPv6).

2.6.3.2 An IPS router shall support the ATN network layer in accordance with RFC 2460 (IPv6) and RFC 4271 (BGP), and RFC 2858 (BGP multiprotocol extensions).

2.6.4 ATN/OSI communications service

2.6.4.1 An ATN/OSI end-system shall be capable of supporting the ATN including the:

a) transport layer in accordance with ISO/IEC 8073 (TP4) and optionally ISO/IEC 8602 (CLTP); and

b) network layer in accordance with ISO/IEC 8473 (CLNP).

An ATN host is an ATN end-system in OSI terminology; an ATN end-system is an ATN host in IPS terminology.

2.6.4.2 An ATN intermediate system (IS) shall support the ATN network layer in accordance with ISO/IEC 8473 (CLNP) and ISO/IEC 10747 (IDRP).

## 2.7 ATN NAMING AND ADDRESSING REQUIREMENTS

The ATN naming and addressing scheme supports the principles of unambiguous identification of intermediate systems (routers) and end-systems (hosts) and provides global address standardization.

2.7.1 The ATN shall provide provisions for unambiguous application identification.

2.7.2 The ATN shall provide provisions for unambiguous addressing.

2.7.3 The ATN shall provide means to unambiguously address all ATN end-systems (hosts) and intermediate systems (routers).

2.7.4 The ATN addressing and naming plans shall allow States and organizations to assign addresses and names within their own administrative domains.

## 2.8 ATN SECURITY REQUIREMENTS

2.8.1 The ATN shall make provisions whereby only the controlling ATS unit may provide ATC instructions to aircraft operating in its airspace.

This is achieved through the current and next data authority aspects of the controller-pilot data link communications (CPDLC) application.

2.8.2 The ATN shall enable the recipient of a message to identify the originator of that message.

2.8.3 ATN end-systems supporting ATN security services shall be capable of authenticating the identity of peer endsystems, authenticating the source of messages and ensuring the data integrity of the messages.

The use of security is the default; however, its implementation is based on local policy.

2.8.4 The ATN services shall be protected against service attacks to a level consistent with the application service requirements.

# TABLES FOR CHAPTER 2

## Table 2-1 mapping of ATN communication priorities

| *Message categories* | *ATN application* | *Corresponding protocol priority* | |
|---|---|---|---|
| | | *Transport layer priority* | *Network layer priority* |
| Network/systems management | | 0 | 14 |
| Distress communications | | 1 | 13 |
| Urgent communications | | 2 | 12 |
| High-priority flight safety messages | CPDLC, ADS-C | 3 | 11 |
| Normal-priority flight safety messages | AIDC, ATIS | 4 | 10 |
| Meteorological communications | METAR | 5 | 9 |
| Flight regularity communications | DLIC, ATSMHS | 6 | 8 |
| Aeronautical information service messages | | 7 | 7 |
| Network/systems administration | DIR | 8 | 6 |
| Aeronautical administrative messages | | 9 | 5 |
| <unassigned> | | 10 | 4 |
| Urgent-priority administrative and U.N. Charter communications | | 11 | 3 |
| High-priority administrative and State/Government communications | | 12 | 2 |
| Normal-priority administrative communications | | 13 | 1 |
| Low-priority administrative communications and aeronautical passenger communications | | 14 | 0 |

*Note.— The network layer priorities shown in the table apply only to connectionless network priority and do not apply to subnetwork priority.*

**Table 2-2. Mapping of ATN network priority to mobile subnetwork priority**

| *Message categories* | *ATN network layer priority* | *Corresponding mobile subnetwork priority (see Note 4)* | | | | | |
|---|---|---|---|---|---|---|---|
| | | *AMSS* | *VDL Mode 2* | *VDL Mode 3* | *VDL Mode 4* | *SSR Mode S* | *HFDL* |
| Network/systems management | 14 | 14 | see Note 1 | 3 | 14 | high | 14 |
| Distress communications | 13 | 14 | see Note 1 | 2 | 13 | high | 14 |
| Urgent communications | 12 | 14 | see Note 1 | 2 | 12 | high | 14 |
| High-priority flight safety messages | 11 | 11 | see Note 1 | 2 | 11 | high | 11 |
| Normal-priority flight safety messages | 10 | 11 | see Note 1 | 2 | 10 | high | 11 |
| Meteorological communications | 9 | 8 | see Note 1 | 1 | 9 | low | 8 |
| Flight regularity communications | 8 | 7 | see Note 1 | 1 | 8 | low | 7 |
| Aeronautical information service messages | 7 | 6 | see Note 1 | 0 | 7 | low | 6 |
| Network/systems administration | 6 | 5 | see Note 1 | 0 | 6 | low | 5 |
| Aeronautical administrative messages | 5 | 5 | not allowed | not allowed | not allowed | not allowed | not allowed |
| <unassigned> | 4 | unassigned | unassigned | unassigned | unassigned | unassigned | unassigned |
| Urgent-priority administrative and U.N. Charter communications | 3 | 3 | not allowed | not allowed | not allowed | not allowed | not allowed |
| High-priority administrative and State/Government communications | 2 | 2 | not allowed | not allowed | not allowed | not allowed | not allowed |
| Normal-priority administrative communications | 1 | 1 | not allowed | not allowed | not allowed | not allowed | not allowed |
| Low-priority administrative communications and aeronautical passenger communications | 0 | 0 | not allowed | not allowed | not allowed | not allowed | not allowed |

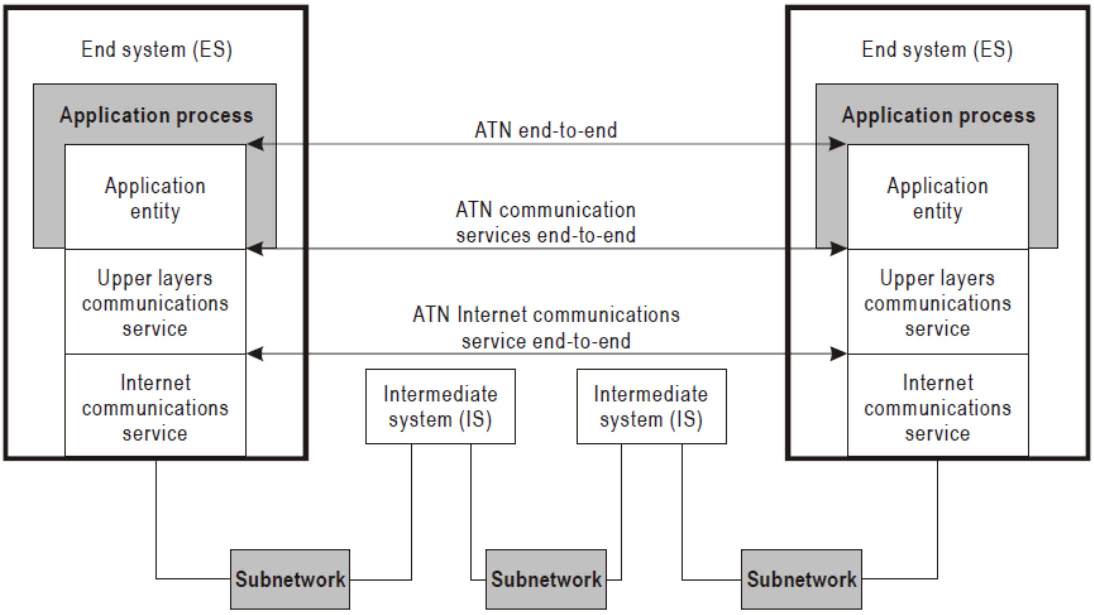
*Note 1.— VDL Mode 2 has no specific subnetwork priority mechanisms.*

*Note 2.— The AMSS SARPs specify mapping of message categories to subnetwork priority without explicitly referencing ATN network layer priority.*

*Note 3.— The term "not allowed" means that only communications related to safety and regularity of flight are authorized to pass over this subnetwork as defined in the subnetwork SARPs.*

*Note 4.— Only those mobile subnetworks are listed for which subnetwork SARPs exist and for which explicit support is provided by the ATN boundary intermediate system (BIS) technical provisions.*

# FIGURE FOR CHAPTER 2




*Note 1.— Shading indicates elements outside the scope of these SARPs. User requirements define the interface between the application entity and the user and ensure the functionality and interoperability of the ATN.*

*Note 2.— The figure represents a simplified model of the ATN and does not depict all of its capabilities (e.g. the store and forward capability which is provided for ATS message handling service).*

*Note 3.— Various end-to-end points have been defined within the ATN to specify certain end-to-end performance requirements. It may be necessary, however, to define different end-to-end points to facilitate the qualification of implementations to those performance requirements. In such cases, the end-to-end points should be clearly defined and correlated with the end-to-end points shown in the figure.*

*Note 4.— An IS is a conceptual representation of functionality and does not correspond precisely to a router. A router which implements the system management application requires the protocols of an end system and when using the system management application is also acting as an end system.*

**Figure 2-1 Conceptual model of the ATN**

# 3. CHAPTER 03 - AFTN NETWORK

## 3.1 DEFINITIONS

***Data signalling rate*** – Data signalling rate refers to the passage of information per unit of time, and is expressed in bits/second. Data signalling rate is given by the formula:

$$\sum_{i=1}^{i=m} \frac{1}{T_i} \log_2 n_i$$

where *m* is the number of parallel channels, $T_1$ is the minimum interval for the *i*th channel expressed in seconds, *ni* is the number of significant conditions of the modulation in the *i*th channel.

a) For a single channel (serial transmission) it reduces to $(1/T)\log_2 n$; with a two-condition modulation (n = 2), it is 1/T.

b) For a parallel transmission with equal minimum intervals and equal number of significant conditions on each channel, it is $m(1/T)\log_2 n$ (m(1/T) in case of a two-condition modulation).

In the above definition, the term "parallel channels" is interpreted to mean: channels, each of which carries an integral part of an information unit, e.g. the parallel transmission of bits forming a character. In the case of a circuit comprising a number of channels, each of which carries information "independently", with the sole purpose of increasing the traffic handling capacity, these channels are not to be regarded as parallel channels in the context of this definition.

***Degree of standardized test distortion*** – The degree of distortion of the restitution measured during a specific period of time when the modulation is perfect and corresponds to a specific text.

***Effective margin*** – That margin of an individual apparatus which could be measured under actual operating conditions.

***Low modulation rates*** – Modulation rates up to and including 300 bauds.

***Margin*** – The maximum degree of distortion of the circuit at the end of which the apparatus is situated which is compatible with the correct translation of all the signals which it may possibly receive.

***Medium modulation rates*** – Modulation rates above 300 and up to and including 3 000 bauds.

***Modulation rate*** – The reciprocal of the unit interval measured in seconds. This rate is expressed in bauds.

Telegra  signals are characterized by intervals of time of duration equal to or longer than the shortest or unit interval. The modulation rate (formerly telegraph speed) is therefore expressed as the inverse of the value of this unit interval. If, for example, the unit interval is 20 milliseconds, the modulation rate is 50 bauds.

***Synchronous operation*** – Operation in which the time interval between code units is a constant.

**3.2 TECHNICAL PROVISIONS RELATING TO TELETYPEWRITER APPARATUS AND CIRCUITS USED IN THE AFTN**

3.2.1 In international teletypewriter circuits of the AFTN, using a 5-unit code, the International Telegraph Alphabet No. 2 (see Table 3-1*) shall be used only to the extent prescribed in 4.1.2 of Volume II.

3.2.2 The modulation rate should be determined by bilateral or multilateral agreement between administrations concerned, taking into account primarily traffic volume.

3.2.3 The nominal duration of the transmitting cycle should be at least 7.4 units (preferably 7.5), the stop element lasting for at least 1.4 units (preferably 1.5).

3.2.3.1 The receiver should be able to translate correctly in service the signals coming from a transmitter with a nominal transmitting cycle of 7 units.

3.2.4 The apparatus in service should be maintained and adjusted in such a manner that its net effective margin is never less than 35 per cent.

3.2.5 The number of characters which the textual line of the page-printing apparatus may contain should be fixed at 69.

3.2.6 The complete circuits should be so engineered and maintained that their degree of standardized test distortion does not exceed 28 per cent on the standardized text:

THE QUICK BROWN FOX JUMPS
OVER THE LAZY DOG
*or*
VOYEZ LE BRICK GEANT QUE
JEXAMINE PRES DU WHARF

3.2.7 The degree of isochronous distortion on the standardized text of each of the parts of a complete circuit should be as low as possible, and in any case should not exceed 10 per cent.

3.2.8 The overall distortion in transmitting equipment used on teletypewriter channels should not exceed 5 per cent.

*3.2.9* The AFTN circuits should be equipped with a system of continuous check of channel condition. Additionally, controlled circuit protocols should be applied.

* All tables and figures are located at the end of this chapter.

## 3.3 CHARACTERISTICS OF INTERREGIONAL AFS CIRCUITS

3.3.1 The interregional AFS circuits being implemented or upgraded should employ high quality telecommunications service. Modulation rate should take into account traffic volumes expected under both normal and alternate route conditions.

## 3.4 TECHNICAL PROVISIONS RELATING TO ATS MESSAGE TRANSMISSION

3.4.1 Interconnection by direct or omnibus channels — low modulation rates — 5-unit code. See 3.5 for medium modulation rates.

## 3.5 TECHNICAL PROVISIONS RELATING TO IN TERNATIONAL GROUND-GROUND DATA INTERCHANGE AT MEDIUM AND HIGHER SIGNALLING RATES

Throughout this section in the context of coded character sets, the term “unit” means the unit of selective information and is essentially equivalent to the term “bit”.

3.5.1 General

3.5.1.1 In international data interchange of characters, a 7-unit coded character set providing a repertoire of 128 characters and designated as International Alphabet No. 5 (IA-5) *should* be used. Compatibility with the 5-unit coded character set of International Telegraph Alphabet No. 2 (ITA-2) should be ensured where applicable.

3.5.1.2 When the provisions of 3.5.1.1 are applied, International Alphabet No. 5 (IA-5) contained in Table 3-2 shall be used.

3.5.1.2.1 The serial transmission of units comprising an individual character of IA-5 shall be with the low order unit ($b_1$) transmitted first.

3.5.1.2.2 when IA-5 is used, each character should include an additional unit for parity in the eighth level position.

3.5.1.2.3 When the provisions of 3.5.1.2.2 are applied, the sense of the character parity bit shall produce even parity in links which operate on the start-stop principle, and odd parity in links using end-to-end synchronous operations.

3.5.1.2.4 Character-for-character conversion shall be as listed in Tables 3-3 and 3-4 for all characters which are authorized in the AFTN format for transmission on the AFS in both IA-5 and ITA-2.

3.5.1.2.5 Characters which appear in only one code set, or which are not authorized for transmission on the AFS shall be as depicted in the code conversion tables.

3.5.2 Data transmission characteristics

3.5.2.1 The data signalling rate shall be chosen from among the following:

*600 bits/s* *4 800 bits/s*

| | |
|---|---|
| *1 200 bits/s* | *9 600 bits/s* |
| *2 400 bits/s* | |

3.5.2.2 Thethe type of transmission for each data signalling rate shall be chosen as follows:

| Data signalling rate | Type of transmission |
|---|---|
| *600 bits/s* | *Synchronous or asynchronous serial transmission* |
| *1 200 bits/s* | *Synchronous or asynchronous serial transmission* |
| *2 400 bits/s* | *Synchronous serial transmission* |
| *4 800 bits/s* | *Synchronous serial transmission* |
| *9 600 bits/s* | *Synchronous serial transmission* |

3.5.2.3 The type of modulation for each data signalling rate shall be chosen as follows:

| Data signalling rate | Type of modulation |
|---|---|
| *600 bits/s* | *Frequency* |
| *1 200 bits/s* | *Frequency* |
| *2 400 bits/s* | *Phase* |
| *4 800 bits/s* | *Phase* |
| *9 600 bits/s* | *Phase-amplitude* |

This does not necessarily apply to ground-ground extensions of air-ground links used exclusively for the transfer of air-ground data, inasmuch as such circuits may be considered as part of the air-ground link.

3.5.3 Ground-ground bit-oriented data link control procedures

The provisions of this section pertain to ground-ground data interchange applications using bit-oriented data link control procedures enabling transparent, synchronous transmission that is independent of any encoding; data link control functions are accomplished by interpreting designated bit positions in the transmission envelope of a frame.

3.5.3.1 The following descriptions shall apply to data link applications contained in this section:

a) Bit-oriented data link control procedures enable transparent transmission that is independent of any encoding.

b) A data link is the logical association of two interconnected stations, including the communication control capability of the interconnected stations.

c) A station is a configuration of logical elements, from or to which messages are transmitted on a data link, including those elements which control the message flow on the link via communication control procedures.

d) A combined station sends and receives both commands and responses and is responsible for control of the data link.

e) Data communication control procedures are the means used to control and protect the orderly interchange of information between stations on a data link.

f) A component is defined as a number of bits in a prescribed order within a sequence for the control and supervision of the data link.

g) An octet is a group of 8 consecutive bits.

h) A sequence is one or more components in prescribed order comprising an integral number of octets.

i) A field is a series of a specified number of bits or specified maximum number of bits which performs the functions of data link or communications control or constitutes data to be transferred.

j) A frame is a unit of data to be transferred over the data link, comprising one or more fields in a prescribed order.

k) A common ICAO data interchange network (CIDIN) switching centre is that part of an automatic AFTN switching centre which provides for the entry, relay, and exit centre functions using the bit-oriented link and CIDIN network procedures specified in this section and includes the appropriate interface(s) with other parts of the AFTN and with other networks.

3.5.3.2 Bit-Oriented Data Link control procedures for Ponit-to-Point, Ground-Ground data Interchange Application employing synchronous transmission facilities

The following link level procedures are the same as the LAPB link level procedures described in ITU CCITT Recommendation X.25, Section 2.

3.5.3.2.1 *Frame format.* Frames shall contain not less than 32 bits, excluding the opening and closing flags, and shall conform to the following format:

| | | | | | |
|---|---|---|---|---|---|
| FLAG<br>F | ADDRESS<br>A | CONTROL<br>C | INFORMATION<br>I | FCS | FLAG<br>F |

3.5.3.2.1.1 A frame shall consist of an opening flag (F), an address field (A), a control field (C), an optional information field (I), a frame check sequence (FCS), and a closing flag sequence (F), and shall be transmitted in that order.

In relation to CIDIN, the opening flag, the fields A and C, the FCS and the closing flag form together the Data Link Control Field (DLCF). The field I is denoted as the Link Data Field (LDF).

3.5.3.2.1.1.1 The flag (F) shall be the 8-bit sequence 01111110 which delimits the beginning and ending of each frame. It shall be permissible for the closing flag of a frame to also serve as the opening flag of the next frame.

3.5.3.2.1.1.2 The address (A) field shall consist of one octet, excluding 0 bits added to achieve transparent transmission, which shall contain the link address of the combined station.

3.5.3.2.1.1.3 The control (C) field shall consist of one octet, excluding 0 bits added to achieve transparent transmission, and shall contain the commands, responses, and frame sequence number components for the control of the data link.

3.5.3.2.1.1.4 The information (I) field shall contain digital data which may be presented in any code or sequence but shall not exceed a maximum of 259 octets, excluding 0 bits added to achieve transparent transmission. The I field shall always be a multiple of 8 bits in length.

3.5.3.2.1.1.5 The frame check sequence (FCS) shall consist of two octets, excluding 0 bits added to achieve transparent transmission, and shall contain the error detecting bits.

3.5.3.2.2 A frame check sequence (FCS) shall be included in each frame for the purpose of error checking.

3.5.3.2.2.1 The error checking algorithm shall be a cyclic redundancy check (CRC).

3.5.3.2.2.2 The CRC polynomial ($P(x)$) shall be

$$X^{16} + x^{12} + x^{5} + 1.$$

3.5.3.2.2.3 The FCS shall be a 16-bit sequence. This FCS shall be the ones' complement of the remainder, $R(x)$, obtained from the modulo 2 division of

$$X^{16}[G(x)] + x^{k}(x^{15} + x^{14} + x^{13} + ... + x^{2} + x^{1} + 1)$$

by the CRC polynomial, $P(x)$.

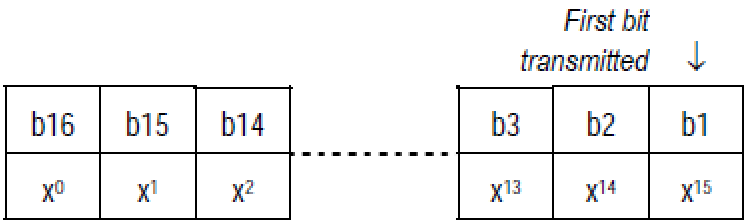
$G(x)$ shall be the contents of the frame existing between, but including neither, the final bit of the opening flag nor the first bit of the FCS, excluding bits inserted for transparent transmission.

$K$ shall be the length of $G(x)$ (number of bits).

3.5.3.2.2.4 The generation and checking of the FCS accumulation shall be as follows:

a) the transmitting station shall initiate the FCS accumulation with the first (least significant) bit of the address (A) field and shall include all bits up to and including the last bit preceding the FCS sequence, but shall exclude all 0 bits (if any) inserted to achieve transparent transmission;

b) upon completion of the accumulation the FCS shall be transmitted, starting with bit b1 (highest order coefficient) and proceeding in sequence to bit b16 (lowest order coefficient) as shown below;




c) the receiving station shall carry out the cyclic redundancy check (CRC) on the content of the frame commencing with the first bit received following the opening flag, and shall include all bits up to and including the last bit preceding the closing flag, but shall exclude all 0 bits (if any) deleted according to the rules for achievement of transparency;

d) upon completion of the FCS accumulation, the receiving station shall examine the remainder. In the absence of transmission error, the remainder shall be 1111000010111000 ($x0$ through $x15$, respectively).

3.5.3.2.3 *Achievement of transparency* – The frame format contents (A, C, link data field, and FCS) shall be capable of containing any bit configuration.

3.5.3.2.3.1 The following rules shall apply to all frame contents, except flag sequences:

a) the transmitting station shall examine the frame contents before transmission, and shall insert a single 0 bit immediately following each sequence of 5 consecutive 1 bits;

b) the receiving station shall examine the received frame contents for patterns consisting of 5 consecutive 1 bits immediately followed by one (or more) 0 bit(s) and shall remove the 0 bit which directly follows 5 consecutive 1 bits.

3.5.3.2.4 *Special transmission sequences and related link states* – In addition to employing the prescribed repertoire of commands and responses to manage the interchange of data and control information, stations shall use the following conventions to signal the indicated conditions:

a) *Abort* is the procedure by which a station in the process of sending a frame ends the frame in an unusual manner such that the receiving station shall ignore the frame. The conventions for aborting a frame shall be:

   1. transmitting at least seven, but less than fifteen, one bits (with no inserted zeros);

   2. receiving seven one bits.

b) *Active link state.* A link is in an active state when a station is transmitting a frame, an abort sequence, or interframe time fill. When the link is in the active state, the right of the transmitting station to continue transmission shall be reserved.

c) *Interframe time fill.* Interframe time fill shall be accomplished by transmitting continuous flags between frames. There is no provision for time fill within a frame.

d) *Idle link state.* A link is in an idle state when a continuous one condition is detected that persists for 15 bit times, or longer. Idle link time fill shall be a continuous one condition on the link.

e) *Invalid frame.* An invalid frame is one that is not properly bounded by two flags or one which is shorter than 32 bits between flags.

3.5.3.2.5 Modes

3.5.3.2.5.1 *Operational mode* – The operational mode shall be the asynchronous balanced mode (ABM).

3.5.3.2.5.1.1 It shall be permissible for a combined station in ABM to transmit without invitation from the associated station.

3.5.3.2.5.1.2 A combined station in ABM shall be permitted to transmit any command or response type frame except DM.

3.5.3.2.5.2 *Non-operational mode* – The non-operational mode shall be the asynchronous disconnected mode (ADM) in which a combined station is logically disconnected from the data link.

3.5.3.2.5.2.1 It shall be permissible for a combined station in ADM to transmit without invitation from the associated station.

3.5.3.2.5.2.2 A combined station in ADM shall transmit only SABM, DISC, UA and DM frames. (See 3.5.3.2.7 for a description of the commands and responses to which these frame types refer.)

3.5.3.2.5.2.3 A combined station in ADM shall transmit a DM when a DISC is received, and shall discard all other received command frames except SABM. If a discarded command frame has the P bit set to “1”, the combined station shall transmit a DM with the F bit set to “1”.

3.5.3.2.6 *Control field functions and parameters* – Control fields contain a command or a response and sequence numbers where applicable. Three types of control fields shall be used to perform:

a) numbered information transfer (I-frames);

b) numbered supervisory functions (S-frames); and

c) unnumbered control functions (U-frames).

The control field formats shall be as shown in Table 8-5. The functional frame designation associated with each type control field as well as the control field parameters employed in performing these functions shall be described in the following paragraphs.

3.5.3.2.6.1 The I-frame type is used to perform information transfers. Except for some special cases it is the only format which shall be permitted to contain an information field.

3.5.3.2.6.2 The S-frame type is used for supervisory commands and responses that perform link supervisory control functions such as acknowledge information frames, request transmission or retransmission of information frames, and to request a temporary suspension of transmission of I-frames. No information field shall be contained in the S-frame.

3.5.3.2.6.3 The U-frame type is used for unnumbered commands and responses that provide additional link control functions. One of the U-frame responses, the frame reject (FRMR) response, shall contain an information field; all other frames of the U-frame type shall not contain an information field.

3.5.3.2.6.4 The station parameters associated with the three control field types shall be as follows:

a) *Modulus.* Each I-frame shall be sequentially numbered with a send sequence count, *N(S)*, having value 0 through modulus minus one (where modulus is the modulus of the sequence numbers). The modulus shall be 8. The maximum number of sequentially numbered I-frames that a station shall have outstanding (i.e. unacknowledged) at any given time shall never exceed one less than the modulus of the sequence numbers. This restriction on the number of outstanding frames is to prevent any ambiguity in the association of transmission frames with sequence numbers during normal operation and/or error recovery.

b) The send state variable $V(S)$ shall denote the sequence number of the next in-sequence I-frame to be transmitted.

   1. The send state variable shall take on the value 0 through modulus minus one (modulus is the modulus of the sequence numbering and the numbers cycle through the entire range).

   2. The value of $V(S)$ shall be incremented by one with each successive in-sequence I-frame transmission, but shall not exceed the value of $N(R)$ contained in the last received frame by more than the maximum permissible number of outstanding I-frames ($k$). See i) below for the definition of $k$.

c) Prior to transmission of an in-sequence I-frame, the value of $N(S)$ shall be updated to equal the value of $V(S)$.

d) The receive state variable $V(R)$ shall denote the sequence number of the next in-sequence I-frame to be received.

   1. $V(R)$ shall take on the values 0 through modulus minus one.

   2. The value of $V(R)$ shall be incremented by one after the receipt of an error-free, in-sequence I-frame whose send sequence number $N(S)$, equals $V(R)$.

e) All I-frames and S-frames shall contain $N(R)$, the expected sequence number of the next received frame. Prior to transmission of either an I or an S type frame, the value of $N(R)$ shall be updated to equal the current value of the receive state variable. $N(R)$ indicates that the station transmitting the $N(R)$ has correctly received all I-frames numbered up to and including $N(R) – 1$.

f) Each station shall maintain an independent send state variable, $V(S)$, and receive state variable, $V(R)$, on the I-frames it sends and receives. That is, each combined station shall maintain a $V(S)$ count on the I-frames it transmits and a $V(R)$ count on the I-frames it has correctly received from the remote combined station.

g) The poll (P/F) bit shall be used by a combined station to solicit (poll) a response or sequence of responses from the remote combined station.

h) The final (P/F) bit shall be used by the remote combined station to indicate the response frame transmitted as the result of a soliciting (poll) command.

i) The maximum number ($k$) of sequentially numbered I-frames that a station may have outstanding (i.e. unacknowledged) at any given time is a station parameter which shall never exceed the modulus.(k) is determined by station buffering limitations and should be the subject of bilateral agreement at the time of circuit establishment.

3.5.3.2.7 *Commands and response* – It shall be permissible for a combined station to generate either commands or responses. A command shall contain the remote station address while a response shall contain the sending station address. The mnemonics associated with all of the commands and responses prescribed for each of the three frame types (I, S, and U) and the corresponding encoding of the control field are as shown in Table 3-6.

3.5.3.2.7.1 The I-frame command provides the means for transmitting sequentially numbered frames, each of which shall be permitted to contain an information field.

3.5.3.2.7.2 The S-frame commands and responses shall be used to perform numbered supervisory functions (such as acknowledgement, polling, temporary suspension of information transfer, or error recovery).

3.5.3.2.7.2.1 The receive ready command or response (RR) shall be used by a station to:

a) indicate that it is ready to receive an I-frame;

b) acknowledge previously received I-frames numbered up to and including $N(R) – 1$;

c) clear a busy condition that was initiated by the transmission of RNR.

It is permissible for a combined station to use the RR command to solicit a response from the remote combined station with the poll bit set to “1”.

3.5.3.2.7.2.2 It shall be permissible to issue a reject command or response (REJ) to request retransmission of frames starting with the I-frame numbered $N(R)$ where:

a) I-frames numbered $N(R) - 1$ and below are acknowledged;

b) additional I-frames pending initial transmission are to be transmitted following the retransmitted I-frame(s);

c) only one REJ exception condition, from one given station to another station, shall be established at any given time: another REJ shall not be issued until the first REJ exception condition has been cleared;

d) the REJ exception condition is cleared (reset) upon the receipt of an I-frame with an $N(S)$ count equal to the $N(R)$ of the REJ command/response.

3.5.3.2.7.2.3 The receive not ready command or response (RNR) shall be used to indicate a busy condition, i.e. temporary inability to accept additional incoming I-frames, where:

a) frames numbered up to and including $N(R) - 1$ are acknowledged;

b) frame $N(R)$ and any subsequent I-frames received, if any, are not acknowledged (the acceptance status of these frames shall be indicated in subsequent exchanges);

c) the clearing of a busy condition shall be indicated by the transmission of an RR, REJ, SABM, or UA with or without the P/F bit set to "1".

3.5.3.2.7.2.3.1

a) A station receiving an RNR frame when in the process of transmitting shall stop transmitting I-frames at the earliest possible time.

b) Any REJ command or response which was received prior to the RNR should be actioned before the termination of transmission.

c) It shall be permissible for a combined station to use the RNR command with the poll bit set to "1" to obtain a supervisory frame with the final bit set to "1" from the remote combined station.

3.5.3.2.7.2.4 It shall be permissible for the selective reject command or response (SREJ) to be used to request retransmission of the single I-frame numbered $N(R)$ where:

a) frames numbered up to $N(R) - 1$ are acknowledged; frame $N(R)$ is not accepted; the only I-frames accepted are those received correctly and in sequence following the I-frame requested; the specific I-frame to be retransmitted is indicated by the $N(R)$ in the SREJ command/response;

b) the SREJ exception condition is cleared (reset) upon receipt of an I-frame with an $N(S)$ count equal to the $N(R)$ of the SREJ;

c) after a station transmits a SREJ it is not permitted to transmit SREJ or REJ for an additional sequence error until the first SREJ error condition has been cleared;

d) I-frames that have been permitted to be transmitted following the I-frame indicated by the SREJ are not retransmitted as the result of receiving a SREJ; and

e) it is permissible for additional I-frames pending initial transmission to be transmitted following the retransmission of the specific I-frame requested by the SREJ.

3.5.3.2.7.3 The U-frame commands and responses shall be used to extend the number of link control functions. Transmitted U-frames do not increment the sequence counts at either the transmitting or receiving station.

a) The U-frame mode-setting commands (SABM, and DISC) shall be used to place the addressed station in the appropriate response mode (ABM or ADM) where:

1. upon acceptance of the command, the station send and receive state variables, $V(S)$ and $V(R)$, are set to zero;

2. the addressed station confirms acceptance at the earliest possible time by transmission of a single unnumbered acknowledgement, UA;

3. previously transmitted frames that are unacknowledged when the command is actioned remain unacknowledged;

4. the DISC command is used to perform a logical disconnect, i.e. to inform the addressed combined station that the transmitting combined station is suspending operation. No information field shall be permitted with the DISC command.

b) The unnumbered acknowledge response (UA) shall be used by a combined station to acknowledge the receipt and acceptance of an unnumbered command.

Received unnumbered commands are not actioned until the UA response is transmitted. No information field shall be permitted with the UA response.

c) The frame reject response (FRMR), employing the information field described below, shall be used by a combined station in the operational mode (ABM) to report that one of the following conditions resulted from the receipt of a frame without an FCS error:

1. a command/response that is invalid or not implemented;

2. a frame with an information field that exceeds the size of the buffer available;

3. a frame having an invalid $N(R)$ count.

An invalid N(R) is a count which points to an I-frame which has previously been transmitted andacknowledged or to an I-frame which has not been transmitted and is not the next sequential I-frame pending transmission.

d) The disconnected mode response (DM) shall be used to report a non-operational status where the station is logically disconnected from the link. No information field shall be permitted with the DM response.

The DM response shall be sent to request the remote combined station to issue a mode-setting command or if sent in response to the reception of a mode-setting command, to inform the remote combined station that the transmitting station is still in ADM and cannot action the mode-setting command.

3.5.3.3 Exception condition reporting and recovery

This section specifies the procedures that shall be employed to effect recovery following the detection or occurrence of an exception condition at the link level. Exception conditions described are those situations that may occur as the result of transmission errors, station malfunction, or operational situations.

3.5.3.3.1 *Busy condition* – A busy condition occurs when a station temporarily cannot receive or continue to receive I-frames due to internal constraints, e.g. due to buffering limitations. The busy condition shall be reported to the remote combined station by the transmission of an RNR frame with the *N*(*R*) number of the next I-frame that is expected. It shall be permissible for traffic pending transmission at the busy station to be transmitted prior to or following the RNR.

The continued existence of a busy condition must be reported by retransmission of RNR at each P/F frame exchange.

3.5.3.3.1.1 Upon receipt of an RNR, a combined station in ABM shall cease transmitting I-frames at the earliest possible time by completing or aborting the frame in process. The combined station receiving an RNR shall perform a time-out operation before resuming asynchronous transmission of I-frames unless the busy condition is reported as cleared by the remote combined station. If the RNR was received as a command with the P bit set to "1", the receiving station shall respond with an S-frame with the F bit set to "1".

3.5.3.3.1.2 The busy condition shall be cleared at the station which transmitted the RNR when the internal constraint ceases. Clearance of the busy condition shall be reported to the remote station by transmission of an RR, REJ, SABM, or UA frame (with or without the P/F bit set to "1").

3.5.3.3.2 N(S) *sequence error* – An *N*(*S*) sequence exception shall be established in the receiving station when an I-frame that is received error free (no FCS error) contains an *N*(*S*) sequence number that is not equal to the receive variable *V*(*R*) at the receiving station.

The receiving station shall not acknowledge (shall not increment its receive variable *V*(*R*)) the frame causing the sequence error, or any I-frames which may follow, until an I-frame with the correct *N*(*S*) number is received. A station that receives one or more I-frames having sequence errors, but which are otherwise error free, shall acceptthe control information contained in the *N*(*R*) field and the P/F bit to perform link control functions, e.g. to receive acknowledgement of previously transmitted I-frames (via the *N*(*R*)), to cause the station to respond (P bit set to "1").

3.5.3.3.2.1 The means specified in 3.5.3.3.2.1.1 and 3.5.3.3.2.1.2 shall be available for initiating the retransmission of lost or errored I-frames following the occurrence of a sequence error.

3.5.3.3.2.1.1 Where the REJ command/response is used to initiate an exception recovery following the detection of a sequence error, only one "sent REJ" exception condition, from one station to another station, shall be established at a time. A "sent REJ" exception shall be cleared when the requested I-frame is received. A station receiving REJ shall initiate sequential (re)transmission of I-frames starting with the I-frame indicated by the *N*(*R*) contained in the REJ frame.

FRMR INFORMATION FIELD BITS FOR BASIC (SABM) OPERATION

*First bit transmitted*

| 1 8 | 9 | 10 12 | 13 | 14 16 | 17 | 18 | 19 | 20 | 21 24 |
|---|---|---|---|---|---|---|---|---|---|
| rejected basic control field | 0 | *V(S)* | *v* | *V(R )* | *w* | *x* | *y* | *z* | set to zero |

where:

rejected basic control field is the control field of the received frame which caused the frame reject;

*V*(*S*) is the current value of the send state variable at the remote combined station reporting the error condition (bit 10 = low order bit);

*V*(*R*) is the current value of the receive state variable at the remote combined station reporting the error condition (bit 14 = low order bit);

*v* set to "1" indicates that the received frame which caused rejection was a response;

*w* set to "1" indicates that the control field received and returned in bits 1 through 8 are invalid or not implemented;

*x* set to "1" indicates that the control field received and returned in bits 1 through 8 was considered invalid because the frame contained an information field which is not permitted with this command. Bit *w* must be set to "1" in conjunction with this bit;

*y* set to "1" indicates that the information field received exceeded the maximum information field length which can be accommodated by the station reporting the error condition. This bit is mutually exclusive with bits *w* and *x* above;

*z* set to "1" indicates that the control field received and returned in bits 1 through 8 contained an invalid *N(R)* count. This bit is mutually exclusive with bit *w*.

3.5.3.3.2.1.2 In the event a receiving station, due to a transmission error, does not receive (or receives and discards) a single I-frame or the last I-frame(s) in a sequence of I-frames, it shall not detect an out-of-sequence exception and, therefore, shall not transmit REJ. The station which transmitted the unacknowledged I-frame(s) shall, following the completion of a system-specified time-out period, take appropriate recovery action to determine the sequence number at which retransmission must begin.

3.5.3.3.2.1.3 A combined station which has timed out waiting for a response should not retransmit all unacknowledged frames immediately. The station may enquire about status with a supervisory frame.

If a station does retransmit all unacknowledged I-frames after a time-out, it must be prepared to receive a subsequent REJ frame with an N(R) greater than its send variable V(S).

Since contention may occur in the case of two-way alternate communications in ABM or ADM, the time-out interval employed by one combined station must be greater than that employed by the other combined station so as to permit contention to be resolved.

3.5.3.3.3 *FCS error* – Any frame with an FCS error shall not be accepted by the receiving station and will be discarded. No action shall be taken by the receiving station as the result of that frame.

3.5.3.3.4 *Frame reject exception condition* – A frame reject exception condition shall be established upon the receipt of an error-free frame which contains an invalid or unimplemented control field, an invalid *N(R),* or an information field which has exceeded the maximum established storage capability. If a frame reject exception condition occurs in a combined station, the station shall either:

a) take recovery action without reporting the condition to the remote combined station; or

b) report the condition to the remote combined station with a FRMR response. The remote station will then be expected to take recovery action; if, after waiting an appropriate time, no recovery action appears to have been taken, the combined station reporting the frame reject exception condition may take recovery action.

Recovery action for balanced operation includes the transmission of an implemented mode-setting command. Higher level functions may also be involved in the recovery.

3.5.3.3.5 *Mode-setting contention* – A mode-setting contention situation exists when a combined station issues a modesetting command and, before receiving an appropriate response (UA or DM), receives a mode-setting command from the remote combined station. Contention situations shall be resolved in the following manner:

a) when the send and receive mode-setting commands are the same, each combined station shall send a UA response at the earliest respond opportunity. Each combined station shall either enter the indicated mode immediately or defer entering the indicated mode until receiving a UA response. In the latter case, if the UA response is not received:

   1. the mode may be entered when the response timer expires; or

   2. the mode-setting command may be reissued;

b) when the mode-setting commands are different, each combined station shall enter ADM and issue a DM response at the earliest respond opportunity. In the case of DISC contention with a different mode-setting command, no further action is required.

3.5.3.3.6 *Time-out functions* – Time-out functions shall be used to detect that a required or expected acknowledging action or response to a previously transmitted frame has not been received. Expiration of the time-out function shall initiate appropriate action, e.g. error recovery or reissuance of the P bit. The duration of the following time-out functions is system dependent and subject to bilateral agreement:

a) combined stations shall provide a time-out function to determine that a response frame with F bit set to “1” to a command frame with the P bit set to “1” has not been received. The time-out function shall automatically cease upon receipt of a valid frame with the F bit set to “1”;

b) a combined station which has no P bit outstanding, and which has transmitted one or more frames for which responses are anticipated shall start a time-out function to detect the no-response condition. The time-out function shall cease when an I- or S-frame is received with the *N*(*R*) higher than the last received *N*(*R*) (actually acknowledging one or more I-frames).

## TABLES FOR CHAPTER 3

### Table 3-1 International Telegraph Alphabets No.2 and No. 3

| *Number of signal* | *Letter case* | *Figure case* | *Impulses 5-unit code* | | |
|---|---|---|---|---|---|
| | | | *Start* | *12345* | *Stop* |
| | | | | *International Code No. 2* | |
| 1 | A | — | A | ZZAAA | Z |
| 2 | B | ? | A | ZAAZZ | Z |
| 3 | C | : | A | AZZZA | Z |
| 4 | D | Note 1 | A | ZAAZA | Z |
| 5 | E | 3 | A | ZAAAA | Z |
| 6 | F | | A | ZAZZA | Z |
| 7 | G | | A | AZAZZ | Z |
| 8 | H | | A | AAZAZ | Z |
| 9 | I | 8 | A | AZZAA | Z |
| 10 | J | Attention signal | A | ZZAZA | Z |
| 11 | K | ( | A | ZZZZA | Z |
| 12 | L | ) | A | AZAAZ | Z |
| 13 | M | . | A | AAZZZ | Z |
| 14 | N | , | A | AAZZA | Z |
| 15 | O | 9 | A | AAAZZ | Z |
| 16 | P | 0 | A | AZZAZ | Z |
| 17 | Q | 1 | A | ZZZAZ | Z |
| 18 | R | 4 | A | AZAZA | Z |
| 19 | S | ' | A | ZAZAA | Z |
| 20 | T | 5 | A | AAAAZ | Z |
| 21 | U | 7 | A | ZZZAA | Z |
| 22 | V | = | A | AZZZZ | Z |
| 23 | W | 2 | A | ZZAAZ | Z |
| 24 | X | / | A | ZAZZZ | Z |
| 25 | Y | 6 | A | ZAZAZ | Z |
| 26 | Z | + | A | ZAAAZ | Z |
| 27 | carriage return | | A | AAAZA | Z |
| 28 | line feed | | A | AZAAA | Z |
| 29 | letters | | A | ZZZZZ | Z |
| 30 | figures | | A | ZZAZZ | Z |
| 31 | space | | A | AAZAA | Z |
| 32 | unperforated tape | | A | AAAAA | Z |
| 33 | signal repetition | | | | |
| 34 | signal α | | | | |
| 35 | signal ß | | | | |

| *Sign* | *Closed circuit* | *Double current* |
|---|---|---|
| A | No current | Negative current |
| Z | Positive current | Positive current |

Note 1.— Used for answer-back facility.

# TABLE 3-2 International Alphabet No.5 (IA -5)

| | | | | $b_7$ | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $b_6$ | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| | | | | $b_5$ | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| $b_4$ | $b_3$ | $b_2$ | $b_1$ | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | 0 | 0 | 0 | 0 | NUL | TC$_7$ (DLE) | SP | 0 | @ | P | ` | p |
| 0 | 0 | 0 | 1 | 1 | TC$_1$ (SOH) | DC$_1$ | ! | 1 | A | Q | a | q |
| 0 | 0 | 1 | 0 | 2 | TC$_2$ (STX) | DC$_2$ | " ④ | 2 | B | R | b | r |
| 0 | 0 | 1 | 1 | 3 | TC$_3$ (ETX) | DC$_3$ | # | 3 | C | S | c | s |
| 0 | 1 | 0 | 0 | 4 | TC$_4$ (EOT) | DC$_4$ | ¤ ② | 4 | D | T | d | t |
| 0 | 1 | 0 | 1 | 5 | TC$_5$ (ENQ) | TC$_8$ (NAK) | % | 5 | E | U | e | u |
| 0 | 1 | 1 | 0 | 6 | TC$_6$ (ACK) | TC$_9$ (SYN) | & | 6 | F | V | f | v |
| 0 | 1 | 1 | 1 | 7 | BEL | TC$_{10}$ (ETB) | ' ④ | 7 | G | W | g | w |
| 1 | 0 | 0 | 0 | 8 | FE$_0$ (BS) | CAN | ( | 8 | H | X | h | x |
| 1 | 0 | 0 | 1 | 9 | FE$_1$ (HT) | EM | ) | 9 | I | Y | i | y |
| 1 | 0 | 1 | 0 | 10 | FE$_2$① (LF) | SUB | * | : | J | Z | j | z |
| 1 | 0 | 1 | 1 | 11 | FE$_3$ (VT) | ESC | + | ; | K | [ | k | { |
| 1 | 1 | 0 | 0 | 12 | FE$_4$ (FF) | IS$_4$ (FS) | ④ , | < | L | \ | l | \| |
| 1 | 1 | 0 | 1 | 13 | FE$_5$① (CR) | IS$_3$ (GS) | – | = | M | ] | m | } |
| 1 | 1 | 1 | 0 | 14 | SO | IS$_2$ (RS) | . | > | N | ^ ④ | n | ‾ ③ |
| 1 | 1 | 1 | 1 | 15 | SI | IS$_1$ (US) | / | ? | O | _ | o | DEL |

*NOTES*

*Note 1.—The format effectors are intended for equipment in which horizontal and vertical movements are effected separately. If equipment requires the action of CARRIAGE RETURN to be combined with a vertical movement, the format effector for that vertical movement may be used to effect the combined movement. Use of FE 2 for a combined CR and LF operation is not allowed for international transmission on AFS networks.*

*Note 2.—The symbol ¤ does not designate the currency of a specific country.*

*Note 3.—Position 7/14 is used for graphic character ‾ (OVERLINE), the graphical representation of which may vary according to national use to represent (TILDE) or another diacritical sign provided that there is no risk of confusion with another graphic character included in the table.*

*Note 4.—The graphic characters in position 2/2, 2/7, 2/12 and 5/14 have respectively the significance of QUOTATION MARK, APOSTROPHE, COMMA and UPWARD ARROW HEAD; however, these characters take on the significance of the diacritical signs DIAERESIS, ACUTE ACCENT, CEDILLA and CIRCUMFLEX ACCENT when they are preceded or followed by the BACKSPACE character (0/8).*

*Note 5.—When graphical representation of the control characters of IA-5 is required, it is permissible to use the symbols specified in International Organization for Standardization (ISO) Standard 2047-1975.*

**TABLE 3-3 Conversion from the International Telegraph Alphabet No. (ITA-2) to the International Alphabet No. 5(I-5)**

| *ITA-2 letter case of signal No.* | | *IA-5 column/row* | | *ITA-2 figure case of signal No.* | | *IA-5 column/row* | |
|---|---|---|---|---|---|---|---|
| 1 | A | 4/1 | A | 1 | – | 2/13 | – |
| 2 | B | 4/2 | B | 2 | ? | 3/15 | ? |
| 3 | C | 4/3 | C | 3 | : | 3/10 | : |
| 4 | D | 4/4 | D | 4 | | 3/15 | ? |
| 5 | E | 4/5 | E | 5 | 3 | 3/3 | 3 |
| 6 | F | 4/6 | F | 6 | | 3/15 | ? |
| 7 | G | 4/7 | G | 7 | | 3/15 | ? |
| 8 | H | 4/8 | H | 8 | | 3/15 | ? |
| 9 | I | 4/9 | I | 9 | 8 | 3/8 | 8 |
| 10 | J | 4/10 | J | 10 | Attention Signal *(Note 3)* | 0/7 | Bel |
| 11 | K | 4/11 | K | 11 | ( | 2/8 | ( |
| 12 | L | 4/12 | L | 12 | ) | 2/9 | ) |
| 13 | M | 4/13 | M | 13 | . | 2/14 | . |
| 14 | N | 4/14 | N | 14 | , | 2/12 | , |
| 15 | O | 4/15 | O | 15 | 9 | 3/9 | 9 |
| 16 | P | 5/0 | P | 16 | 0 | 3/0 | 0 |
| 17 | Q | 5/1 | Q | 17 | 1 | 3/1 | 1 |
| 18 | R | 5/2 | R | 18 | 4 | 3/4 | 4 |
| 19 | S | 5/3 | S | 19 | ' | 2/7 | ' |
| 20 | T | 5/4 | T | 20 | 5 | 3/5 | 5 |
| 21 | U | 5/5 | U | 21 | 7 | 3/7 | 7 |
| 22 | V | 5/6 | V | 22 | = | 3/13 | = |
| 23 | W | 5/7 | W | 23 | 2 | 3/2 | 2 |
| 24 | X | 5/8 | X | 24 | / | 2/15 | / |
| 25 | Y | 5/9 | Y | 25 | 6 | 3/6 | 6 |
| 26 | Z | 5/10 | Z | 26 | + | 2/11 | + |
| 27 | CR | 0/13 | CR | 27 | CR | 0/13 | CR |
| 28 | LF | 0/10 | LF | 28 | LF | 0/10 | LF |
| 29 | LTRS | * | | 29 | LTRS | * | |
| 30 | FIGS | * | | 30 | FIGS | * | |
| 31 | SP | 2/0 | SP | 31 | SP | 2/0 | SP |
| 32 | | * | | 32 | | * | |

** No conversion shall be made for these positions and the signal/character shall be removed from the data.*

*Note 1.— The end-of-message signal NNNN (in letter and figure case) shall convert to ETX (0/3).*

*Note 2.— The start-of-message signal ZCZC (in letter and figure case) shall convert to SOH (0/1).*

*Note 3.— Figures case of Signal No. 10 shall only be converted upon detection of the AFTN priority alarm which shall convert to five occurrences of BEL (0/7).*

*Note 4.— When converting from ITA-2, a STX (0/2) character shall be inserted once at the beginning of the next line following detection of CR LF or LF CR at the end of the Origin Line.*

*Note 5.— The sequence of seven signal 28 (LF) shall convert to one VT (0/11) character.*

**TABLE 3-4 Conversion from the International Alphabet No. 5 (IA-5) to the International Telegraph Alphabet No. 2(ITA-2)**

| Row \ Col. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| 0 | * | * | 31FL | 16F | 2F | 16L | 2F | 16L |
| 1 | Note 5 | * | 2F | 17F | 1L | 17L | 1L | 17L |
| 2 | * | * | 2F | 23F | 2L | 18L | 2L | 18L |
| 3 | Note 1 | * | 2F | 5F | 3L | 19L | 3L | 19L |
| 4 | * | * | 2F | 18F | 4L | 20L | 4L | 20L |
| 5 | * | * | 2F | 20F | 5L | 21L | 5L | 21L |
| 6 | * | * | 2F | 25F | 6L | 22L | 6L | 22L |
| 7 | Note 2 | * | 19F | 21F | 7L | 23L | 7L | 23L |
| 8 | * | * | 11F | 9F | 8L | 24L | 8L | 24L |
| 9 | * | * | 12F | 15F | 9L | 25L | 9L | 25L |
| 10 | 28 FL | * | 2F | 3F | 10L | 26L | 10L | 26L |
| 11 | Note 3 | * | 26F | 2F | 11L | 2F | 11L | 2F |
| 12 | * | * | 14F | 2F | 12L | 2F | 12L | 2F |
| 13 | 27FL | * | 1F | 22F | 13L | 2F | 13L | 2F |
| 14 | * | * | 13F | 2F | 14L | 2F | 14L | 2F |
| 15 | * | * | 24F | 2F | 15L | 2F | 15L | * |

** No conversion shall be made for these positions and the signal/character shall be removed from the data.*

*Example:* *To find the ITA-2 signal to which the character 3/6 of IA-5 is to be converted, look at column 3, row 6. 25F means figure case of signal No. 25 (L = letter case, FL = either case designation).*

*Note 1.—* *The character 0/3 (ETX) shall convert to the ITA-2 sequence signals 14L, 14L, 14L, 14L (NNNN).*

*Note 2. —* *The signal 0/7 (BEL) shall only be converted when a sequence of 5 occurrences is detected, which shall convert to the ITA-2 sequence signals 30, 10F, 10F, 10F, 10F, 10F, 29.*

*Note 3. —* *The character sequence CR CR LF VT (0/11) ETX (0/3) shall convert to the ITA-2 sequence signals 29, 27, 27, 28, 28, 28, 28, 28, 28, 28, 28, 14L, 14L, 14L, 14L.*

*Note 4. —* *To prevent redundant generation of figure and letter characters in ITA-2 when converting from IA-5, no case designation shall be assigned to ITA-2 non-printing functions (signals No. 27, 28, 29, 30, 31).*

*Note 5. —* *The character 0/1 (SOH) shall convert to the ITA-2 sequence signals 26L, 3L, 26L, 3L (ZCZC).*

## TABLE 3-5 Control field formats

| Control field format for | Control field bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Information transfer (I frame) | 0 | | *N(S)* | | *P* | | *N(R)* | |
| Supervisory commands/responses (S frame) | 1 | 0 | *S* | *S* | *P/F* | | *N(R)* | |
| Unnumbered commands/responses | 1 | 1 | *M* | *M* | *P/F* | *M* | *M* | *M* |

where:

*N(S)* = send sequence count (bit 2 = low order bit)
*N(R)* = receive sequence count (bit 6 = low order bit)
*S* = supervisory function bits
*M* = modifier function bits
*P* = poll bit (in commands)
*F* = final bit (in responses)

## TABLE 3-6 Commands and responses

| *Type* | *Commands* | | *Responses* | | *C field encoding* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* |
| Information transfer | I | (information) | | | 0 | | *N(S)* | | *P* | | *N(R)* | |
| Supervisory | RR | (receive ready) | RR | (receive ready) | 1 | 0 | 0 | 0 | *P/F* | | *N(R)* | |
| | RNR | (receive not ready) | RNR | (receive not ready) | 1 | 0 | 1 | 0 | *P/F* | | *N(R)* | |
| | REJ | (reject) | REJ | (reject) | 1 | 0 | 0 | 1 | *P/F* | | *N(R)* | |
| Unnumbered | | | DM | (disconnected mode) | 1 | 1 | 1 | 1 | *P/F* | 0 | 0 | 0 |
| | SABM | (set asynchronous balanced mode) | | | 1 | 1 | 1 | 1 | *P* | 1 | 0 | 0 |
| | DISC | (disconnect) | | | 1 | 1 | 0 | 0 | *P* | 0 | 1 | 0 |
| | | | UA | (unnumbered acknowledgement) | 1 | 1 | 0 | 0 | *F* | 1 | 1 | 0 |
| | | | FRMR | (frame reject) | 1 | 1 | 1 | 0 | *F* | 0 | 0 | 1 |

# 4. CHAPTER 04 - AIRCRAFT ADDRESSING SYSTEM

4.1 The aircraft address shall be one of 16 777 214 twenty-four-bit aircraft addresses allocated by ICAO to the State of Registry or common mark registering authority and assigned as prescribed in the Appendix to this chapter.

4.1.1 Non-aircraft transponders that are installed on aerodrome surface vehicles, obstacles or fixed Mode S target detection devices for surveillance and/or radar monitoring purposes shall be assigned 24-bit aircraft addresses.

4.1.1.1 The mode S transponders used under specific conditions stated in 4.1.1 shall not have any negative impact on the performance of existing ATS surveillance systems and ACAS.

# APPENDIX TO CHAPTER 4. A WORLDWIDE SCHEME FOR THE ALLOCATION, ASSIGNMENT AND APPLICATION OF AIRCRAFT ADDRESSES

## 1. GENERAL

Global communications, navigation and surveillance systems shall use an individual aircraft address composed of 24 bits. At any one time, no address shall be assigned to more than one aircraft. The assignment of aircraft addresses requires a comprehensive scheme providing for a balanced and expandable distribution of aircraft addresses applicable worldwide.

## 2. DESCRIPTION OF THE SCHEME

Table 9-1 provides for blocks of consecutive addresses available to States for assignment to aircraft. Each block is defined by a fixed pattern of the first 4, 6, 9, 12 or 14 bits of the 24-bit address. Thus, blocks of different sizes (1 048 576, 262 144, 32 768, 4 096 and 1 024 consecutive addresses, respectively) are made available.

## 3. MANAGEMENT OF THE SCHEME

The International Civil Aviation Organization (ICAO) shall administer the scheme so that appropriate international distribution of aircraft addresses can be maintained.

## 4. ALLOCATION OF AIRCRAFT ADDRESSES

4.1 Blocks of aircraft addresses shall be allocated by ICAO to the State of Registry or common mark registering authority. Address allocations to States shall be as shown in Table 4-1.

4.2 A State of Registry or common mark registering authority shall notify ICAO when allocation to that State of an additional block of addresses is required for assignment to aircraft.

4.3 In the future management of the scheme, advantage shall be taken of the blocks of aircraft addresses not yet allocated. These spare blocks shall be distributed on the basis of the relevant ICAO region:

Addresses starting with bit combination 00100: AFI region

Addresses starting with bit combination 00101: SAM region

Addresses starting with bit combination 0101: EUR and NAT regions

Addresses starting with bit combination 01100: MID region

Addresses starting with bit combination 01101: ASIA region

Addresses starting with bit combination 1001: NAM and PAC regions

Addresses starting with bit combination 111011: CAR region

In addition, aircraft addresses starting with bit combinations 1011, 1101 and 1111 have been reserved for future use.

4.4 Any future requirement for additional aircraft addresses shall be accommodated through coordination between ICAO and the States of Registry or common mark registering authority concerned. A request for additional aircraft addresses shall only be made by a registering authority when at least 75 per cent of the number of addresses already allocated to that registering authority have been assigned to aircraft.

4.5 ICAO shall allocate blocks of aircraft addresses to non-Contracting States upon request

## 5. ASSIGNMENT OF AIRCRAFT ADDRESSES

5.1 When required for use by suitably equipped aircraft entered on a national or international register, individual aircraft addresses within each block shall be assigned to aircraft by the State of Registry or common mark registering authority.

5.2 Aircraft addresses shall be assigned in accordance with the following principles:

a) at any one time, no address shall be assigned to more than one aircraft with the exception of aerodrome surface vehicles on surface movement areas. If such exceptions are applied by the State of Registry, the vehicles which have been allocated the same address shall not operate on aerodromes separated by less than 1 000 km;

b) only one address shall be assigned to an aircraft, irrespective of the composition of equipment on board. In the case when a removable transponder is shared by several light aviation aircraft such as balloons or gliders, it shall be possible to assign a unique address to the removable transponder. The registers 0816, 2016, 2116, 2216 and 2516 of the removable transponder shall be correctly updated each time the removable transponder is installed in any aircraft;

c) the address shall not be changed except under exceptional circumstances and shall not be changed during flight;

d) when an aircraft changes its State of Registry, the previously assigned address shall be relinquished and a new address shall be assigned by the new registering authority;

e) the address shall serve only a technical role for addressing and identification of aircraft and shall not be used to convey any specific information; and

f) the addresses composed of 24 ZEROs or 24 ONEs shall not be assigned to aircraft.

## 6. APPLICATION OF AIRCRAFT ADDRESSES

6.1 The aircraft addresses shall be used in applications which require the routing of information to or from individual suitably equipped aircraft. Attention

Examples of such applications are the aeronautical telecommunication network (ATN), SSR Mode S and airborne collision avoidance system (ACAS).

This Standard does not preclude assigning the aircraft addresses for special applications associated with the general applications defined therein. Examples of such special applications are the utilization of the 24-bit address in a pseudo-aeronautical earth station to monitor the aeronautical mobile-satellite service ground earth station and in the fixed Mode S transponders to monitor the

Mode S ground station operation. Address assignments for special applications are to be carried out in conformance with the procedure established by the State to manage the 24-bit address assignments to aircraft.

6.2 An address consisting of 24 ZEROs shall not be used for any application.

# TABLE 4-1 Allocation of aircraft addresses to states

| *State* | *Number of addresses in block* | | | | | *Allocation of blocks of addresses (a dash represents a bit value equal to 0 or 1)* |
|---|---|---|---|---|---|---|
| | *1 024* | *4 096* | *32 768* | *262 144* | *1 048 576* | |
| Democratic People's Republic of Korea | | | * | | | 0111 00 100 --- -- ---------- |
| Democratic Republic of the Congo | | * | | | | 0000 10 001 100 -- ---------- |
| Denmark | | | * | | | 0100 01 011 --- -- ---------- |
| Djibouti | * | | | | | 0000 10 011 000 00 ---------- |
| Dominican Republic | | * | | | | 0000 11 000 100 -- ---------- |
| Ecuador | | * | | | | 1110 10 000 100 -- ---------- |
| Egypt | | | * | | | 0000 00 010 --- -- ---------- |
| El Salvador | | * | | | | 0000 10 110 010 -- ---------- |
| Equatorial Guinea | | * | | | | 0000 01 000 010 -- ---------- |
| Eritrea | * | | | | | 0010 00 000 010 00 ---------- |
| Estonia | * | | | | | 0101 00 010 001 00 ---------- |
| Ethiopia | | * | | | | 0000 01 000 000 -- ---------- |
| Fiji | | * | | | | 1100 10 001 000 -- ---------- |
| Finland | | | * | | | 0100 01 100 --- -- ---------- |
| France | | | | * | | 0011 10 --- --- -- ---------- |
| Gabon | | * | | | | 0000 00 111 110 -- ---------- |
| Gambia | | * | | | | 0000 10 011 010 -- ---------- |
| Georgia | * | | | | | 0101 00 010 100 00 ---------- |
| Germany | | | | * | | 0011 11 --- --- -- ---------- |
| Ghana | | * | | | | 0000 01 000 100 -- ---------- |
| Greece | | | * | | | 0100 01 101 --- -- ---------- |
| Grenada | * | | | | | 0000 11 001 100 00 ---------- |
| Guatemala | | * | | | | 0000 10 110 100 -- ---------- |
| Guinea | | * | | | | 0000 01 000 110 -- ---------- |
| Guinea-Bissau | * | | | | | 0000 01 001 000 00 ---------- |
| Guyana | | * | | | | 0000 10 110 110 -- ---------- |
| Haiti | | * | | | | 0000 10 111 000 -- ---------- |
| Honduras | | * | | | | 0000 10 111 010 -- ---------- |
| Hungary | | | * | | | 0100 01 110 --- -- ---------- |
| Iceland | | * | | | | 0100 11 001 100 -- ---------- |
| India | | | | * | | 1000 00 --- --- -- ---------- |
| Indonesia | | | * | | | 1000 10 100 --- -- ---------- |
| Iran, Islamic Republic of | | | * | | | 0111 00 110 --- -- ---------- |
| Iraq | | | * | | | 0111 00 101 --- -- ---------- |
| Ireland | | * | | | | 0100 11 001 010 -- ---------- |
| Israel | | | * | | | 0111 00 111 --- -- ---------- |
| Italy | | | | * | | 0011 00 --- --- -- ---------- |
| Jamaica | | * | | | | 0000 10 111 110 -- ---------- |
| Japan | | | | * | | 1000 01 --- --- -- ---------- |
| Jordan | | | * | | | 0111 01 000 --- -- ---------- |
| Kazakhstan | * | | | | | 0110 10 000 011 00 ---------- |
| Kenya | | * | | | | 0000 01 001 100 -- ---------- |
| Kiribati | * | | | | | 1100 10 001 110 00 ---------- |
| Kuwait | | * | | | | 0111 00 000 110 -- ---------- |
| Kyrgyzstan | * | | | | | 0110 00 000 001 00 ---------- |
| Lao People's Democratic Republic | | * | | | | 0111 00 001 000 -- ---------- |
| Latvia | * | | | | | 0101 00 000 010 11 ---------- |

| *State* | *Number of addresses in block* 1 024 | 4 096 | 32 768 | 262 144 | 1 048 576 | *Allocation of blocks of addresses (a dash represents a bit value equal to 0 or 1)* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lebanon | | | * | | | 0 1 1 1 | 0 1 | 0 0 1 | - - - | - - | - - - - - - - - - - |
| Lesotho | * | | | | | 0 0 0 0 | 0 1 | 0 0 1 | 0 1 0 | 0 0 | - - - - - - - - - - |
| Liberia | | * | | | | 0 0 0 0 | 0 1 | 0 1 0 | 0 0 0 | - - | - - - - - - - - - - |
| Libyan Arab Jamahiriya | | | * | | | 0 0 0 0 | 0 0 | 0 1 1 | - - - | - - | - - - - - - - - - - |
| Lithuania | * | | | | | 0 1 0 1 | 0 0 | 0 0 0 | 0 1 1 | 1 1 | - - - - - - - - - - |
| Luxembourg | * | | | | | 0 1 0 0 | 1 1 | 0 1 0 | 0 0 0 | 0 0 | - - - - - - - - - - |
| Madagascar | | * | | | | 0 0 0 0 | 0 1 | 0 1 0 | 1 0 0 | - - | - - - - - - - - - - |
| Malawi | | * | | | | 0 0 0 0 | 0 1 | 0 1 1 | 0 0 0 | - - | - - - - - - - - - - |
| Malaysia | | | * | | | 0 1 1 1 | 0 1 | 0 1 0 | - - - | - - | - - - - - - - - - - |
| Maldives | * | | | | | 0 0 0 0 | 0 1 | 0 1 1 | 0 1 0 | 0 0 | - - - - - - - - - - |
| Mali | | * | | | | 0 0 0 0 | 0 1 | 0 1 1 | 1 0 0 | - - | - - - - - - - - - - |
| Malta | * | | | | | 0 1 0 0 | 1 1 | 0 1 0 | 0 1 0 | 0 0 | - - - - - - - - - - |
| Marshall Islands | * | | | | | 1 0 0 1 | 0 0 | 0 0 0 | 0 0 0 | 0 0 | - - - - - - - - - - |
| Mauritania | * | | | | | 0 0 0 0 | 0 1 | 0 1 1 | 1 1 0 | 0 0 | - - - - - - - - - - |
| Mauritius | * | | | | | 0 0 0 0 | 0 1 | 1 0 0 | 0 0 0 | 0 0 | - - - - - - - - - - |
| Mexico | | | * | | | 0 0 0 0 | 1 1 | 0 1 0 | - - - | - - | - - - - - - - - - - |
| Micronesia, Federated States of | * | | | | | 0 1 1 0 | 1 0 | 0 0 0 | 0 0 1 | 0 0 | - - - - - - - - - - |
| Monaco | * | | | | | 0 1 0 0 | 1 1 | 0 1 0 | 1 0 0 | 0 0 | - - - - - - - - - - |
| Mongolia | * | | | | | 0 1 1 0 | 1 0 | 0 0 0 | 0 1 0 | 0 0 | - - - - - - - - - - |
| Morocco | | | * | | | 0 0 0 0 | 0 0 | 1 0 0 | - - - | - - | - - - - - - - - - - |
| Mozambique | | * | | | | 0 0 0 0 | 0 0 | 0 0 0 | 1 1 0 | - - | - - - - - - - - - - |
| Myanmar | | * | | | | 0 1 1 1 | 0 0 | 0 0 0 | 1 0 0 | - - | - - - - - - - - - - |
| Namibia | * | | | | | 0 0 1 0 | 0 0 | 0 0 0 | 0 0 1 | 0 0 | - - - - - - - - - - |
| Nauru | * | | | | | 1 1 0 0 | 1 0 | 0 0 1 | 0 1 0 | 0 0 | - - - - - - - - - - |
| Nepal | | * | | | | 0 1 1 1 | 0 0 | 0 0 1 | 0 1 0 | - - | - - - - - - - - - - |
| Netherlands, Kingdom of the | | | * | | | 0 1 0 0 | 1 0 | 0 0 0 | - - - | - - | - - - - - - - - - - |
| New Zealand | | | * | | | 1 1 0 0 | 1 0 | 0 0 0 | - - - | - - | - - - - - - - - - - |
| Nicaragua | | * | | | | 0 0 0 0 | 1 1 | 0 0 0 | 0 0 0 | - - | - - - - - - - - - - |
| Niger | | * | | | | 0 0 0 0 | 0 1 | 1 0 0 | 0 1 0 | - - | - - - - - - - - - - |
| Nigeria | | * | | | | 0 0 0 0 | 0 1 | 1 0 0 | 1 0 0 | - - | - - - - - - - - - - |
| Norway | | | * | | | 0 1 0 0 | 0 1 | 1 1 1 | - - - | - - | - - - - - - - - - - |
| Oman | * | | | | | 0 1 1 1 | 0 0 | 0 0 1 | 1 0 0 | 0 0 | - - - - - - - - - - |
| Pakistan | | | * | | | 0 1 1 1 | 0 1 | 1 0 0 | - - - | - - | - - - - - - - - - - |
| Palau | * | | | | | 0 1 1 0 | 1 0 | 0 0 0 | 1 0 0 | 0 0 | - - - - - - - - - - |
| Panama | | * | | | | 0 0 0 0 | 1 1 | 0 0 0 | 0 1 0 | - - | - - - - - - - - - - |
| Papua New Guinea | | * | | | | 1 0 0 0 | 1 0 | 0 1 1 | 0 0 0 | - - | - - - - - - - - - - |
| Paraguay | | * | | | | 1 1 1 0 | 1 0 | 0 0 1 | 0 0 0 | - - | - - - - - - - - - - |
| Peru | | * | | | | 1 1 1 0 | 1 0 | 0 0 1 | 1 0 0 | - - | - - - - - - - - - - |
| Philippines | | | * | | | 0 1 1 1 | 0 1 | 0 1 1 | - - - | - - | - - - - - - - - - - |
| Poland | | | * | | | 0 1 0 0 | 1 0 | 0 0 1 | - - - | - - | - - - - - - - - - - |
| Portugal | | | * | | | 0 1 0 0 | 1 0 | 0 1 0 | - - - | - - | - - - - - - - - - - |
| Qatar | * | | | | | 0 0 0 0 | 0 1 | 1 0 1 | 0 1 0 | 0 0 | - - - - - - - - - - |
| Republic of Korea | | | * | | | 0 1 1 1 | 0 0 | 0 1 1 | - - - | - - | - - - - - - - - - - |
| Republic of Moldova | * | | | | | 0 1 0 1 | 0 0 | 0 0 0 | 1 0 0 | 1 1 | - - - - - - - - - - |
| Romania | | | * | | | 0 1 0 0 | 1 0 | 1 0 0 | - - - | - - | - - - - - - - - - - |
| Russian Federation | | | | | * | 0 0 0 1 | - - | - - - | - - - | - - | - - - - - - - - - - |
| Rwanda | | * | | | | 0 0 0 0 | 0 1 | 1 0 1 | 1 1 0 | - - | - - - - - - - - - - |
| Saint Lucia | * | | | | | 1 1 0 0 | 1 0 | 0 0 1 | 1 0 0 | 0 0 | - - - - - - - - - - |

| *State* | *Number of addresses in block* | | | | | *Allocation of blocks of addresses (a dash represents a bit value equal to 0 or 1)* |
|---|---|---|---|---|---|---|
| | *1 024* | *4 096* | *32 768* | *262 144* | *1 048 576* | |
| Saint Vincent and the Grenadines | * | | | | | 0000 10 111 100 00 - - - - - - - - - - |
| Samoa | * | | | | | 1001 00 000 010 00 - - - - - - - - - - |
| San Marino | * | | | | | 0101 00 000 000 00 - - - - - - - - - - |
| Sao Tome and Principe | * | | | | | 0000 10 011 110 00 - - - - - - - - - - |
| Saudi Arabia | | | * | | | 0111 00 010 - - - - - - - - - - - - - - - |
| Senegal | | * | | | | 0000 01 110 000 - - - - - - - - - - - - |
| Seychelles | * | | | | | 0000 01 110 100 00 - - - - - - - - - - |
| Sierra Leone | * | | | | | 0000 01 110 110 00 - - - - - - - - - - |
| Singapore | | | * | | | 0111 01 101 - - - - - - - - - - - - - - - |
| Slovakia | * | | | | | 0101 00 000 101 11 - - - - - - - - - - |
| Slovenia | * | | | | | 0101 00 000 110 11 - - - - - - - - - - |
| Solomon Islands | * | | | | | 1000 10 010 111 00 - - - - - - - - - - |
| Somalia | | * | | | | 0000 01 111 000 - - - - - - - - - - - - |
| South Africa | | | * | | | 0000 00 001 - - - - - - - - - - - - - - - |
| Spain | | | | * | | 0011 01 - - - - - - - - - - - - - - - - - - |
| Sri Lanka | | | * | | | 0111 01 110 - - - - - - - - - - - - - - - |
| Sudan | | * | | | | 0000 01 111 100 - - - - - - - - - - - - |
| Suriname | | * | | | | 0000 11 001 000 - - - - - - - - - - - - |
| Swaziland | * | | | | | 0000 01 111 010 00 - - - - - - - - - - |
| Sweden | | | * | | | 0100 10 101 - - - - - - - - - - - - - - - |
| Switzerland | | | * | | | 0100 10 110 - - - - - - - - - - - - - - - |
| Syrian Arab Republic | | | * | | | 0111 01 111 - - - - - - - - - - - - - - - |
| Tajikistan | * | | | | | 0101 00 010 101 00 - - - - - - - - - - |
| Thailand | | | * | | | 1000 10 000 - - - - - - - - - - - - - - - |
| The former Yugoslav Republic of Macedonia | * | | | | | 0101 00 010 010 00 - - - - - - - - - - |
| Togo | | * | | | | 0000 10 001 000 - - - - - - - - - - - - |
| Tonga | * | | | | | 1100 10 001 101 00 - - - - - - - - - - |
| Trinidad and Tobago | | * | | | | 0000 11 000 110 - - - - - - - - - - - - |
| Tunisia | | | * | | | 0000 00 101 - - - - - - - - - - - - - - - |
| Turkey | | | * | | | 0100 10 111 - - - - - - - - - - - - - - - |
| Turkmenistan | * | | | | | 0110 00 000 001 10 - - - - - - - - - - |
| Uganda | | * | | | | 0000 01 101 000 - - - - - - - - - - - - |
| Ukraine | | | * | | | 0101 00 001 - - - - - - - - - - - - - - - |
| United Arab Emirates | | * | | | | 1000 10 010 110 - - - - - - - - - - - - |
| United Kingdom | | | | * | | 0100 00 - - - - - - - - - - - - - - - - - - |
| United Republic of Tanzania | | * | | | | 0000 10 000 000 - - - - - - - - - - - - |
| United States | | | | | * | 1010 - - - - - - - - - - - - - - - - - - - - |
| Uruguay | | * | | | | 1110 10 010 000 - - - - - - - - - - - - |
| Uzbekistan | * | | | | | 0101 00 000 111 11 - - - - - - - - - - |
| Vanuatu | * | | | | | 1100 10 010 000 00 - - - - - - - - - - |
| Venezuela | | | * | | | 0000 11 011 - - - - - - - - - - - - - - - |
| Viet Nam | | | * | | | 1000 10 001 - - - - - - - - - - - - - - - |
| Yemen | | * | | | | 1000 10 010 000 - - - - - - - - - - - - |
| Yugoslavia | | | * | | | 0100 11 000 - - - - - - - - - - - - - - - |
| Zambia | | * | | | | 0000 10 001 010 - - - - - - - - - - - - |
| Zimbabwe | * | | | | | 0000 00 000 100 00 - - - - - - - - - - |

| State | Number of addresses in block | | | | | Allocation of blocks of addresses (a dash represents a bit value equal to 0 or 1) |
|---|---|---|---|---|---|---|
| | 1 024 | 4 096 | 32 768 | 262 144 | 1 048 576 | |
| Other allocations | | | | | | |
| ICAO[1] | | | * | | | 1111 00 000 – – – – – – – – – – – – – – |
| ICAO[2] | * | | | | | 1000 10 011 001 00 – – – – – – – – – – |
| ICAO[2] | * | | | | | 1111 00 001 001 00 – – – – – – – – – – |

1. ICAO administers this block for assigning temporary aircraft addresses as described in section 7.

2. Block allocated for special use in the interest of flight safety.

# CHAPTER 05 - AERONAUTICAL MOBILE AIRPORT COMMUNICATIONS SYSTEM (AEROMACS)

## 5.1 DEFINITIONS

***Adaptive modulation.*** A system's ability to communicate with another system using multiple burst profiles and a system's ability to subsequently communicate with multiple systems using different burst profiles.

***Aerodrome.*** A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.

***Aeronautical Mobile Airport Communications System (AeroMACS).*** A high capacity data link supporting mobile and fixed communications on the aerodrome surface.

***AeroMACS downlink (DL).*** The transmission direction from the base station (BS) to the mobile station (MS).

***AeroMACS uplink (UL).*** The transmission direction from the mobile station (MS) to the base station (BS).

***AeroMACS handover.*** The process in which a mobile station (MS) migrates from the air-interface provided by one base station (BS) to the air-interface provided by another BS. A break-before-make AeroMACS handover is where service with the target BS starts after a disconnection of service with the previous serving BS.

***Base station (BS).*** A generalized equipment set providing connectivity, management, and control of the mobile station (MS).

***Bit error rate (BER).*** The number of bit errors in a sample divided by the total number of bits in the sample, generally averaged over many such samples.

***Burst profile.*** Set of parameters that describe the uplink or downlink transmission properties associated with an interval usage code. Each profile contains parameters such as modulation type, forward error correction (FEC) type, preamble length, guard times, etc.

***Convolutional turbo codes (CTC).*** Type of forward error correction (FEC) code.

***Data transit delay***. In accordance with ISO 8348, the average value of the statistical distribution of data delays. This delay represents the subnetwork delay and does not include the connection establishment delay.

***Domain.*** A set of end systems and intermediate systems that operate according to the same routing procedures and that is wholly contained within a single administrative domain.

***Forward error correction.*** The process of adding redundant information to the transmitted signal in a manner which allows correction, at the receiver, of errors incurred in the transmission.

***Frequency assignment.*** A logical assignment of centre frequency and channel bandwidth programmed to the base station (BS).

***Mobile station (MS).*** A station in the mobile service intended to be used while in motion or during halts at unspecified points. An MS is always a subscriber station (SS).

***Partial usage sub-channelization (PUSC).*** A technique in which the orthogonal frequency division multiplexing (OFDM) symbol subcarriers are divided and permuted among a subset of sub-channels for transmission, providing partial frequency diversity.

***Residual error rate.*** The ratio of incorrect, lost and duplicate subnetwork service data units (SNSDUs) to the total number of SNSDUs that were sent.

***Service data unit (SDU).*** A unit of data transferred between adjacent layer entities, which is encapsulated within a protocol data unit (PDU) for transfer to a peer layer.

***Service flow.*** A unidirectional flow of media access control layer (MAC) service data units (SDUs) on a connection that is providing a particular quality of service (QoS).

***Subscriber station (SS).*** A generalized equipment set providing connectivity between subscriber equipment and a base station (BS).

***Subnetwork entry time.*** The time from when the mobile station starts the scanning for BS transmission, until the network link establishes the connection, and the first network user “protocol data unit” can be sent.

***Subnetwork service data unit (SNSDU).*** An amount of subnetwork user data, the identity of which is preserved from one end of a subnetwork connection to the other.

***Time division duplex (TDD).*** A duplex scheme where uplink and downlink transmissions occur at different times but may share the same frequency.

## 5.2 INTRODUCTION

Note 1.— Aeronautical mobile airport communications system (AeroMACS) is a high capacity data link supporting mobile and fixed communications, related to the safety and regularity of flight, on the aerodrome surface.

Note 2.— AeroMACS is derived from the IEEE 802.16-2009 mobile standards. AeroMACS profile document (RTCA DO345 and EUROCAE ED 222) lists all features from these standards which are mandatory, not applicable or optional. AeroMACS profile differentiates between base station and mobile station functionality and contains, for each feature, a reference to the applicable standards.

## 5.3 GENERAL

5.3.1 AeroMACS shall conform to the requirements of this and the following chapters.

5.3.2 AeroMACS shall only transmit when on the surface of an aerodrome.

5.3.3 AeroMACS shall support aeronautical mobile (route) service (AM(R) S) communications.

5.3.4 AeroMACS shall process messages according to their associated priority.

5.3.5 AeroMACS shall support multiple levels of message priority.

5.3.6 AeroMACS shall support point to point communication.

5.3.7 AeroMACS shall support multicast and broadcast communication services.

5.3.8 AeroMACS shall support internet protocol (IP) packet data services.

5.3.9 AeroMACS shall provide mechanisms to transport ATN/IPS and ATN/OSI (over IP) based messaging.

5.3.10 AeroMACS should support voice services.

Note.— Manual on the Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocols (Doc 9896) provides information on voice service over IP .

5.3.11 AeroMACS shall support multiple service flows simultaneously.

5.3.12 AeroMACS shall support adaptive modulation and coding.

5.3.13 AeroMACS shall support handover between different AeroMACS BSs during aircraft movement or on degradation of connection with current BS.

5.3.14 AeroMACS shall keep total accumulated interference levels with limits defined by the International Telecommunication Union — Radiocommunication Sector (ITU-R) as required by national/international rules on frequency assignment planning and implementation.

5.3.15 AeroMACS shall support a flexible implementation architecture to permit link and network layer functions to be located in different or same physical entities.

## 5.4 RADIO FREQUENCY (RF) CHARACTERISTICS

### 5.4.1 General Radio Characteristics

5.4.1.1 Aero MACS shall operate in time division duplex (TDD) mode.

5.4.1.2 AeroMACS shall operate with a 5 MHz channel bandwidth.

5.4.1.3 AeroMACS MS antenna polarization shall be vertical.

5.4.1.4 AeroMACS BS antenna polarization shall have a vertical component.

5.4.1.5 AeroMACS shall operate without guard bands between adjacent AeroMACS channels.

5.4.1.6 AeroMACS shall operate according to the orthogonal frequency division multiple access method.

5.4.1.7 AeroMACS shall support both segmented partial usage sub-channelization (PUSC) and PUSC with all carriers as sub-carrier permutation methods.

5.4.2 Frequency bands

5.4.2.1 AeroMACS equipment shall operate in the band from 5 030 MHz to 5 150 MHz in channels of 5 MHz bandwidth.

Note 1.— Information on the technical characteristics and operational performance of AeroMACS is contained in the AeroMACS Minimum Operational Performance Specification (MOPS) (EUROCAE ED-223 / RTCA DO-346) and AeroMACS Minimum Aviation System Performance Standard (MASPS) (EUROCAE ED-227).

Note 2.— The last centre frequency of 5 145 MHz is selected as the reference frequency for the numbering of AeroMACS channels. AeroMACS nominal centre frequencies are numbered downward from the reference frequency in 5 MHz steps.

5.4.2.2 The mobile equipment shall operate at centre frequencies offset from the preferred frequencies, with an offset of 250 kHz step size.

Note.— The nominal centre frequencies are the preferred centre frequencies for AeroMACS operations. However, the base stations should have the capability to deviate from the preferred centre frequencies to satisfy potential national spectrum authority implementation issues (i.e. to allow AeroMACS operations without receiving or causing interference to other systems operating in the band such as MLS and AMT).

5.4.3 Radiated power

5.4.3.1 The maximum mobile station equivalent isotropic radiated power (EIRP) shall not exceed 30 dBm.

5.4.3.2 The maximum base station EIRP in a sector shall not exceed 39.4 dBm.

5.4.3.3 In order to meet ITU requirements, the total base station EIRP in a sector should be decreased from that peak, considering the antenna characteristics, at elevations above the horizon. Further information is provided in the guidance material.

Note 1.— EIRP defined as antenna gain in a specified elevation direction plus the average AeroMACS transmitter power. While the instantaneous peak power from a given transmitter may exceed that level when all of the subcarriers randomly align in phase, when the large number of transmitters assumed in the analysis is taken into account, average power is the appropriate metric.

Note 2.— If a sector contains multiple transmit antennas (e.g., multiple input multiple output (MIMO) antenna), the specified power limit is the sum of the powers from each antenna.

5.4.4 Minimum receiver sensitivity

5.4.4.1 AeroMACS receiver sensitivity shall comply with Table 7-1, AeroMACS receiver sensitivity values.

Note 1.— The computation of the sensitivity level for AeroMACS is described in the Aeronautical Mobile Airport Communications System(AeroMACS) Manual (Doc 10044).

Note 2.— AeroMACS receiver would be 2 dB more sensitive than indicated if Convolutional Turbo Codes (CTC) is used.

Note 3.— The sensitivity level is defined as the power level measured at the receiver input when the bit error rate (BER) is equal to 1 × 10-6 and all active sub-carriers are transmitted in the channel. In general the requisite input power depends on the number of active sub-carriers of the transmission.

Note 4.— The values in Table 7-1 assume a receiver noise figure of 8 dB.

Note 5.— The sensitivity values in Table 7-1 assume absence of any source of interference except for thermal and receiver noise.

**Table 7-1. AeroMACS receiver sensitivity values**

| Modulation scheme using convolutional codes (CC) encoding scheme | Rep. Factor | MS Sensitivity | BS Sensitivity |
|---|---|---|---|
| 64 QAM 3/4 | 1 | -74.3 dBm | -74.5 dBm |
| 64 QAM 2/3 | 1 | -76.3 dBm | -76.5 dBm |
| 16 QAM 3/4 | 1 | -80.3 dBm | -80.5 dBm |
| 16 QAM 1/2 | 1 | -83.8 dBm | -84.0 dBm |
| QPSK 3/4 | 1 | -86.3 dBm | -86.5 dBm |
| QPSK 1/2 | 1 | -89.3 dBm | -89.5 dBm |
| QPSK 1/2 with repetition 2 | 2 | -92.3 dBm | -92.5 dBm |

*Note .— A 64 QAM transmission is optional for MS.*

5.4.5 Spectral mask and emissions

5.4.5.1 The power spectral density of the emissions when all active sub-carriers are transmitted in the channel shall be attenuated below the maximum power spectral density as follows:

(a) on any frequency removed from the assigned frequency between 50 and 55 per cent of the authorized bandwidth: 26 + 145 log (per cent of BW/50) dB;

(b) on any frequency removed from the assigned frequency between 55 and 100 per cent of the authorized bandwidth: 32 + 31 log (per cent of (BW)/55) dB;

(c) on any frequency removed from the assigned frequency between 100 and 150 per cent of the authorized bandwidth: 40 +57 log (per cent of (BW)/100) dB; and

(d) on any frequency removed from the assigned frequency beyond 150 per cent of the authorized bandwidth: 50 dB.

Note.— The power spectral density at a given frequency is the power within a bandwidth equal to 100 kHz centred at this frequency, divided by this measurement bandwidth. It is made clear that the measurement of the power spectral density should encompass the energy over at least one frame period.

5.4.5.2 AeroMACS shall implement power control.

5.4.5.3 AeroMACS minimum rejection for adjacent (+/–5MHz) channel, measured at BER=10-6 level for a victim signal power 3 dB higher than the receiver sensitivity, shall be 10 dB for 16 QAM 3/4.

5.4.5.4 AeroMACS minimum rejection for adjacent (+/–5MHz) channel, measured at BER=10-6 level for a victim signal power 3 dB higher than the receiver sensitivity, shall be 4 dB for 64 QAM 3/4.

5.4.5.5 AeroMACS minimum rejection for second adjacent (+/–10MHz) channel and beyond, measured at BER=10-6 level for a victim signal power 3 dB higher than the receiver sensitivity, shall be 29 dB for 16 QAM 3/4.

5.4.5.6 AeroMACS minimum rejection for second adjacent (+/–10MHz) channel and beyond, measured at BER=10-6 level for a victim signal power 3 dB higher than the receiver sensitivity, shall be 23 dB for 64 QAM 3/4.

Note.— For additional clarification to the requirements stated in 7.4.5.3, 7.4.5.4, 7.4.5.5 and 7.4.5.6, refer to IEEE 802.16-2009 section 8.4.14.2.

5.4.6 Frequency tolerance

5.4.6.1 AeroMACS BS transmitter frequency tolerance shall be better than +/- 2 × 10-6 of nominal channel frequency.

5.4.6.2 AeroMACS MS transmitter centre frequency shall be locked to that of the BS transmission centre frequency with a tolerance better than 2 per cent of the subcarrier spacing.

5.4.6.3 AeroMACS MS shall track the frequency of the BS and shall defer any transmission if synchronization is lost or exceeds the tolerances given above.

## 5.5 PERFORMANCE REQUIREMENTS

5.5.1 AeroMACS communications service provider

5.5.1.1 The maximum unplanned service outage duration on a per aerodrome basis shall be 6 minutes.

5.5.1.2 The maximum accumulated unplanned service outage time on a per aerodrome basis shall be 240 minutes/year.

5.5.1.3 The maximum number of unplanned service outages shall not exceed 40 per year per aerodrome.

Note.– The requirements given in 7.5.1.1 to 7.5.1.3 refer to the overall service provision by the AeroMACS communication service provider on the aerodrome surface. This may include other media which can provide alternate communication paths in the event of an AeroMACS failure.

5.5.1.4 Connection resilience. The probability that a transaction will be completed once started shall be at least 0.999 for AeroMACS over any one-hour interval.

Note.— Connection releases resulting from AeroMACS handover between base stations, log-off or circuit pre-emption are excluded from this specification.

5.5.2 Doppler shift

5.5.2.1 AeroMACS shall operate with a Doppler shift induced by the movement of the MS up to a radial speed of 92.6 km (50 NM) per hour, relative to the BS.

5.5.3 Delay

5.5.3.1 Subnetwork entry time shall be less than 90 seconds.

5.5.3.2 Subnetwork entry time should be less than 20 seconds.

5.5.3.3 The from-MS data transit delay (95th percentile) for the highest priority data service, shall be less than or equal to 1.4 seconds over a window of 1 hour or 600 SDUs, whichever is longer.

5.5.3.4 The to-MS data transit delay (95th percentile) for the highest priority data service, shall be less than or equal to 1.4 seconds over a window of 1 hour or 600 SDUs, whichever is longer.

5.5.4 Integrity

5.5.4.1 AeroMACS BS and MS shall support mechanisms to detect and correct corrupt SNSDUs.

5.5.4.2 AeroMACS BS and MS shall only process SNSDUs addressed to themselves.

5.5.4.3 The residual error rate, to/from MS should be less than or equal to 5 × 10-8 per SNSDU.

Note.— There are no integrity requirements for SNSDU residual rate to the BS and MS as the requirement is entirely satisfied by the end-to-end systems in the aircraft and air traffic service provider.

5.5.4.4 The maximum bit error rate shall not exceed 10-6 after CTC-FEC, if the received signal is equal to or greater than the minimum sensitivity level for the modulations scheme used, as given in Table 7-1.

5.5.5 Security

5.5.5.1 AeroMACS shall provide a capability to protect the integrity of messages in transit.

Note. The capability includes cryptographic mechanisms to provide integrity of messages in transit.

5.5.5.2 AeroMACS shall provide a capability to protect the availability of the system.

Note. The capability includes measures to ensure that the system and its capacity are available for authorized uses during unauthorized events.

5.5.5.3 AeroMACS shall provide a capability to protect the confidentiality of messages in transit.

Note. The capability includes cryptographic mechanisms to provide encryption/decryption of messages.

5.5.5.4 AeroMACS shall provide an authentication capability.

Note. The capability includes cryptographic mechanisms to provide peer entity authentication, mutual peer entity authentication, and data origin authentication.

5.5.5.5 AeroMACS shall provide a capability to ensure the authenticity of messages in transit.

Note. The capability includes cryptographic mechanisms to provide authenticity of messages in transit.

5.5.5.6 AeroMACS shall provide a capability to authorize the permitted actions of users of the system.

Note. The capability includes mechanisms to explicitly authorize the actions of authenticated users. Actions that are not explicitly authorized are denied.

5.5.5.7 If AeroMACS provide interfaces to multiple domains, AeroMACS shall provide capability to prevent intrusion from lower integrity domain to higher integrity domain.

## 5.6 SYSTEM INTERFACES

5.6.1 AeroMACS shall provide data service interface to the system users.

5.6.2 AeroMACS shall support notification of the status of communications.

Note.— This requirement could support notification of the loss of communications (such as join and leave events).

## 5.7 APPLICATION REQUIREMENTS

5.7.1 AeroMACS shall support multiple classes of services to provide appropriate service levels to applications.

5.7.2 If there is a resource contention, AeroMACS shall pre-empt services with a lower priority than those given in Annex 10, Volume II, 5.1.8