ETSI TECHNICAL REPORT

ETR 270

May 1996

Source: ETSI TC-SES

Reference: DTR/SES-05016

ICS: 33.060.50

Key words: aeronautical, AMSS, earth station, satellite, mobile, TFTS, S-PCN, radio

Satellite Earth Stations and Systems (SES); Survey on the need for an ETS for Aircraft Earth Stations (AES) in the Aeronautical Mobile Satellite Service (AMSS)

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Foreword

This ETSI Technical Report (ETR) has been produced by the Satellite Earth Stations and Systems (SES) Technical Committee of the European Telecommunications Standards Institute (ETSI).

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

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1 Scope

This ETSI Technical Report (ETR) surveys current standardization activities in the field of Aircraft Earth Stations (AES). It identifies the major international, regional and national specification bodies who have currently published, or are about to publish specifications for Aircraft Earth Stations. It establishes the background and membership of these bodies.

This ETR reviews and summarises the scope of the identified specifications and examines their interdependencies. It examines the relevance of these specifications for regulatory type approval and the requirements of the radio communication authorities. This review examines the full regulatory field of airworthiness and telecommunications and establishes the voluntary or mandatory nature of existing specifications, and further, their relationship to the requirements presently stated within the European area. This ETR identifies areas not covered by existing specifications.

This ETR identifies the parties interested in an ETS for Aircraft Earth Stations.

This ETR examines the legal necessity for an ETS for Aircraft Earth Stations, as a result of existing Directives and conditions.

This ETR makes recommendations as a result of these investigations.

2 References

For the purposes of this ETR, the following references apply:

[1] ITU: "Radio Regulations".

[2] ICAO Annex 10 Vol. 1: "Standards and Recommended Practices for Aeronautical Telecommunications Services".

[3] EC DG XIII (1993): "ATLAS Study on a Future European Air Traffic Management (ATM) System".

[4] Airbus Industries (1995): "Global Market Forecast 1995 - 2014".

[5] RTCA DO-210: "Minimum Operational Performance Standards for Aeronautical Mobile Satellite Services (AMSS)".

[6] ETS 300 326: "Radio Equipment and System (RES); Terrestrial Flight Telephone System (TFTS)".

[7] ARINC Characteristic 741: "Aviation Satellite Communication System, parts 1-4".

[8] "ICAO Circulars"

[9] European Union 3922/91/EEC (1991): "Harmonisation of Technical Requirements and Administrative Procedures in Civil Aviation".

[10] European Radiocommunications Office (1995): ERO Report 26 "Satellite Personal Communications Services (S-PCS)".

[11] EC DG VII (1995): "White Paper on Air Traffic Management".

[12] EC DG III (1995): "Telecommunications Terminal Equipment Regulatory Framework Position Paper".

[13] EC DG XIII (1995): "Telecommunications Certification: The Way Ahead - Working Paper".

[14] European Union 83/189/EEC (1983): "Procedure for the Provision of Information in the Field of Information Technology".

[15] European Union 85/C 136/01 (1983): "New Approach to Technical Harmonisation"

[16] European Union 86/361/EEC (1986): "Mutual recognition/ type approval of TTE".

[17] European Union 88/182/EEC (1988): "Procedure for the Provision of Information in the Field of Information Technology".

[18] European Union 89/336/EEC (1989): "EMC Directive".

[19] ETR 169 (1995): "Satellite Earth Stations and Systems (SES); Common Technical Regulations (CTRs) in the satellite earth station equipment field".

[20] European Union 91/263/EEC (1991): "Approximation of the Laws of the Member States concerning Telecommunications Terminal Equipment".

[21] European Union 92/31/EEC (1992): "Approximation of Laws in EU on EMC".

[22] European Union 93/65/EEC (1993): "Definitions and Use of Compatible Specifications for the Procurement of ATM Equipment".

[23] European Union 93/97/EEC (1993): "Satellite Earth Stations".

[24] European Union 94/10/EC (1994): "Harmonisation of Technical Requirements and Administrative Procedures in Civil Aviation".

[25] European Union 94/46/EC (1994): "Satellite Communications".

[26] European Union 94C 108/06 (1994): "Mutual Recognition of Licensing of Telecommunications Services".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this ETR, the following definitions apply:

aeronautical (ground) earth station: 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 mobile-satellite service.

Aeronautical Mobile-Satellite Service (AMSS): A mobile satellite service in which the mobile earth stations are located onboard aircraft; survival stations, and emergency position indicating beacons may also participate in the service.

Aeronautical Mobile-Satellite (R) Service: An aeronautical mobile-satellite service reserved for communications relating to safety and regularity of flights, primarily along national or international civil air routes.

Aircraft Earth Station (AES): A mobile earth station in the aeronautical mobile-satellite service, other than a survival craft station, located on board an aircraft.

Mobile Earth Station (MES): An earth station in the mobile satellite service intended to be used in motion or during halts at unspecified points.

Mobile Satellite Service (MSS): A radio-communications service:
- between mobile earth stations and any one or more space stations, or between space stations used by this service; or
- between mobile earth stations by means of one or more space stations.

This service may also include feeder links.

out-of-band emission: Emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions.

public correspondence: Any telecommunication which the offices and stations must, by reason of them being at the disposal of the public, accept for transmission.

spurious emission: Emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

telecommunication: Any transmission, emission or reception of signs, signals, writing, images and sounds of intelligence of any nature by wire, radio, optical or other electromagnetic systems.

unwanted emissions: Consist of spurious emissions and out-of-band emissions.

3.2 Abbreviations

For the purposes of this ETR, the following abbreviations apply:

ADS	Automatic Dependent Surveillance
AEA	Association of European Airlines
AEEC	Airlines Electronic Engineering Committee (USA)
AES	Aircraft Earth Station
AMS(R)S	Aeronautical Mobile Satellite en-Route Service
AMSS	Aeronautical Mobile Satellite Service
ARINC	Aeronautical Radio Incorporated (USA)
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATLAS	Air Traffic Land and Airborne System
ATM	Air Traffic Management
ATS	Air Traffic Systems
C of A	Certificate of Airworthiness
CAA	Civil Aviation Authority
CD	Council Directive
CEC	Commission of the European Communities
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CNS	Communication, Navigation, Surveillance
DECT	Digital Enhanced Cordless Telecommunications
EATCHIP	European Air Traffic Control Harmonisation and Integration Programme (ECAC/EUROCONTROL)
EATMS	European Air Traffic Management System
EBU	European Broadcasting Union
EC	European Commission
ECAC	European Civil Aviation Conference
EFTA	European Free Trade Association
EMC	Electromagnetic Compatibility
EN	European Norm (standards by CEN/CENELEC)
ETS	European Telecommunication Standards (by ETSI)
ERO	European Radiocommunications Office
ETR	ETSI Technical Report
ETSI	European Telecommunications Standards Institute
EU	European Union
EUROCAE	European Organisation for Civil Aviation Equipment
EUROCONTROL	European Organisation for the Safety of Air Navigation
FAA	Federal Aviation Administration (USA)
FANS	Future Air Navigation System
FMS	Flight Management System
GDP	Gross Domestic Product
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile communications

HIPERLAN	High Performance Radio Local Area Network
IACA	International Air Carrier Association
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
INMARSAT	International Mobile Satellite Organisation
ISO	International Standards Organisation
ITAEG-Air	Information Technology Advisory Expert Group "Air"
IT	Information Technology
ITSTC	Information Technology Steering Committee (CEN/CENELEC/ETSI joint body)
ITU	International Telecommunications Union
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirement
JAR TSO	Joint Aviation Requirement Technical Standards Order
JTSO	Joint Technical Standards Order
MES	Mobile Earth Stations
MLS	Microwave Landing System
MOPS	Minimum Operational Performance Specification
MOU	Memorandum Of Understanding
MPS	Minimum Performance Specification
MSS	Mobile Satellite Service
NAA	National Aviation Authority (USA)
NASA	National Aeronautic and Space Administration (USA)
RAS	Radio Astronomy Service
RF	Radio Frequency
RR	Radio Regulation (ITU)
RTCA	Radio Technical Commission for Aeronautics (USA)
RTCM	Radio Technical Commission for Maritime (USA)
S-PCN	Satellite Personal Communications Networks (ETSI terminology)
S-PCS	Satellite Personal Communications Services (ERO terminology)
SARPS	Standards and Recommended Practices (ICAO)
SATCOM	Satellite Communications
SATNAV	Satellite Navigation
SES	Satellite Earth Station
SSR	Secondary Surveillance Radar
TBR	Technical Basis for Regulation (ETSI)
TETRA	Trans-European Trunked Radio system
TFTS	Terrestrial Flight Telephone System
TRAC	Technical Recommendations Application Committee (now NTRAC)
TSO	Technical Standards Order
TTE	Telecommunication Terminal Equipment
USA	United States of America

4 Executive summary

Satellite communications (essentially of a public correspondence nature) with aircraft using frequencies from the AMS(R)S allocation at 1,5/1,6 GHz bands has been operating under ITU RR 729A for some years and are now technically proven. Some 600 aircraft world-wide, mostly wide body long range types have been equipped, which includes around 90 from European airlines. European manufacturing interests, for both aircraft and Aircraft Earth Station(AES) are well represented in the market.

In the immediate future notable developments will occur requiring a focus on standards. As part of the ICAO FANS programme, air traffic satellite communications will commence replacing HF, first on Pacific routes, later North Atlantic and elsewhere. Mandatory carriage of AES will affect European aircraft, primarily those operated by large and medium operators on trans-oceanic routes.

Other satellite communications using frequencies from AMSS and MSS bands for personal and business purposes will appear later. Compact, cheaper equipment is likely to exploit the potential General Aviation market (some 45 000 light aircraft plus many thousands of other flying machines). The prospects of cross border and trans-continental travel underlines the need to harmonise systems, and protect other users of the spectrum. Such use is likely to be a more serious interference threat than AMS(R)S operations, which may be quite small. Aviation and telecommunication authorities have contributory parts in these measures. As one of a range of measures, this review has examined the need for standards.

In this report, clause 7 examines the various bodies having a concern, directly or indirectly with aeronautical radio in aircraft. Clause 8 then looks at the scope and interdependence of existing specifications. Clauses 9 to 11 address various institutional aspects, and clauses 12 and 13 cover the important area of the legislative need for an ETS for AES. Clause 14 outlines future actions followed by clause 15, "Summary of findings and recommendations".

In this review, it is seen that airworthiness certification is the process which ensures that an aircraft and all its components, are fit for the purpose of safe flight. The obligation originates in Article 31 of the ICAO Convention and is exercised by national Civil Aviation Authorities (CAAs) for aircraft on their register. The European legislation in Council Regulation 3922/91/EEC [9] calls for European harmonisation, appointing the EC to oversee, and the Joint Aviation Authorities (JAA) to administer the arrangements. The JAA is presently under EU review with the intention of strengthening its role. JAA requirements for radio are promulgated through mandatory Joint Technical Standards Orders which designate, by normative reference, the Minimum Performance Specifications (MPS) of EUROCAE or alternatively RTCA in the USA.

MPS for AES are developed initially as voluntary standards which use the internationally agreed standards of ICAO as their basic references, supplemented with other specific parameters for the development of an operational performance specification. Appropriate ITU regulatory provisions and ITU-R Recommendations are incorporated. National or EU legislative actions subsequently convert MPS to mandatory standards. In the preparation of MPS, carried out in the USA, no reference is made to EU Directives or Regulations. In the field of aviation other specifications are produced, e.g. ARINC/AEEC Characteristics, which have no mandatory force and are entirely voluntary. The final action is the installation and proving in the aircraft, followed by the issue of the Certificate of Airworthiness ("C of A").

The installation and use of radio in aircraft for purposes other than for flight control or air safety are only required to meet the tests of physical safety of the aircraft and its passengers or cargo (so called "no hazard") and non-interference to other radio or flight control systems. Specifications for these can be developed independently from the normal airworthiness processes for safety systems.

Four recommendations are made. Firstly, that the necessity for an ETS for AES operating in the AMS(R)S is reviewed in conjunction with the JAA, taking into account relevant EU legislation. Secondly, that an ETS for MES used on board aircraft and operating in the AMSS or MSS, either installed or carried on board, should be developed, for later provision of a TBR. Thirdly, that in both cases it is recommended that ETSI should seek co-operation with international bodies. Finally, that ETSI should seek clarification from the European Commission on the applicability of various EU Directives to AES and the possible regulatory content of an ETS, given current developments in the legislation (e.g. TTE and SES Directives).

5 Introduction and background

Satellite communications with aircraft have been in operation for a number of years providing public correspondence type services on AMS(R)S frequencies under the dispensation of RR 729A. The scale has been moderate with some 700 aircraft world-wide including 90 from European airlines, and 100 or so General Aviation aircraft, participating in the service.

Under ICAO plans, formulated by their Committee on Future Air Navigation Systems (FANS) and now official policy, much of the air-traffic communications of the future, particularly that presently on HF will be converted to satellite communications. The Pacific area is scheduled to commence soon, followed by the North Atlantic and other desert and ocean areas. Europe is likely to remain primarily on VHF with satellite only in difficult fringe areas, if used at all. Aircraft flying these routes will be obliged to fit AES, either as a new installation or as retro-fit, and European Civil Aviation Authorities (CAAs) will be required to certify and approve the equipment and the installation for aircraft on their register.

Proposals are now also appearing for other satellite services with aircraft using frequencies from AMSS and MSS allocations which demand attention in regard to the objectives of efficient use of the spectrum, unwanted emissions, and sharing of the band with other mobile earth station users. In particular, new global systems providing Satellite Personal Communication Services (S-PCS [10]) will appear in the market, with smaller, cheaper terminals. The interference potential of these services could be very high if such equipment at competitive call rates emerges as a reality.

The area of the development of specifications, standards, conformance testing, and the respective roles of telecommunication and aviation authorities, together with their overlaid framework of international agreement is not fully understood in this context of radio in aircraft. Important ITU and ICAO treaty provisions must be observed, as well as their legislative effect in the EU and EFTA countries. The requirements of air safety attract priority attention and often specialist treatment, which needs clarification particularly in relation to standards for non-safety communications equipment, such as TFTS, which are installed or taken aboard.

The purpose of this review is to examine the processes pertaining to approval of radio in aircraft with particular reference to AES and to produce recommendations for further future action.

6 Working methods

The guidelines provided to the ETSI Project Team PT 71V with the task to prepare a draft ETR (see annexes J and K) included exploratory work of existing procedures in the aeronautical services, and a study of their documentation against the background of current European Union legislation. This entailed a comprehensive survey of all documentation generally available in the public domain to provide an accurate and up-to-date picture of the various active organisations, their inter-relationships, and their output documents.

Three PT 71V working sessions of nominally two weeks were spent at ETSI over the period September to December 1995 carrying out research and preparing the ETR itself. A PT 71V Steering Committee meeting was held in each period, with the final meeting on 6 December 1995.

To give complete and accurate details of events and future plans, additional research by telephone discussion, and for a number of important interests, personal visits were also undertaken by PT 71V. It was considered important by the PT 71V Steering Committee, for example, to obtain a sample of the views of the manufacturing interests, the airline interest, and those of the prime international organisations in the field.

Personal visits were made to the following:

- Airbus Industries;
- Racal Avionics;
- INMARSAT;
- European Commission's Directorates General DG III, VII and XIII;
- EUROCONTROL;
- ICAO;
- British Airways;
- EUROCAE;

- IATA.

Other contacts were also made with:

- ECAC;
- JAA;
- AECMA;
- RTCA.

The Project Team PT 71V was assisted by a Steering Committee, providing the clarification on the survey guidelines where necessary. All items contained in the survey guidelines were covered, and each clause of the report was fully reviewed and approved by the PT 71V Steering Committee, following the necessary amendments.

The final draft report was delivered by PT 71V to the ETSI Secretariat on 8 December 1995.

7 Surveyed bodies

In the following subclauses, the various organisations and other bodies concerned with the preparation; application; or in some other contributory manner, with Aircraft Earth Station specifications are identified. The term specification is used in its most general sense: to denote a document which specifies parameters and the conditions under which they apply, and which may later receive agreement and recognition as a standard for specific purposes through appropriate agreements. This clause does not discuss the question of interdependence of the various specifications. This is the subject of a later clause. The survey concentrates mainly on the AMS(R)S service as the subject of particular interest. The membership of the various organisations described is presented in tabular form in annex A.

7.1 Bodies with mandatory authority

7.1.1 ITU

The International Telecommunications Union (ITU) was created in 1932 by the fusion of the International Telegraphic Union and the International Radiotelegraph Union, both being international bodies of long standing. The ITU now has over 162 signatories. It is recognised by the United Nations as the specialised agency with responsibility for telecommunications. In the course of its work, the ITU has created the Radio Regulations, which receives continuous amendment through agreements made at World Radio Conferences (WRC). There is no provision for amendment other than that enacted at world conferences, to which all members are invited.

The principal feature contained in the Radio Regulations is the Table of Frequency Allocations which assigns frequency bands from 9 kHz to 400 GHz amongst radio services and to 3 world Regions:

- Region 1: Europe + ex-USSR + Africa;
- Region 2: America (North and South);
- Region 3: Asia (except ex-USSR) + Pacific.

Allocations to the three Mobile Satellite Services, Land, Maritime and Aeronautical are made in the Radio Regulations in the band 1 525 MHz and 1 559 MHz in the space-to-Earth direction and in the band 1 626,5 MHz and 1 660,5 MHz in the Earth-to-space direction. The Aeronautical Mobile Satellite Service is allocated, on a primary basis, the bands 1 545 to 1 555 MHz for space-to-Earth and 1 645,5 to 1 656,5 MHz for Earth-to-space. These transmissions relate to the radio path between the satellite and the aircraft. Those from the ground to the satellite are part of the Fixed Satellite Service (FSS) which uses allocations at 4 GHz and 6 GHz. Proposals have been made to the ITU for the modification of the above (land, maritime and aeronautical) to allocations to the Mobile Satellite Service (so called generic allocations).

The Radio Regulations contain tables of transmitter Frequency Tolerances and ITU-R Recommendation figures for the Maximum Permitted spurious Emission Power levels banded in 4 frequency bands. In general, these are worst case limits and system performance requirements usually have to employ limits which are significantly better in order to ensure satisfactory performance.

The Radio Regulations contain no specifications or requirement other than those related to spectrum use, i.e. frequency, emission characteristics, tolerances, power and bandwidth. Radio Regulations have the force of treaty documents and compliance is obligatory.

ITU summary:

(i) The ITU is the specialised agency within the UN for matters concerning telecommunications. Practically all independent world countries are members.

(ii) The ITU Radio Regulations have treaty status and its provisions are mandatory amongst members.

(iii) The Radio Regulations have 3 main requirements:

- frequencies used by services;
- frequency tolerances;
- levels of maximum unwanted spurious emissions.

7.1.2 International Civil Aviation Organisation (ICAO)

The Convention on International Civil Aviation was opened for signature in Chicago in September 1944. With the 26th ratification, received on 6 March 1947, it became a formal international treaty. Chapters VII to XIII in Part 2 of the treaty made provision for the setting up the International Civil Aviation Organisation (ICAO) which was recognised in October 1947 by the United Nations as a specialised agency linked to the UN Economic and Social Council. ICAO membership currently extends to 183 contracting States. The ICAO Convention and its Annexes, contains a number of provisions of direct relevance to this review, including the following:

(i) Article 37: Adoption of international standards and procedures

ICAO is required to adopt and amend from time to time, as necessary, international standards and recommended practices and procedures dealing with communications systems and navigation aids. Each contracting State undertakes to collaborate in securing the highest practicable degree of uniformity in regulations, standards, procedures etc.

(ii) Article 38: Departures from International Standards

This article requires a State to give immediate notification to ICAO of any differences between its own practices and that established by the international standard.

(iii) Article 31: Certificates of Airworthiness ("C of A")

Every aircraft engaged in international navigation is required to be "provided with a Certificate of Airworthiness issued or rendered valid by the state in which it is registered".

ICAO Standards and Recommended Practices (SARPs)

ICAO SARPs are contained in 18 Annexes to the Convention of which Annex 10 is the Telecommunication Annex. The Annexes have the same status and force as the Treaty itself. Incorporation of SARPS into the Annexes is made through a process of preparation of text in Panels, then agreement at world wide Divisional Meetings, followed by a written consultation procedure with all Member States in which a majority must affirm their support for inclusion.

In accordance with Article 38 of the ICAO Convention, provision is made for any State to communicate a difference with particular parts of Annex provisions. This is rarely done for any significant parameter, and practically never by major aviation countries.

The distinction between a Standard and a Recommended Practice is that the former are "necessary for safety or regularity of fight" and are obligatory. Recommend Practices are "of safety, regularity or efficiency" and compliance is expected rather than imposed. In the Annexes, Standards are variously described as specifications, or system characteristics, which for systems for communications, navigation or surveillance purposes will specify at least the following elements:

- frequency of operation, tolerances, levels of maximum (ITU or better);
- modulations;
- signal strength over service area;
- call signs/identification marks;
- receiver sensitivity;
- signal format, timings and protocol;
- monitoring and close-down when system is outside normal operational parameters;
- operational procedures, where these are essential.

The main objectives of these standards are:

(i) To ensure that the performance is adequate and safe, and is maintained safe, for the operational purpose;

(ii) To enable aircraft to fly world-wide with a "standard" set of equipment;

(iii) To facilitate the specification and manufacture of equipment to a standardized performance and capability, for installation in any aircraft without the need for special adaptations.

ICAO SARPS address the ground element in air/ground co-operative systems in considerably greater depth and scope than the airborne element. The national regulatory procedure for the two elements also differs. The first is within the prerogative of the national Civil Aviation Authority (CAA) without the need for any published specification, as these services are normally operated under governmental control. The second falls within the remit of the national airworthiness authorities (see below) and is carried out for the aircraft, its components (including radio) and their installation through formal regulatory processes against published specifications and requirements. It is worth noting that the national airworthiness authorities are usually a division of the national Civil Aviation Authorities (CAAs).

ICAO summary:

(i) ICAO is the specialised agency of the UN with competence in Civil aviation. The standards agreed by the International Civil Aviation Organisation and published in Annex 10 to the ICAO Convention are binding on signatories to the Convention and are the starting point for the performance requirements of internationally standardized systems. The Aeronautical Mobile Satellite System falls within this definition (Article 37);

(ii) the ICAO Convention requires Members States to provide a Certification of Airworthiness for all aircraft on its Register of Aircraft (Article 31);

(iii) the radio station and the personnel must be licensed in accordance with the requirements of the appropriate authority (Article 31);

(iv) ICAO Standards and Recommendations contained in Annex 10 to the Convention address the system specification for signatories, which include practically all world countries;

(v) in May 1996 the Council of ICAO is expected to approve the consultation with ICAO Members States of the Standards for the Aeronautical Mobile Satellite Service, prior to their incorporation into Annex 10. Included in these specifications are extensive provisions covering aircraft earth station operating parameters performance, protocols and procedures. Compliance with this specification is mandatory for all ICAO Member States. The ICAO specifications dealing with the RF characteristics of the aircraft earth station can be found in Annex 10 to the ICAO Convention. National regulatory machinery and other provisions laid down in the national laws complete the regulation process.

7.1.3 European Union

The European Union (EU) consists of 15 West European Countries (see annex A) who are signatory to the Rome and Maastricht Treaties. The Union is to create political and economic harmonisation between its member states. The Union has law making and enforcement powers through its various organs: - the Council of Ministers (the deliberative body); the European Parliament; the European Commission (the executive) and the European Court of Justice (the judiciary). EU legislation are framed and published as Regulations (binding without the need for national law) and Directives (binding in Member States to the extent necessary). Decisions, Recommendations and Opinions are non-binding apart from certain decisions which impose duties usually in a specific country or area.

For the purposes of this report, the European Commission is the most relevant body. The European Commission itself, is composed of 23 Directorates. Of these, three in particular are concerned with standardization activities related to aircraft earth stations. These are DG III for standardization policy (all industry sectors); DG VII for Transport (including Civil Aviation) and DG XIII for telecommunications in general, in particular for the exploitation of satellite telecommunications technology. The European Union's most significant policies on Standardization and specifically on aviation technical matters have been stated in:

(i) Council Directive 93/65/EEC [22] is the definitive legislation relating to air traffic management and systems. This Directive gives the European Commission power to issue standardization mandates to CEN/CENELEC/ETSI to "complement the specifications of EUROCONTROL";

(ii) Council Regulation 3922/91/EEC [9] on the harmonisation of technical requirements and administrative procedures in the field of civil aviation encompasses the work of the Joint Aviation Authorities (JAA);

(iii) The White Paper on Air Traffic Management [11] from December 1995, developed by DG VII (Transport), articulates current European Commission policy in this area. It makes explicit reference to the need for harmonisation and standardization, and the economic significance of the activities. Major institutional changes are also proposed in an effort to alleviate congestion in European airspace, enhance safety and reduce costs to industry. The final objective being to further enhance the free movement of goods and services in market.

A more complete survey of the relevant legislation is given at clause 10.

EU summary:

(i) The European Union has legislative authority in the field of specifications for aircraft radio equipment in the context of standardization to promote air traffic management efficiency;

(ii) exercises a direct chain of functional responsibility through the Council Regulation 3922/91/EEC [9] to the work of the Joint Aviation Authorities.

7.1.4 European Civil Aviation Conference (ECAC)

The European Civil Aviation Conference (ECAC) was established in 1964 at an intergovernmental conference which granted the organisation an intermediate status between complete independence and a subordinate regional organisation of ICAO. The membership is currently 33 (see annex A). The original constitution has been amended in 1968, 1976, 1979 and 1984. Its aims are to review generally the development of European air transport in order to promote co-ordination, better utilisation and orderly development of air transport and to consider any special problems that may arise. Ministers for Transport are the participating members in the main Assembly body, with Director General of Civil Aviation normally attending Plenary Sessions (Final and Intermediate). Two Economic Committees deal with air transport matters (e.g. route licensing, bilateral agreements), whilst the Technical and Facilitation Committees working groups discuss and agree the detailed matters.

ECAC is notable for its work in two main technical areas:

(i) in April 1990, the ECAC Ministers alarmed at the increasing congestion and delays in European air traffic, launched the ECAC strategy for the nineteen nineties and appointed EUROCONTROL to pursue solutions to the problem. From this, the EUROCONTROL EATCHIP and EATMS programmes were initiated and are currently being developed;

(ii) in the airworthiness field, ECAC has an interest in the operation of the Joint Aviation Authorities.

The role of ECAC may be perceived as one of conferring a measure of inter-governmental agreement on those aspects it chooses to address and agree. ECAC endorsement acts as a de facto agreement between the ECAC Transport Ministers in Europe and is effectively an informal statement of official governmental policy.

ECAC Summary:

(i) ECAC has quasi inter-governmental status whereby Transport Ministers of the 33 ECAC states agree policy across a wide field of civil aviation matters.

(ii) ECAC has accepted the role of overseeing the operation of the Joint Aviation Authority for the Airworthiness of aircraft. The work of the JAA includes setting standards for the certification of radio equipment on aircraft as one of their tasks.

7.1.5 EUROCONTROL

The EUROCONTROL International Convention on Co-operation for the Safety of Air Navigation was created in 1960 to operate, on a joint basis, the air traffic services in the Upper Airspace of its members. In the amended convention of 1986, that obligation was deleted and replaced with one of providing air traffic services when requested by individual members. There are now some 19 signatories, which includes all of the countries of Western Europe (see annex A).

The EUROCONTROL Organisation through its General Directorate undertakes a wide range of tasks in the field of air traffic management, which includes inter-alia studies, tests and trials of new systems and techniques, planning co-ordination of medium and long term plans, collection of users changes and many other related tasks.

In 1989, EUROCONTROL was requested by ECAC to set up a programme of planning co-ordination for the introduction of future air traffic systems in Europe based on the ICAO FANS Recommendations. The European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) together with the European Advanced Air Traffic Management Systems (EATMS) activities were subsequently set up to deal with the medium and long term. The Central Flow Control Management Unit located in Brussels deals with the tactical control of air traffic congestion.

In the field of standardization, the CEC Mandate M/027 of 15 September 1993 recognised the role and connection between the technical specifications of EUROCONTROL and the Standards to be drawn up by CEN/CENELEC/ETSI in the Directive 93/65/EEC [22].

The work of EUROCONTROL in the standards fields relate exclusively to the functional, technical and operational material used in the air traffic management infrastructure. They complement and conform to the SARPS of ICAO, extending their applicability into detailed technical and procedural aspects of the system engineering of ATC systems. The interface with the aircraft earth station is minimal only, and confined to the communications link from ground control to the pilot, through successive elements of the ground system, provider's infrastructure and the space system providers organisation.

EUROCONTROL summary:

(i) EUROCONTROL is a treaty organisation of 19 European States with the responsibility for the operation of their members air traffic services when requested, and with the effective co-ordination, planning and studies of new systems and techniques.

(ii) EUROCONTROL has an indirect standardization responsibility through CEN and CENELEC under Council Directive 93/65/EEC [22] for producing technical specifications for systems within its competence.

(iii) There does not appear to be any enforcing machinery to ensure the application of EUROCONTROL standards since the procurement of systems remains primarily a national responsibility.

(iv) The EUROCONTROL organisation would not appear to hold any institutional competence in the field of the specification and approval of radio equipment in aircraft other than their interest in the basic interface parameters for air/ground systems.

(v) As part of its study activities, EUROCONTROL follows closely the developments in satellite communications and navigation as applied to air traffic management.

7.1.6 Joint Aviation Authorities (JAA) of Europe

The Joint Aviation Authorities (JAA) is a co-operative venture between 20 European counties enacted in 1987 in the field of airworthiness, flight crew licensing, operation and maintenance of aircraft through a MOU. Its objectives are to create uniformity in safety regulatory requirements through Joint Aviation Requirements (JARs). The JAA Board consists of the Director Generals of Civil Aviation of the member countries whose duties are to define strategy and operate the budget. The JAA Committee is the specialist management committee for the executive work of the JAA. The JAA has its headquarters in Hoofdorp in Holland with a General Secretary and a small (22) support team.

Some (4) JAA members have adopted JARs as their sole code and the Executive Committee consists of one member from each of these, plus one from other members. The Chairman of JAAC and JAAEC is the same person, elected on a yearly basis, from one of the 4 countries who have adopted sole code operation. The four countries are Denmark, France, Spain and UK.

The JAA is an associated body of the ECAC. The JAA received recognition in Council Regulation 3922/91/EEC [9] as dealing with "the harmonisation of technical requirements and administrative procedures in the field of civil aviation". Article 3 of this regulation lays down that the JAR codes referred to in the Annex to the regulation, as being those applicable in the Community coming into force on 1st. January 1992. This annex contains the JAR TSO (Technical Standards Order) which in turn includes TSOs for radio equipment on aircraft.

In relation to AES, the JAA may be seen as a standard setting body for the airworthiness approval of aircraft and aircraft equipment for European Union member states, and a voluntary body for others, in respect of the codes listed in the Annex II of CR 3922/91/EEC [9]. At the present time, the JAA is in the process of incorporating TSOs for individual aircraft radio systems. The TSOs currently in operation are at annex I to this report.

The membership of the JAA is at annex A.

7.1.7 Civil Aviation Authorities (CAAs) at national level

The national CAAs have responsibility for civil aviation regulation and implementation within their State and for discharging the obligations arising from signature of the ICAO Convention. They are the focus for all civil aviation activity, and a partner with military colleagues in matters of common aviation interest, often quite substantial. Traditionally, this activity has covered the total field of aviation, including economic policy and licensing, operation of air traffic services, the regulation of airlines, international affairs and the approval of aircraft and systems. A process of fragmentation and liberalisation is nevertheless being followed in some countries in Europe which may well expand.

In regard to the operation of aviation radio on the ground, or from an aircraft, there will normally be two quite separate complementary elements. Firstly, the license to radiate a radio transmission which meets frequency regulations controlled by the telecommunications administrations. There is, secondly, the authorisations to provide a service to aircraft which is safe and appropriate for the purpose. This is controlled by the National Aviation Authority. These may be combined or separate. These national responsibilities emanate on the one hand from the ITU with its telecommunications regime, and on the other hand from the ICAO civil aviation regime. The mutual recognition of radio licenses between states is implicitly within ITU rules. Also the mutual recognition of Certificates for services and safety approval are fully recognised within the ICAO framework.

The approval of radio equipment for use in aircraft, and its installation and performance when installed will also be exercised within the functions, direct or delegated, of the national Civil Aviation Authority. In Germany and Norway aircraft radio equipment is type approved by the National Telecommunications Administrations (NTAs). In France and Switzerland for APC equipment (working in public telecommunications frequency bands) the type approval is given by the NTAs. In many countries, this airworthiness approval often amounts to an acceptance of the approval granted in the country of manufacture of the aircraft.

In the context of this report, national CAAs:

(i) Hold responsibilities at national level for the policy and application of matters concerned with the operation of air traffic services, and for the Airworthiness approval of radio equipment in aircraft;

(ii) In the exercise of this responsibility conformity with the standards of ICAO Annex 10 (Telecommunications) is obligatory. Annex 10 specifies Standards and Recommended Practices for equipment used in the Aeronautical Mobile Satellite Service (AMSS). The specification includes provisions which address the AES;

(iii) In respect of radio equipment in aircraft Article 31 of the ICAO Convention requires each member state to approve the radio equipment in all aircraft on its register. Mutual acceptance of other states approval, usually the country of manufacture, is often adopted as a convenient method of satisfying the requirement.

7.1.8 CEPT

The European Conference of Postal and Telecommunications Administrations (CEPT) was founded in 1959 and has 34 members drawn from EC, EFTA and other adjacent European states. Only European members of the Universal Postal Union, or of ITU, are admitted. Its essential aims are the establishment of closer relations between member administrations, and the harmonisation and practical improvement of their administrative and technical services. It has three main Committees: Postal, Radio-communications (the ERC), and General Telecommunications matters.

Prior to 1988, CEPT was active in the field of standardization, a role which has diminished with the transfer of these activities to ETSI. In 1993 the CEPT and ETSI agreed a MOU to co-operate in the field of radio in accordance with an agreed procedural framework.

Essentially, CEPT is a voluntary body with a highly influential role in radio regulatory matters. Towards this purpose, it receives mention as a consultative body in the TTE Directive 91/263/EEC [20] in association with the TRAC Committee. An MOU governs the relations between the EC and CEPT.

The ERC focuses on radio matters covering such aspects as frequency management, licensing and compatibility, without duplicating the work of other specialised bodies such as EBU, ICAO, etc. In the preparations for the conferences of ITU, the CEPT can provide an important co-ordination function, often resulting in the presentation of a joint position to the Conference.

The CEPT interface with aviation is confined to the following:

- informal discussions on the aviation use of frequency bands, in which it may also act as a co-ordinator of its members policies on ITU or ITU-R matters;

- co-ordination and development of specifications, frequency plans, and administrative arrangements for non- safety radio systems used in aircraft e.g. TFTS.

7.1.9 National telecommunications administrations

National telecommunications administrations have the responsibility, either by themselves or jointly with other agencies of the government, for a wide range of matters within the telecommunications field. Prime amongst these are the following (in the context of this review):

- administering the obligations undertaken by signature of the ITU Convention, including in particular the control and management of the requirements of the Radio Regulations;

- control of the processes of radio licensing, awarding licenses to service operators for the setting up of radio stations to serve a public or private need;

- the development and publication of specifications for radio systems used as appropriate in broadcasting, mobile, satellite, and other fields;

- participation in the national process concerning the allocation and use of radio frequencies by service users, in accordance with the ITU Table of Allocations;

- the investigation and clearing of radio interference, particularly where this is suffered by a safety service. Action to prevent re-occurrence using permissible sanctions.

In many countries, it is the normal procedure for the authority responsible for civil aviation to undertake the task of management of the spectrum allocated to aeronautical services, and for the development of specifications of aviation equipment used on the ground and in aircraft. The Certificate of Airworthiness is issued by the CAAs and permits the particular service to be used, and the corresponding license is issued by the Telecommunications administration which permits transmission.

In the bands allocated to the AMS(R)S, a number of players are involved. These include the space segment provider and the ground system provider (both possibly multi-national in composition), set within a competitive framework. Cross border agreements are made on licensing, clearance of interference, charging and general supervision.

In the bands allocated to AMSS and MSS, where public correspondence only is the service provided, the national telecommunications administrations will have complete responsibility (specification, type approval and licensing). In these cases the airworthiness requirement is minimal and limited to ensuring the physical and electrical safety of the aircraft, and its passengers - where public transport is concerned.

7.2 Organisations producing specifications

7.2.1 ITU - R

The ITU-R is the ITU technical sector in charge of Radiocommunications. The terms of reference are officially defined in the constitution of the ITU, formally approved at the Plenipotentiary Conference of 1989. The duties are:

- "to study technical and operating questions relating specially to radio communication without limit of frequency range, and to issue Recommendations with a view to providing technical basis for efficient use of the frequency spectrum and the geostationary orbit, and with a view to standardizing telecommunications on a world wide basis. These studies shall not generally, address economic questions but where they involve comparing technical alternations, economic factors may be taken into consideration".

The ITU-R is composed of Study Groups who carry out the detailed technical drafting, later approved by the Plenary Assembly. One Study Group deals exclusively with Mobile radio matters, with one of its Working Group devoted to Mobile Satellite aspects.

ITU-R responds to Questions from a variety of sources including its own Study Groups, and from all of the ITU internal organs. Its most important output is in the form of Recommendations, addressing the planning and regulation of radio services. An important task undertaken by ITU-R is the preparatory technical work for ITU World Radio Conferences now held bi-annually. Their output is advisory in the form of Recommendations for consideration by the Conference.

The scope of the ITU-R work is wide ranging addressing problem areas, systems - including some of a very tentative nature, procedural matters where they impact on technical or operational matters of importance, functional and technical requirements. Whilst standardization receives mention in the official statement of work, only a very small proportion of the output could be in the nature of internationally agreed standards. Moreover, ITU-R, itself does not impose any binding obligation to comply unless the material is specially mentioned in ITU Radio Regulations in that context. This method is unsuitable for material which is constantly or frequently changing since the highly formalised procedures of ITU Conference is an inefficient means of maintaining a coherent tracking of the requirement. It is not suitable for most aeronautical applications which may have to respond rapidly to urgent operational imperatives.

A number of ITU-R Recommendations address Aeronautical Mobile Satellite matters.

More recently, concern has appeared within some aviation circles on the concept of frequency sharing between safety services and non-safety services (including other Mobile Satellite Services) which have led to new recommendations. The World Radio communication Conference in 1995 (WRC-95) discussed the question of allocations in this context.

ITU-R Summary:

(i) ITU-R is the technical advisory element for radio in the ITU organisational framework. Its main body, the Assembly reports through the ITU Administrative Council to the ITU Plenipotentiary Conference, held every 4 years;

(ii) ITU-R produces Recommendations which have no mandatory force unless specifically mentioned in ITU Radio Regulations in that context. This is a very small proportion of the ITU-R output;

(iii) ITU-R work in the field of standards is not significant. Such standards are voluntary only and can not be described as internationally agreed;

(iv) ITU-R Study Group 8 has produced a number of important Recommendations on Mobile and Aeronautical Mobiles Satellite (R) matters. Some address the concern of the aviation community that aeronautical safety communications will be intermixed with other non safety communications including possibly Maritime Satellite and Land Mobile Satellite traffic.

7.2.2 Radio Technical Commission for Aeronautics (RTCA) of USA

Formed in 1936, the Radio Technical Commission for Aeronautics (RTCA) is an association of approximately 130 USA organisations, with participants from both government, industry and airlines (including the FAA, Dept of Defence, USA Coastguard, NASA etc.). A sister organisation, RTCM, deals with maritime matters. It conducts its business through its Assembly, the main deliberative organ, the Executive Committee Technical Advisors and Special Committees. Membership is open to any USA organisation identified with some aspect of RTCA work, non-USA organisations can hold associate membership. Whilst not a government body or agency, the RTCA nevertheless operates with official approval and support.

RTCA's scope of activities in the field of aviation electronics and telecommunications is wide and the subjects it chooses to address are covered with appropriate expertise in considerable depth. It has 19 active Special Committees and has published over 80 significant documents, reports and other publications in the aviation field. Some examples of areas of interest and their significance are:

(i) Minimum Performance Specification (MPS) for all radio equipment in aircraft. Those are voluntary specifications which usually receive the formal endorsement of the USA Federal Aviation Administration (FAA) in its mandatory Technical Standards Orders (TSOs);

(ii) RTCA MPS are important documents since most aviation radio installed in transport, and General Aviation aircraft is manufactured in, and installed in aircraft manufactured in the USA;

(iii) RTCA MPS form the basis of the equivalent derived European MPS developed in EUROCAE. EUROCAE MPS through the endorsement of the JAA (in its JTSOs) and ECAC assume mandatory authority.

In the field of aircraft radio, the RTCA develops and agrees Minimum Performance Specifications (MPS) for systems within its special committees, which include representation from the USA Government, (FAA) military, airlines and industry. These MPS, when accepted by the Federal Aviation Administration (FAA) become a formal USA regulation, (Technical Standard Order) for the purposes of type approval.

The importance of the RTCA work lies in the collaborative involvement of all USA interested organisations coupled with the fact that a greater proportion of the world's commercial aircraft and the radio and other systems installed are manufactured in the US. Effectively the performance standards for all avionics and air traffic systems in commercial aircraft are developed and controlled by bodies in the USA. In addition to this, RTCA (with the support of the FAA) have met with ICAO with the further aim of facilitating the work of ICAO by utilising RTCA’s standards making machinery.

The RTCA has developed and agreed DO-210 in respect of satellite communications systems. This document is under consideration by the USA FAA as a TSO, and is the present specification against which aircraft satellite equipment performance is manufactured. RTCA DO-210 is in conformity with ICAO Standards and is in the public domain. Other RTCA documents are also used for the certification of aeronautical equipment e.g. RTCA DO-160 and RTCA DO-178.

RTCA Summary:

The RTCA:

(i) is a voluntary body, with membership drawn from aviation interests in the USA concerned with air traffic navigation and communication systems;

(ii) Minimum Performance Specifications (MPS) for radio systems in aircraft developed by RTCA are the main documents for standardization purposes and are normally adopted, with minor additions by the USA Federal Aviation Administration;

(iii) the greater portion of the world's aircraft and practically all the radio equipment in aircraft is manufactured in the USA;

(iv) European Joint Technical Standards Orders (JTSOs) are aligned as much as possible with FAA TSOs and RTCA MPS;

7.2.3 ARINC of USA

The Aeronautical Radio Incorporated (ARINC) was set up by the major USA airlines to provide a focus for airline concerns in the field of radio systems. Non USA airlines were permitted to join as associate members. Their activities now cover a wide area of aviation radio and electronics including the operation of HF and VHF air-ground services (voice and data) research and development, as well as the preparation of ARINC specifications.

ARINC specifications, produced in conjunction with their specialist support committee AEEC, are specifically developed for airline application and supplement the mandatory MPS into other detailed avionics areas so that the radio equipment and the cabling are interchangeable between aircraft and between avionics manufacturers. In an airline context they play an important and highly influential role since they provide a practical base of high expertise and knowledge in an area which accounts for an appreciable proportion of the first cost, and operating cost, for modern high technology aircraft. ARINC specifications, as with RTCA specifications are compliant with all requirements in ICAO Standards and Recommended Practices. Their system performance limits normally incorporate a margin for "run-down" whilst in service so as to extend the periods before removal and adjustment.

ARINC Summary:

(i) ARINC has been set up by USA airlines (principally) to provide an airline link between the mandatory requirement for aircraft radio and the operational needs of airlines for interchangeable equipment built to enhanced performance characteristics;

(ii) ARINC specifications, which include comprehensive details of equipment, are voluntary only and are principally used for the procurement and installation of radio systems in aircraft;

(iii) ARINC Characteristic 741 relates to the satellite earth stations for use in aircraft.

7.2.4 INMARSAT

Recently renamed, the International Mobile Satellite Organisation (INMARSAT) is an international organisation which operates satellites providing communications services to ships, land vehicles and aircraft. It began operation in 1982, and is owned and funded by telecommunications organisations (known as Signatories) from over 75 countries, which include 19 countries in Europe. The European membership is displayed in annex A.

Service providers, who are usually INMARSAT signatories, operate ground stations which link mobile users with public or private telephone and data networks. The INMARSAT signatories are usually national telecommunications authorities, but some are private companies, and others are government agencies.

INMARSAT operates through a constellation of eight geostationary satellites providing world-wide coverage in all parts except for the extreme polar regions. Latest satellite include an onboard navigation package, the Global Navigation Satellite System (GNSS), which may be used by aircraft in complement to the Global Positioning System (GPS) for more accurate positioning.

The technical definition of the system is contained in the INMARSAT System Definition Manual (SDM). This SDM is compatible with ARINC Characteristic 741 developed by the AEEC. The INMARSAT SDM is also compatible with the ICAO SARPS, and with RTCA DO-210 which has resulted from the very close collaboration between these organisations during the (parallel) development of standards for ground and for airborne equipment.

INMARSAT is currently the only provider of services via satellite to aircraft. This situation is expected to change with the emergence, in the USA and elsewhere, of alternative suppliers of satellite communications.

7.2.5 EUROCAE

The European Organisation for Civil Aviation Electronics (EUROCAE) was established in 1963 with the following aims:

- to advance the application of electronics to civil aviation including common civil/military applications;
- to work in Europe on an international level to study technical problems facing users and manufacturers of electronic equipment for aviation and all related questions;
- to advise and assist international bodies in the establishment of international standards;
- to study other appropriate technical or operational subjects as decided from time to time.

The membership which is voluntary is composed of representatives from major national civil aviation authorities, EUROCONTROL, electronic equipment, manufacturers, aircraft constructors and some trade associations. RTCA, IATA and SITA are corresponding members. About two thirds of the full members are from European Companies in the aerospace and electronics field. There are 6 non-European members from USA and Canada. Membership varies from some 40 to 60, but the number of airlines who originally supported the work have now declined to infrequent attendance's only.

Amongst other things, as a principal output, EUROCAE produces Minimum Performance Specification (MPS) and Minimum Operational Performance Specification (MOPS) for aircraft radio systems and equipment. The collaboration with RTCA in the USA is a very close and a prime objective of their work is to achieve a good harmonisation between USA and European requirements. Exceptionally they may incorporate requirements which are necessary for operation in the European air traffic environment. Normally these are not major in character.

EUROCAE Summary:

(i) EUROCAE is a voluntary European organisation with members from national aviation authorities, manufacturers, and airlines. A main task is the development of Minimum Performance Specification, harmonised as far as possible with the equivalent RTCA MPS developed in the USA.

(ii) EUROCAE MPS attract mandatory force through endorsement by the Joint Aviation Authority and EU Council Regulation 3922/91/EEC [9].

The Joint Aviation Authorities (JAA) accept EUROCAE Minimum Performance Specifications as meeting the European mandatory requirement for aircraft radio system (see list of JAA TSOs at annex I).

7.2.6 CEN

CEN is one of the three official Standardization bodies of the EU. It is a non-profit organisation formed under Belgian law, with the specific purpose of creating an open market place in Europe for products and services. It works in co-operation with the European Commission and the EFTA Secretariat to prepare a single set of harmonised Standards, removing national differences that could give rise to arbitrary technical barriers to trade.

In the course of its work, CEN accepts mandates from the European Commission and EFTA to develop standards in areas where the free movement of goods has to be guaranteed or where trade barriers are known to exist due to conflicting national requirements. In particular, CEN has carried out work in response to the following EC directives: active implantable medical devices, explosives, gas appliances, construction products, simple pressure vessels, safety of machinery, safety of toys etc. CEN has

265 active Technical Committees and published its 2 000th standard in May 1995, including some 700 mandated standards. CEN expects to publish over 700 standards in 1995, with 800 at the draft stage. A further 2 000 standards are at the public enquiry stage. In all, CEN produced over 2 055 publications in 1995.

Other work in the field of Information Technology has been carried out in co-operation with the other official standardization bodies CENELEC and ETSI. Particular collaboration with CENELEC has been carried out to promote standardization in Europe based on the Open Systems Interconnection (OSI) model developed by ISO to permit interconnection of information systems. Indeed, close co-operation and co-ordination occurs between CEN/CENELEC and ETSI to avoid duplication, contradiction or overlap of standards.

7.2.7 CENELEC

CENELEC is the European Committee for Electrotechnical standardization. CENELEC is one of the three official Standardization bodies of the European Union. CENELEC was formed in 1973 by the merger of earlier standardization bodies in the Electrotechnical field. It is a non-profit organisation formed under Belgian law, with the specific purpose of creating an open market place in Europe for electrical and electronic products and services. Its membership is drawn from the National Electrotechnical Committees of 18 West European countries. It has seven affiliated members from Central and Eastern Europe. It has also forged strong links with thirteen major European industry associations. It works in co-operation with the European Commission and the EFTA Secretariat to prepare a single set of harmonised Electrotechnical Standards, removing national differences that could give rise to arbitrary technical barriers to trade.

In the course of its work, CENELEC accepts mandates from the European Commission to develop standards in areas where the free movement of goods has to be guaranteed or where trade barriers are known to exist due to conflicting national requirements. Most notably, recent work has been carried out in response to the Low Voltage Directive, the EMC Directive, and Directives for explosive atmospheres, measuring instruments, electrical safety of machines, construction products, power engineering, railway equipment and signalling, broadcast receivers et al. Other work in the field of Information Technology has been carried out in co-operation with the other official standardization bodies CEN and ETSI. Collaboration with CEN has been carried out to promote standardization in Europe base on the Open Systems Interconnection (OSI) model developed by ISO to permit interconnection of information systems. In particular, CENELEC is an active member of ITAEG-Air, providing the Secretariat for this activity.

Close co-operation and co-ordination occurs between CEN/CENELEC and ETSI to avoid duplication, contradiction or overlap of standards. As the rate of technological progress continues to increase, steps have been taken to further streamline the standardization process. International co-operation also occurs with IEC. By the end of 1994, CENELEC had a total of 74 Technical Committees, with 239 Working Groups and 60 Task Forces. CENELEC produced 439 official standards in 1994 and published its 2000th standard in 1995. These standards are subjected to a full public enquiry process before publication in the European Journal.

7.2.8 ETSI

ETSI is the European Telecommunications Standards Institute. It is one of the three official standardization bodies of the EU. Located in the South of France, ETSI is an independent, self funding organisation with a membership approaching 400 organisations from 23 countries, representing leading European telecommunication interests. These include Manufacturers, Public Network Operators, Users, Research Bodies and Administrations. ETSI also has a growing Associate membership from outside of Europe.

In the course of its work, ETSI accepts mandates from the European Commission to develop standards in areas where the free movement of goods has to be guaranteed or where trade barriers are known to exist due to conflicting national requirements. In particular, ETSI has carried out standardization work in response to the EMC, TTE, and SES Directives. This work has also resulted in the development of Common Technical Regulations. ETSI has developed standards across the broad range of telecommunications including Cellular and wireless technologies, GSM, DECT, TETRA, HIPERLAN, TFTS and the new mobile services and technologies.

ETSI has 13 main Technical Committees, with over 62 active Sub Technical Committees and over 2 000 technical experts working on specific technical projects. For particularly complex or urgent

standards, ETSI may establish Project Teams of European experts to work full-time on the creation of draft standards, resulting in very rapid development (54 active in 1994). ETSI has published approximately 600 standards and interim standards, with over a 100 draft standards currently being developed. These standards are subject to a full public enquiry process before publication in the European Journal.

Other work in the field of Information Technology has been carried out in co-operation with the other official standardization bodies CEN and CENELEC. Indeed, close co-operation and co-ordination occurs between CEN/CENELEC and ETSI to avoid duplication, contradiction or overlap of standards. As the rate of technological progress continues to increase, steps have been taken to further streamline the standardization process. ETSI is a member of ITAEG-Air.

7.2.9 ITAEG-Air

ITAEG-Air was formed following a European Commission Mandate to the official European standardization bodies CEN/CENELEC/ETSI. Under Council Directive 93/65/EEC, relating to the definition and use of compatible specifications for the procurement in Europe of Air Traffic Management systems and equipment, the Commission may give standardization mandates to the European standardization bodies. Accordingly, mandate M/027 as issued to CEN/CENELEC/ETSI by the Commission, inviting these bodies to develop a programme of European standards complementary to EUROCONTROL standards.

ITAEG-Air (Information Technology Advisory Expert Group) was composed of experts from CEN/CENELEC/ETSI and other interested parties including EUROCONTROL, JAA, AECMA, EUROCAE etc. It held a series of meetings between November 1993 and May 1995, culminating in a report identifying a programme of standardization which was sent to the European Commission in July 1995. At the time of writing of this ETR, no definite response to the programme had been received from the EC. The prerogative for the management of any programme of standardization resulting from mandates received from the EC lies with CEN/CENELEC/ETSI. The programme identified by ITAEG-Air was substantial and included satellite telecommunications equipment. It is clear that some co-ordination will be necessary with ITAEG-Air or its successor - presuming a positive response from the EC to the proposals made by ITAEG-Air.

7.3 Organisations and bodies with a direct interest

7.3.1 International Air Transport Association (IATA)

The International Air Transport Association (IATA) with its headquarters in Montreal is the association of the worlds major airlines, and includes some USA airlines, although the latter are also members of the American Air-Transport Association (ATA) - a USA only association. IATA interests cover the total spectrum of airline operations, and it is particularly notable for its work in the field of agreements on air fares.

IATA take a strong interest in technical matters and maintain a permanent staff who follow world and regional events in technical matters concerning air transport operations. They participate as an observer at all ICAO, ITU, EUROCONTROL, RTCA, ARINC and other meetings - presenting the airline position and contributing generally to the development of policies and standards.

7.3.2 Association of European Airlines (AEA)

The Association of European Airlines (AEA), with its headquarters in Brussels, is an association of major European airlines (see annex A). The AEA provides the main European focus for scheduled airlines and represents their interests at the European meetings of the EC and other organisations, and with governments in this region.

The AEA tends to concentrate its efforts in the areas of airline performance, operating costs, route development and similar air transport matters, with a lesser emphasis on technical aspects. However the Technical and Operations Committee monitors closely airworthiness developments in general, and the functioning of the JAA. Most AEA members operate aircraft which will be involved in satellite communications for their longer range routes and will be affected by developments in the standards and certification of the aircraft systems.

The AEA as an association deeply concerned with the economics of air transport may be expected to take a keen interest in cost penalties which would be incurred through increased regulations.

7.3.3 International Air Carrier Association (IACA)

The International Air Carrier Association (IACA) represents the interests of the air charter companies and is active across the range of aviation, although not in the same depth or scope as IATA which represents the scheduled carriers. IACA has a number of European members.

7.3.4 European Association of Aerospace Industries (AECMA)

The European Association of Aerospace Industries (AECMA) was set up in 1950. Its objectives are to promote the development of the European Aerospace Industry by representing its interests in the area of standardization and regulations. The members are the national aerospace associations of nine countries: Belgium, France, Germany, Italy, Netherlands, Spain, Sweden, UK, plus the major aerospace companies. The industry employs some 350 000 people directly, and almost 1 million indirectly, with an annual turnover of more than 37 MECU.

AECMA produces a large number of common aerospace industry standards, and with the JAA the association plays an essential role in the production of the JARs for the certification of civil aircraft in Europe. These Standards are referenced in the series EN 2000 to EN 9999. During the year 1994, AECMA has published 254 standardization documents. A total of 51 standards were submitted to CEN for formal vote and 43 received ratification.

In 1990, AECMA created AECMA-CERT as an independent body for second party certification on the basis of ISO 9001 or ISO 9002 (EN 2000 and EN 3042). AECMA-CERT is seeking official recognition by JAA. It is co-operating with CENELEC/CECC certification and intends to co-operate with the USA PRI/NADAP (Performance Review Institute/ National Aerospace and Defence Contractors Accreditation Programme).

7.3.5 Satellite services providers

The following organisations are given as examples of satellite service providers to aircraft:

- Satellite Aircom:

  is a consortium offering satellite voice and data services to aircraft. The consortium is composed of France Telecom, IDB-M, Telstra, SITA and Teleglobe Canada. Satellite Aircom customers total more than 30 airlines and airframe manufacturers.

- Skyphone:

  is a consortium formed by British Telecom, Singapore Telecom and Telenor AS (the Norwegian PTT, which is also representing the PTTs of Denmark, Finland, Iceland and Sweden).

- Skyways Alliance:

  is a consortium composed of the Thai Comms Authority, COMSAT, INDOSAT of Indonesia, KDD of Japan, Korean Telecom, Philippines Telecom, Telecom Italia and Telecom Malaysia.

7.3.6 Satellite earth station equipment manufacturers

Two European companies are involved in the manufacturing of satellite equipment for aircraft. Racal Avionics, in association with Honeywell USA has provided a substantial proportion of the equipment presently fitted in aircraft. Dassault Electronique manufactures antenna systems which have been widely fitted in all modern types of aircraft. Both manufacturers offer equipment which meets RTCA DO-210 and ARINC 741.

8 Review of scope and interdependency of identified specifications

8.1 Introduction

Clause 7 identified the sources of all of the concerned specifications, or standards, prepared and agreed by various national and international bodies in the field of radio systems for aircraft. This subclause reviews that material in the context of establishing their scope, interdependency and their mandatory status. In this analysis no distinction is made between the fact that some are described as standards and others as specifications since in their preparation there has been no uniform interpretation of the meaning of those terms. The analysis addresses the situation in the context of the Aeronautical Earth Stations operating in the AMS(R)S and fitted in civil aircraft which are required to deal with both safety messages in conformity with RR 3630 of the Radio Regulations as well as public correspondence, with no differences except that of priority of treatment as required by RR 729A. Annexes J and K of this ETR show the main characteristics of these inter-relationships.

8.2 The role of ICAO

The prime focus in all aspects of radio systems used in civil aviation for air navigation and where there is a need for world-wide standardization or interface system parameters, is the International Civil Aviation Organisation (ICAO). The obligation stated in Article 37 of the ICAO Convention empowers and requires the development of suitable Standards, and imposes the obligation on all Member States to implement and adhere to their provisions. Annex 10 to the Convention therefore contains specifications for all systems in the circumstances where:

a) aviation safety demands international agreement and international uniformity to preserve and continue a sufficient level of safety for the airlines of all counties;

b) the facilitation of global operations is dependant on agreed and harmonised system parameters so that aircraft with approved standard equipment can operate world-wide as required by their route network;

c) the acceptance by all Members States of other members approvals for aircraft on their registry as an explicit obligation under Article 33 of the Convention.

ICAO Standards and Recommended Practices (SARPs)

ICAO SARPs address those system parameters necessary for air safety and are developed through specialist panels and working groups, followed by world wide discussion and agreement at ICAO Divisional meetings. Inclusion in Annex 10 requires the assent of a majority of member states, following a written consultative procedure. Specifications for new replacement systems must also include the transition and implementation timetables in sufficient detail to allow adequate amortisation of existing equipment, and an economic programme of refit. There is exceptional provision for urgent amendment action through an accelerated procedure where air safety may be at risk, or where the amendment is of a minor nature. The full process may take from six months for modifications to existing agreed systems, to many years where a new entry system is concerned.

The two levels of status: Standards and Recommended Practices (SRP), facilitate the process of establishing effective and workable agreements in which material still in process of evolution, or where temporary difficulty may be present, may be classified as a Recommendation, and later upgraded to Standard level. ICAO specifications normally address essential air-ground interface parameters, e.g. signal strengths in coverage areas, power output, frequency and tolerance, modulations, signal protocols, and service failure warnings etc.

The requirements of ITU Radio Regulations in respect of frequencies, tolerances, spurious levels will in all instances be observed and complied with. ICAO SARPs make no reference to test procedures or environmental requirements. The treatment of the ground element in co-operative air-ground systems is usually more comprehensive and detailed than that in the aircraft. This establishes a world-wide uniformity in the ground service provision, and assists countries with less well developed, or no, industrial resource to procure their ground systems and guarantee the service to a safe and acceptable level.

8.3 The role of RTCA of USA

In recognition of the specialised needs of aircraft equipment, informal consultative procedures have evolved to ensure that this equipment, whilst meeting the requirements laid down by ICAO, will also be reliable, compact and interchangeable between aircraft constructors and between radio manufacturers. Cost and weight are important factors, as is also reliability under the extremes of climatic conditions experienced by aircraft in flight, as is also the avoidance of the necessity for frequent, and costly, removal from service for maintenance purposes. The RTCA provides the machinery for these discussions. The forum is deliberately wide, with participation from regulators, manufacturers and airlines and others.

Documents output from this machinery, described as Minimum Performance Specifications, are initially voluntary and without mandatory authority. In the USA, where a considerable proportion of the aircraft and aircraft radio industry is situated, the RTCA is the main development machinery for this activity. This concentration in the USA is a direct consequence of their large home market for transport aircraft (in excess of 60% of world totals) and the co-location of a large proportion of the world's aviation manufacturing resources. At this stage of the evolution of the MPS, the involvement of EUROCAE, and other European interested parties, provides an input to contribute generally to the discussion, or to adapt the specification for the special conditions in Europe. USA airspace operations, whilst generally in line with other world regions, may not be representative of Europe or of areas similar to Europe.

The RTCA Document DO-210, published in 1992, is the present definitive document for the Minimum Operational Performance Standard for satellite communication equipment in aircraft, and is fully compatible with the ICAO SARPs. The document was developed and agreed by RTCA Special Committee 165, whose membership included: USA Agencies such as FAA and FCC, ARINC, USA Industry, airlines and INMARSAT, plus many representatives from European Civil Aviation Authorities, industry and airlines. The document has been amended on three occasions (including the present 1995 draft) reducing the levels of spurious emissions in the bands adjacent to the AMS(R)S allocations.

8.4 The role of FAA of USA

In the USA, the regulatory process is completed by the conversion of the RTCA MPS, with necessary amendments, into a mandatory Technical Standard Order which is published and implemented by the Federal Aviation Administration (FAA), a branch of the Department of Transportation. In general the FAA modifications are for clarification, and for institutional certification purposes. USA aircraft constructors in the manufacture and supply of fully equipped aircraft to world airlines receive their Certificate of Airworthiness (C of A), including the radio, from the FAA. The "C of A" is subsequently mutually transferred to the country in which the air carrier is situated. During periods of dry and wet leasing of aircraft (a very common activity) and sale to other airlines, this process will, over the life of the aircraft, result in the initial "C of A" being transferred through numerous aircraft operators and many countries. Many aircraft purchased by European airlines go through such a process.

It is anticipated that RTCA DO-210 MPS for the Aeronautical Mobile Satellite Service will receive FAA validation and be issued in Technical Standard Order (TSO) form to become the main mandatory instrument for airworthiness approval. It will then be necessary for the JAA and EUROCAE, to validate the MPS in the JAA TSO and EUROCAE ED series for European Airworthiness Approvals purposes.

8.5 The role of the Joint Aviation Authorities (JAA) of Europe

The JAA has a central role in the machinery of European Airworthiness Regulation. Under EU Council Regulation 3922/91/EEC [9], Joint Airworthiness Requirements (JARs) produced by the JAA are recognised as providing the common technical requirements for airworthiness purposes. The JAA Joint Technical Standards Orders (JTSOs) at annex F, invoke the appropriate RTCA MPSs and/or their equivalent EUROCAE documents, as the requirements necessary for aircraft radio certification.

The advent of the mandatory carriage of satellite communications for air traffic purposes, expected shortly for Pacific flights and later for North Atlantic flights, will entail the incorporation of RTCA DO-210 into the TSO scheme.

8.6 The role of the national aviation authorities

National airworthiness legislation remains a national prerogative and in the countries where the JAA has a mandate, the approval of aircraft radio, operates on the basis of the JAA accepted specification. European national aviation regulatory authorities normally publish their national requirement and a small number may supplement the JAA document and publish the amended version as their national MPS.

8.7 Non-ICAO systems

The procedure described above applies to those systems in aircraft which are backed by an ICAO agreed specification in ICAO Annex 10. Other systems carried by aircraft, often to meet mandatory safety requirements, such as airborne weather radar and radio altimeters, being self contained do not normally have a specification agreed under an international treaty. In these cases the performance specification is developed directly against the operational requirement itself and follows the same procedural sequence as described.

8.8 ARINC characteristics

The ARINC Characteristics are derived from the USA mandatory requirement by the Airline Electronic Engineering Committee (AEEC) as a standardization and procurement document for inter-changeability, and for in service operational purposes. Airline and aircraft constructors purchasing predominantly use the ARINC document in which the radio manufacturers have collaborated and equipment to its requirements is readily available. Other aircraft operators, particularly General Aviation, without the mandatory requirement to carry Class A equipment (for public transportation) will fit the aircraft with equipment conforming to the basic TSO, generally for a reduced environmental requirement in terms of min and max. temperatures, vibration etc.

The "form and fit" specification for the installation of satellite communications equipment in aircraft are those of ARINC Characteristic 741. It is a comprehensive document covering every aspect of the aircraft installation and particularly the physical characteristics of the units and their interconnection. For AES, there are usually three separate units (RF generation, Processing and HPA), with additional control, selection equipment and antenna. Compliance with ARINC 741 ensures that equipment is interchangeable between manufacturers, and between aircraft. Performance figures and other essential system characteristics are included to create a comprehensive document suitable for procurement action by airline, or aircraft manufacturer. ARINC 741 is an indispensable document for these purposes. It is not however backed by any mandatory instrument, and is not the specification for airworthiness type approval purposes.

8.9 Aircraft Earth Stations (AES) - the present situation

At the present time some 600 aircraft have been fitted with AES equipment for public correspondence traffic. A less stringent approval process has been applied (since the system is not required for air navigation) in which the important aspects are interference with other equipment on board, general physical safety, and other non safety related and minor requirements.

In respect of the specification for AES, the RTCA have finalised their Minimum Performance Specification DO-210. The Federal Aviation Administration is considering the question of the issue of a Technical Standard Order based on this document. The use of the AES for air navigation, soon to be implemented in the Pacific area, will result in the issue of a mandatory carriage instruction by the Pacific countries providing the air traffic services in the area and necessary approval to the requirements of the country, or regions, airworthiness requirements in the State of Registry of the aircraft. This necessarily will include those European countries whose airlines transit the Pacific. The Atlantic Ocean area is expected to follow within the next two or three years.

8.10 General aspects

The review above indicates the status, scope and interrelationship between the various specifications. The process described is the direct consequence and the implementation of Article 37 and 31 of the ICAO Convention and has worked satisfactorily for many years. A country, or group of countries, in their sovereign right, may demand the mandatory carriage of equipment and systems in their airspace which are not agreed within the ICAO. Such a process is rarely implemented and would only be practicable in the cases of operational justification on safety grounds but nevertheless does not offend any international agreements. The USA has, for example, demanded that aircraft using USA airspace carry special Collision Avoidance System (CAS) equipment after a certain date (to allow time for the re-equipment of USA and foreign aircraft). In such a situation the MPS would be nationally developed and implemented.

The above process represents the generality of ICAO based specifications and their translation into MPS and approval for aircraft components. The gestation period for new internationally agreed systems, such as MLS or any aeronautical satellite system which extend over some years, allows for parallel processing between the ICAO and the RTCA activity. This gradual evolution is beneficial and conductive to a more refined output. Nevertheless European sourcing of amendments, major or minor, to existing MPS is not precluded and precedents exist where a European initiative has driven, or significantly influenced the process.

8.11 Non-safety systems

AES which do not operate in the AMS(R)S bands and which provide public correspondence and which do not provide functions which support air traffic services are not required to meet full airworthiness requirements, but they must be approved for general safety (see annex D).

8.12 Summary

The above review traces the present process by which the international treaty obligations of the ICAO are processed through various organisations and machinery to emerge as the basis of the national regulation for radio in aircraft.

The process is characterised by the following:

(i) The basic standards for most systems are specified and laid down in ICAO Annex 10 [2]. These incorporate any requirement stated in ITU Radio Regulations and ITU-R Recommendations in regard to frequencies, tolerances, levels of unwanted emissions etc.;

(ii) The machinery for the development of MPS for aircraft radio is essentially informal, replacing the normal official consultation process by a process of internal discussion between all concerned and interested parties in the USA. The output is then subjected to the regulatory process through official administrative actions which may amend, supplant, or complement the agreed informal document, converting it in to a Technical Standard Order for mandatory application;

(iii) The process is presently dominated by USA interests and participants, as a direct consequence of the large home market (60 per cent of the worlds transport aircraft) and the concentration of the worlds aircraft manufacturing, and aircraft radio manufacturing resource in that country. European influence can be applied but is unlikely to force through any measures which does not meet the acceptance of the major USA interests;

(iv) The majority of the aircraft purchased from USA, or European aircraft manufacturers are delivered complete with radio, sometimes to the specific preference of the airline, but always with a full Certificate of Airworthiness which is automatically accepted by the country of delivery (if necessary under a written bilateral agreement) and placed on their register of aircraft;

(v) The type approval method employed in the USA, and in the few instances where a European manufacturing source is the applicant, is by self certification against laid down performance limits. Independent testing by third parties is not mandatory;

(vi) Joint Technical Standards Orders (JTSO) approved by the JAA are intended to have mandatory force in EU Member States under Council Regulation 3922/91/EEC [9]. At present these do not include Aircraft Earth Stations for use in satellite communications;

(vii) No specification, or testing of AES to any other EC Directive is presently applied in the approval and certification processes;

(viii) At the present time RTCA DO-210 is the RTCA finalised Minimum Performance Specification for these systems, and is fully compatible with ICAO Standards. The USA Federal Aviation Administration is currently reviewing this material with a view to the issue of a mandatory Technical Standards Order (TSO). A European JAA TSO would follow;

(ix) ARINC Specification 741 is the airline procurement document for AES and has no mandatory significance, other than that it is compatible with ICAO SARPS and RTCA DO-210;

(x) The INMARSAT Systems Definition Manual (SDM) is concerned with system operation and has no role in the type approval of airborne equipment for the purposes of meeting airworthiness safety requirements;

(xi) Non safety systems are permitted to be installed on the basis of "no hazard" to the operation of the aircraft and other aircraft (safety) systems. There is no mandatory airworthiness requirement to prove satisfactory operation.

An overview of aeronautical satellite communications from a European operational perspective, and a review of the processes of aircraft airworthiness are at annexes B, C and D.

9 Requirements of the radio regulatory authorities

9.1 Regulation of the RF spectrum

The regulation of the management and use of the Radio Frequency (RF) spectrum is one of the most important aspects of the control and use of radio frequencies for radio transmission and reception. Nationally, it is exercised by national telecommunications authorities through a variety of institutional mechanisms depending on the internal workings of the country concerned, and is finally controlled through the terms of the radio license allied to the equipment system performance in terms of the occupied bandwidth, and the out of band unwanted emissions.

Observance of the license terms and the detection and clearance of harmful interference to other users is the follow-on function consequential to the license issue and is normally exercised by the same authority who usually has the power of closure, or in extreme cases the removal of license and possible confiscation of equipment. The responsibilities of the Telecommunications authority embody both a national and an international duty to preserve spectrum use.

9.2 ITU Radio Regulations

The international obligations arise through the ITU Radio Regulations which contain in Article S.5.IV the Frequency Allocation Table to Radio Services. A radio service must as a necessary condition use a frequency allocated to the service in that country. This is the normal situation, although exceptionally temporary Non Interference Basis (NIB) assignments may be made. The ITU Radio Regulations also contain limits for spurious emissions, which are generally a compromise between the services within all of the bands included. In particular, Radio Regulations S.18.1 and S.18.6 requires an aircraft to hold a radio license containing certain details and S.42.2 requires administrations to take all practicable steps to ensure that mobile and mobile earth stations does not cause harmful interference to essential radio services. These obligations must be taken very seriously in an intensely populated advanced area such as Europe with many separate administrations.

9.3 Licensing of aeronautical radio communications

With regard to aircraft, Article 30 of the ICAO Convention recognises the necessity that a "license to install such (radio) apparatus has been issued by the appropriate authorities of the State in which the aircraft is registered." The common practice of wet or dry lease of aircraft is covered by Radio Regulation S.18.11 which permits mutual recognition of the license issued by the State of Registry. As a separate matter, Article 31 of the ICAO Convention requires a Certificate of Airworthiness ("C of A") for the aircraft. The international licensing and certification requirement, from which the national requirements flows, is a joint matter in which the two separate requirements must be met with firstly the "C of A" to allow the aircraft to fly, and secondly the radio license to allow transmission. A third requirement for crew competence, again in the two areas, is also required but does not impact upon this work.

9.4 National radio regulation

National regulatory authorities in their exercise of the important control function to ensure freedom without harmful interference normally publish specifications prescribing the unwanted emission levels for particular equipment with which compliance is a precondition for issue of license. European agreed specifications within the ETSI framework also exist for many.

9.5 Aeronautical radio regulatory requirements

An outline of the radio regulatory requirements for aircraft radio equipment in general has been given, which applies equally to the Aircraft Earth Station (AES). The process is characterised by the following:

(i) International obligations under the ITU Convention must be met. The ICAO Convention also recognises the necessity for a radio license for all aircraft issued by the appropriate national authority for all aircraft;

(ii) National regulations must be laid down to ensure that the frequency and conditions of operation are in accordance with the ITU Radio Regulations as supplemented by national or European agreements, and with the need to protect other users, both national and extra-national;

(iii) At present aircraft radio equipment specification and approval is often carried out completely within aviation circles and then vetted by the radio regulatory authority for observance of spectrum requirements. The radio license remains, however, the responsibility of the radio regulatory authority.

10 Legal necessity for an ETS for aircraft earth stations

10.1 Introduction

To promote competition in the market place and the free movement of equipment, goods and services, the European Union has developed a body of EU Regulations and Directives to Member States. This is partially in response to the existing laws of individual Member States, where National legislation may have the effect of creating barriers to trade between Member States and obstacles to competition in the market.

Many of the areas where market restrictions have traditionally been heaviest, are where State monopolies exist or existed. Such monopolies were able to use legislation to protect their position. Over the years, the EU has worked steadily to open up these markets and to remove such artificial barriers to trade. Indeed, many of the monopolies have moved into the private sector, creating quite difficult problems of unfair competition. Equally, the great mass of differing State legislation has proved difficult to untangle - in that much of the purpose of regulation in the first instance has been lost in the mists of time. Replacing it with more relevant and appropriate legislation, is a slow and time consuming process.

Telecommunications and Civil Aviation are two examples of different fields, where State monopolies dominated and where substantial protective State legislation exists. In both areas, the need for these special protective measures were seen by States as essential. However, these measures varied significantly from State to State (although they often had the same intention), so creating barriers, dividing the market and inhibiting competition. In an effort to remove these arbitrary barriers, the European Commission has developed a progressive process of harmonisation, culminating where necessary in Council Regulations, Directives, Council Decisions, Recommendations, Common Technical Regulations (CTRs) and European Standards.

10.2 Key EU legislation

The following is a brief overview of existing legislation that is significant in this field. It is necessarily concise, giving only those aspects essential to this report. A table of relevant EU legislation is given at annex E, from which the following represents a summary of those that are most significant for this report. The reader is advised to consult the original text of these documents to gain a more detailed understanding.

10.2.1 Provision of information in IT (83/189/EEC, 88/182/EEC)

Council Directive on "Procedure for the Provision of Information in the Field of Technical Standards and Regulations (83/189/EEC, 88/182/EEC)" lays down the procedure for the notification by States of National Standards to the European Commission and the European Standards Institutions. It also provides a mechanism by which those Standards Institutions may become involved in the development of a Standard by another party, or in the development of a European Standard. It requires Member States to notify the European Commission of new standards and gives the Commission the power to take action if there is a risk of barriers being created, including the power to request the European standardization bodies to develop a European standard within a given time limit.

This Council Directive is a fundamental piece of enabling legislation in the field of Standardization and is used as the basis for developing an open market between Member States, by the removal of technical barriers to trade caused by individual State's technical regulations. It also recognises the way in which Technical Standards may be used as barriers to trade.

10.2.2 TTE Directive (91/263/EEC)

Council Directive on "Approximation of the Laws of the Member States concerning Telecommunications Terminal Equipment (91/263/EEC)" states those requirements that must be met, before telecommunications terminal equipment may be placed on the market with the purpose of connection to the public telecommunications network. It requires Member States to take all necessary steps to ensure that such equipment is placed on the market only if it complies with this Directive, is properly installed and maintained and used for its intended purpose. EC Type Examination is effectively required in many cases. Member States must ensure the disconnection from the public telecommunications network, if equipment does not comply with this Directive or is not used for its intended purpose.

The scope of the Directive is wide, telecommunications terminal equipment meaning any equipment intended to be directly or indirectly connected to or inter-working with the public network, including radio-communications equipment. Thus equipment fitted on aircraft, such as TFTS, is included. The Directive was clearly originally drawn up with the objective of protecting the public telecommunications network. However, it is unclear what threats such equipment may pose to a public network, that should require such strong legal protective measures. Additionally, there is little (intra-community) cross-border trade, at the present time, in such equipment (e.g. telephone handsets) - largely because the network connection requirements vary considerably from State to State. Indeed, a high percentage of terminal equipment is imported into the EU.

It now appears that the European Commission is planning a considerable revision of the TTE Directive, moving toward a less stringent regulatory regime by conformity assessment. Essentially, permitting self certification by manufacturers with appropriate market surveillance. Accordingly, DG III and DG XIII have developed position papers on the subject [12] [13] and are intending to make proposals in 1996 for a revised Directive. These proposals will include similar actions on the closely related Satellite Earth Station Directive.

10.2.3 SES Directive (93/97/EEC)

Council Directive on "Supplementing Directive 91/263/EEC in respect of Satellite Earth Station Equipment (93/97/EEC)" [23] is specific to satellite earth station equipment to enable the mutual recognition of their conformity and to permit their free circulation in the EU. A Satellite Earth Station (SES) is generally defined in order to allow for technical development, covering any equipment intended for transmission and or reception of radio-communications with a satellite (or other space based system). The Directive excludes purpose built satellite earth stations intended as part of the public terrestrial telecommunications network. Due to the generality of the definitions and the references to public telecommunications networks, the scope of the Directive appears to include Aircraft Earth Stations.

The SES Directive [23] requires manufacturers to comply with similar requirements as laid down in the TTE Directive 91/263/EEC [20] and also places similar obligations on Member States to ensure compliance and take enforcement action in the case of non-compliance. Paragraph 3 of Article 4 of the Directive, requires the "avoidance of harmful interference between space based and terrestrial communications systems and other technical systems". This is in addition to the requirement in the TTE Directive [20] for the "effective use of the radio frequency spectrum".

These requirements lead to the necessity for Common Technical Regulations (for safety of persons, spectrum use, EMC and inter-working with public telecommunications network) derived from harmonised standards and effectively, to the EC Type examination of such equipment in many cases. These requirements would be in addition to any made for the airworthiness certification of such equipment (which are concerned with aspects related to the safety of aircraft). The Directive also requires that Member States notify the European Commission of those bodies designated for the purpose of certification, product checks and surveillance.

The Directive also recognises the problem of access by the third country markets such as the USA and Japan, stating that these must be dealt with in the GATT negotiations. It also recognises the need for transitional arrangements to be set out in common technical regulations, to allow manufacturers the time to adapt the design and production of satellite earth station equipment to meet the requirements of the Directive - on a case by case basis.

10.2.4 EMC Directive (89/336/EEC)

Council Directive on "Approximation of the Laws of the Member States Relating to Electromagnetic Compatibility (89/336/EEC, as amended)" sets out to harmonise national legislation of the Member States on electromagnetic compatibility. It covers almost all electrical and electronic equipment or equipment using the heating effect of radio waves for industrial or medical purposes. It requires that such equipment shall not cause interference to radio and telecommunications apparatus and shall have adequate intrinsic immunity from such interference. The Directive has been amended to allow for a transition period, but comes into full effect on the 1st. January 1996. Following this date, all equipment must comply with the Directive and bear an EC mark of conformity. The manufacturer (or agent in the EU) must declare conformity.

Member States are required to take the appropriate action to ensure that only products that comply with this Directive are placed on the market or taken into service when installed, maintained and used for the purpose it was intended. Conformity is achieved by compliance to the relevant European Standard (Product Standard or Generic Standard if not available) or by constructing a Technical File, if no appropriate standard exists or if the equipment is unable to fully comply with a Standard. There appears to be a conflict of applicability between this Directive and Council Regulation 3922/91/EEC [9].

10.2.5 Airworthiness regulation (3922/91/EEC)

Council Regulation on "Harmonisation of Technical Requirements and Administrative Procedures in the Field of Civil Aviation (3922/91/EEC)" sets out the technical requirements and administrative procedures to be applied to aircraft and aircraft products to ensure their free movement in the market. A Council Regulation is directly binding on Member States. In particular, it adopts the Joint Aviation Requirements (JARs) developed by the Joint Aviation Authorities (JAA) and which are listed in the Annex to the Council Regulation. These requirements cover the design, manufacture, operation and maintenance of aircraft and the persons and organisations involved in those tasks. The JARs referred to in the Annex to the Council Regulation represent a very significant body of technical requirements. Some JARs are still under development and are to be notified to the Commission for inclusion in the Council Regulation when they are complete.

The Council Regulation makes provision for the mutual recognition and free movement of products certified in accordance with the Council Regulation. The scope of the Council Regulation appears to be restricted to aspects concerned directly with the safety of aircraft and their operation. Its purpose is to remove those technical barriers, created between Member States, due to differing technical requirements. An important distinction is therefore effectively made between the scope of this Council Regulation (covering the safety of aircraft) and other EU legislation such as the TTE Directive, which may also apply (e.g. to cover aspects related to the inter-working with the public telecommunications network).

Currently, it seems that Member States (or more correctly National Aviation Authorities) and the JAA believe that this Council Regulation is not presently legally effective as, apart from JAR 145 (for the maintenance of aircraft), none of the JAR codes have been translated into the 11 "official languages". Other complications arise from the JAA Arrangements, which seem to recognise different classes of State membership of the JAA - effectively requiring some States to comply fully with the JARs whilst others may not have to comply or may not be able to comply.

Interestingly, attempts have been made to exclude aviation products from the EMC Directive, on the basis that Council Regulation 3922/91/EEC [9] applies (or more particularly that the JARs referred to in the Annexes to the Regulation apply) and is more specific than the EMC Directive. However, the EMC Directive is concerned with apparatus "placed on the market" (i.e. offered for sale), whilst Council Regulation 3922/91/EEC [9], as implemented by the JARs, is only concerned with equipment actually installed in aircraft.

Furthermore, the Airworthiness Type Certification of a product is only given following an application to fit the equipment to a particular aircraft. The certificate is then limited to that equipment and the particular modifications made to it for the particular class of aircraft. Thus a "once and for all" type approval (or indeed self declaration) for EMC aspects, is not given for aircraft equipment. It is therefore, unclear whether 3922/91/EEC [9] would guarantee the free movement of equipment in the market, given the above and the reservations of the National Aviation Authorities on the implementation of this Council Regulation. Some legal clarification seems necessary.

10.2.6 ATM Directive (93/65/EEC)

Council Directive on "Definition and use of Compatible Technical Specifications for the Procurement of Air Traffic Management Equipment and Systems (93/65/EEC)" is intended to hasten the harmonisation process in Europe in the field of Air Traffic Management (ATM), to enable competition and the free movement of ATM equipment. In particular, the Directive allows the Commission to adopt "EUROCONTROL Standards" and technical specifications into Community law, making them mandatory on Member States. An initial list of EUROCONTROL standards is given in the Annex to the Directive. The scope of the Directive appears to be confined to aspects that relate directly to the safety of air traffic.

EUROCONTROL standards are in practice, technical specifications (rather than "Standards" - a term which has a special meaning) and contain a mixture of functional, operational and inter-operability requirements, recommendations and guidance material. The technical areas covered by EUROCONTROL standards include communications systems, surveillance systems, automated assistance to ATC and navigation systems. The Directive permits the European Commission to issue standardization mandates to the official standardization bodies to develop standards complementary to the EUROCONTROL standards.

Although aircraft products are not explicitly mentioned, it is clear that this Directive would cover inter-operability of air/ground systems where they are necessary for the safety of Air Traffic Management (ATM). In practice this would therefore include appropriate aspects of aircraft systems that interact or communicate with, or depend upon ground systems associated with air traffic management. In practice EUROCONTROL specifications would not specify, for example, spectrum performance. However, this Directive clearly permits the European Commission to issue standardization mandates for the development of complementary standards for airborne equipment used for air traffic management purposes.

10.2.7 International treaty obligations

In addition to EU Legislation, the EU States are bound by various International Treaties and Conventions (see annex A). These include, for example, the ICAO Convention, the ITU Convention, the JAA Arrangements and the EUROCONTROL Convention (with the exceptions of Italy and Spain, who are not presently members of EUROCONTROL). The ICAO and ITU Conventions are prime international treaties with world-wide membership, which demand compliance from signatories to their standards and regulations. Conflict between world-wide provisions and a European rule, regulation or standard should be avoided whenever possible. Curiously, whilst most EU legislation is unlikely to conflict with the Articles and Annexes of the ICAO and ITU Conventions, there is scope for conflict between the JAA Arrangements, the EUROCONTROL Convention and EU legislation.

The JAA itself, does not have legal authority over the JAA Member States. Indeed, not all the members of the JAA have equal status, neither are they bound by the same requirements, obligations or privileges. JAA standards are not subject to open public enquiry processes. Mutual recognition of products and services is not guaranteed under the JAA Arrangements for all its members (JAA membership approximates to EU + EFTA). Furthermore, the JAA has no legal power to act on behalf of all its members, say, in signing International Mutual Recognition Agreements. Such agreements can only be bilateral i.e. between individual States.

EUROCONTROL Standards are implicitly obligatory on Member States, but no effective enforcement mechanism yet exists. EUROCONTROL standards are not subject to open public enquiry processes and are developed within closed groups chaired by EUROCONTROL personnel. Such "standards" may have significant market impact and may include a variety of operational and functional requirements, technical specifications as well as policy and guidance material. When adopted by the EU, their mandatory nature has the potential to introduce further significant differences between various technical regulations, that will require additional interpretation and resolution by the relevant legal authorities.

10.3 Future developments

The European Commission have undertaken to publish a White paper on Air Traffic Management. This paper is likely to make provisions towards an ATC Authority for Europe and for a separate Safety Regulatory body. The indications are that this paper will also emphasise the need to make Standards available early and to utilise the services of the Official Standards Bodies, in order to speed up the process of harmonisation and integration of national Air Traffic Management Systems. For this to be effective, closer alignment will be necessary for the respective standardization and certification processes and much closer co-operation will be necessary between the official bodies than is presently the case. In particular, the applicability of various legislation will require resolution in order to avoid confusion, conflicts, overlapping and duplication.

It is likely that an agreement on co-operation between EUROCONTROL and the JAA will be drawn up in the near future. Such an agreement is likely to address the need for co-operation and co-ordination on the development of Safety Regulatory and Air Traffic Services regulations and their mutual compatibility. This may effectively lead to a simple division of responsibility and authority between the air and the ground aspects and mutual agreement on air/ground compatibility issues.

10.4 Summary

Examination of above EU legislation indicates that all apply to Aircraft Earth Stations to some degree. In essence, the SES Directive (for Satcomm) and TTE Directive (e.g. TFTS) are both directly applicable for aspects including the effective use of the radio frequency spectrum. Arising from these Directives is the need for CTRs for the safety of persons, spectrum use, EMC and inter-working with public telecommunications network. The EMC directive requires that apparatus shall not cause interference to radio and telecommunications apparatus and shall have adequate intrinsic immunity from such interference.

EU Council Regulation 3922/91/EEC [9] covers aspects concerned directly with the safety of aircraft and their operation. The ATM Directive covers aspects including the inter-operability of air/ground systems, where they are necessary for the safety of Air Traffic Management and the further integration of European Air Traffic Management Systems.

The requirements that arise from these Directives are not in conflict, but rather are complementary. It should come as no surprise that such a significant body of legislation applies to Aircraft Earth Stations, given the nature of the equipment, the need to ensure the safety of aircraft and to provide adequate protection for the radio spectrum. Rather, it points to the need for proper co-ordination and co-operation between those bodies responsible for setting Standards, those responsible for the certification of apparatus and those responsible for approving its purpose and its operation. It is clear that there is some scope for rationalising both Standards development processes and the processes of Certification. It is also clear that relatively little active co-operation presently exists between those parties that have legitimate but different interests in this area. The most obvious candidate to resolve this problem is the successor committee to ITAEG-Air, tasked with developing Standards in the Air Traffic domain.

11 Relevance of existing specifications for regulatory type approval

Existing specifications for AES were constructed for the purposes of interpreting ICAO SARPS (in the AMS(R)S) into Minimum Operational Performance Standards and as a practical means of demonstrating compliance to airworthiness safety-regulatory requirements. In Europe this means compliance to EU Council Regulation 3922/91/EEC [9] and the JAR TSOs referred to in the Annex to the Council Regulation. They were not constructed in order to provide a means of compliance with other EU legislation such as the EMC, TTE or SES Directives.

Much of the detailed technical specifications contained in documents such as RTCA DO-210 relates more to inter-operability with aircraft, satellite and ground systems. However, many of the parameters contained in DO-210 (such as frequency stability, intermodulation and adjacent channel rejection etc.) are satisfactory for the purposes of Radio-Regulatory type approval. Other aspects such as EMC may be more difficult to address, given the often unique environment that a particular piece of equipment may find itself in, when installed in a particular aircraft. Indeed, many EMC problems have to be resolved at installation by careful individual engineering design. Generic standards for various EMC aspects are contained within another RTCA document (DO-160C) or its EUROCAE equivalent (ED-14C) which is widely referred to in JAA JTSOs.

Therefore, at the very least, additional consideration may be necessary to take into account these other aspects for which the EMC, TTE and SES Directives were developed, such as effective use of the spectrum, avoidance of harmful interference and inter-working with the public network. Spectrum performance parameters given in RTCA DO-210 could be used for the preparation of standards for Radio-Regulatory type approval, combined with elements contained in DO-160C covering EMC aspects.

12 Technical requirements not covered by specifications

12.1 Technical requirements of EU legislation

Clause 10 of this report has examined the legal necessity for an AES ETS. This clause analyses the technical requirements and compares these in a general way with existing AES specifications.

12.1.1 Airworthiness regulation (3922/91/EEC)

The provisions of 3922/91/EEC [9] are obligatory and address the harmonisation of technical requirements and administrative procedures in civil aviation. At the present it confines attention exclusively to airworthiness matters. Annex 2 to the Regulation lists the JAR TSOs of the JAA for type certification purposes. The list of TSOs (annex I of this report) does not presently contain a specification for AES. The status of CR 3922/91/EEC [9] with respect to the other Directives relating to telecommunications (as below) is presently under review with the possibility that the decisions will release aircraft equipment from their requirements. However, it is a reasonable assumption that a JAA TSO for AES would, by normative reference validate the RTCA DO-210 MPS which is the present MPS and de-facto standard for manufacture and testing. The analysis below is based on that assumption.

12.1.2 EMC Directive (89/336/EEC)

This Directive addresses harmonised standards for EMC, and designates CENELEC as the competent body to administer the processes. The Directive covers radio and also other apparatus and has two objectives, one to promote cross-border trade by a removal of barriers, and two to protect radio services from interference. EMC is defined as the ability to function in an environment without introducing intolerable electromagnetic disturbances to anything in that environment. In addition to not causing electromagnetic disturbance the equipment must also have an adequate intrinsic immunity capability. Certification with appropriate marking is a laid down requirement.

EUROCAE document ED-14C (identical with RTCA DO-160C), contains a list of environmental standardized conditions (including vibration, dust, moisture and EMC) and test procedures to be used for performance validation of airborne equipment according to their environmental categories. As a consequence of the CENELEC/EUROCAE agreement of 1994, this document has been put forward as the basis for approval against the EMC Directive. Its status as a means of compliance to the EMC Directive is presently uncertain. It has not been submitted to public enquiry processes, nor published in the European Journal. Considerable confusion still remains regarding the Standards to be applied, certification and marking of aeronautical products.

12.1.3 SES Directive (93/97/EEC)

This Directive applies to Satellite Earth Stations which include AES and invokes the applicability of the TTE (see CD 91/263/EEC) and EMC (see CD 89/336/EEC) Directives for SES [23]. In addition to the usual emphasis for removal of barriers to trade, this CD contains three important requirements: for EMC, for effective use of spectrum, and for the avoidance of interference. Conformity assessment either by examination, or by declaration, is allowed. CEN/CENELEC/ETSI are nominated as the bodies concerned with technical standards.

12.1.4 TTE Directive (91/263/EEC)

This Directive sets out the requirements for telecommunications equipment and AES are assumed to be within its terms. Article 4 states the seven objectives of which two are relevant, i.e. EMC and effective use of spectrum. Equipment may be subject to EC type examination, or by declaration of conformity. Notified bodies and test laboratories must be advised to the EC and marking is a requirement. An approvals Committee (ACTE) is set up to assist the Commission.

12.1.5 ATM Directive (93/65/EEC)

The Air Traffic Management (ATM) Directive (93/65/EEC) applies to the definition and use of compatible technical specifications for air traffic management equipment and systems. Article 1 makes reference, inter-alia, to communications systems, of which AES operating in the AMS(R)S could be construed as loosely coming within. The Directive appoints EUROCONTROL as a consultative body advising the Commission on mandates. Standards produced by EUROCONTROL normally receive approval by the Commission as European standards. The Directive makes no reference to conformance requirements.

12.2 Analysis of EU legislation in aviation

CR 3922/91/EEC [9] and CD 93/65/EEC are both directed at harmonisation, the first for air safety and uniform standards, and the second to promote the harmonisation and integration of the separate national air traffic systems in Europe, believed to be one cause of air traffic delay and congestion. There is only slight mention of the removal of barriers to cross-border trade. Both make reference to the existence and need to observe standards, and both designate an existing specialist body to oversee and assist the Commission, i.e. the JAA for the first, and EUROCONTROL for the second. The adoption by the JAA of a JTSO for AES, by normative reference or other means, would automatically meet all the requirements of CR 3922/91/EEC [9], and in the absence of an objection from EUROCONTROL (perhaps an unlikely event) the spirit of CD 93/65/EEC also.

12.3 Analysis of SES, TTE and EMC Directives

Effective use of the radio frequency spectrum appears in two of these. This can be difficult to demonstrate without a statement of criteria. ETSI Technical Report ETR 169 [19] studied this and suggested parameters such as the number of analogue voice channels per 100 kHz, or satellite spacing and frequency re-use. The latter widens the field into orbit utilisation and frequency co-ordination criteria developed and employed in ITU procedures.

A full evaluation of spectrum efficiency should necessarily include total system requirement and implementation which is not possible by addressing only the mobile element. Comparison with services of similar type is helpful but cannot be conclusive since operational requirements (which often are dominant parameters) create important differences. For example in the aeronautical service, Doppler shift is important, as is also the ability to perform at ambient temperatures of minus 30 to plus 70 degrees, and at vibration levels not normally experienced in other mobile satellite services. The very high system availability and integrity required in the AMS(R)S, considerably more stringent than other mobile services, will probably have to be achieved by a trade-off with other system parameters. Nevertheless a comparison may be useful as a broad indication, provided the conclusions are interpreted with care. Such a procedure is consistent with the discussion in ETR 169 [19].

Article 4 of the SES Directive addresses EMC which has the two separate components of emission products, and secondly immunity from out of band interference. The definition of EMC at Article (4) of 89/336/EEC emphasises the conflicting nature of these two points. The first requirement is that the equipment must "function satisfactorily" and do so without "introducing intolerable electromagnetic disturbances to anything in the environment." This is quite vague prescription to meet and is capable of many interpretations. Article 4(a) provides the qualification that the apparatus shall be so constructed that "the electromagnetic disturbance it generates does not exceed a level allowing radio and telecommunications equipment and other apparatus to operate as intended". The definition of apparatus appears to exclude radio which appears to accord it priority over other systems employing radio waves for industrial or other purposes.

Article 6(b) permits special measures for receiving or transmitting stations used for safety purposes, which could apply in the case of AES operating for air traffic purposes. Article 7 pre-supposes the existence of standards as the practical implementation provisions. The SES Directive 93/97/EEC clearly expresses in ‘Whereas 8’ the applicability of the EMC Directive to SES.

In the case of AES, EMC has the separate facets of (i) the aircraft environment itself and (ii) the general radio environment. The aircraft environment has two dimensions, those of installation and of specification. The first is design dependant and calls for considerable skill from the aircraft designer to place all of the up to 27 antenna operating in a possible maximum of 18 separate frequency bands in positions which minimise interactions whilst still giving appropriate priority to critical navigation systems. This is in the area of acquired skills and is completely outside the scope of legislation. Specifications, and primarily levels of unwanted emissions, are pertinent to both (i) and (ii) above. Levels quoted in specifications tend to be arrived at from considerations of their practical realisation at realistic cost without impairment of performance. Like systems should however have similar capabilities, hence comparison could be a justifiable indicator of achievable levels.

Immunity is an intrinsic feature of system design, and is a complex subject raising issues of acceptable interference, which itself is application related. For example, the loss of a few bits in a telephone conversation due to interference has less potential for disastrous consequences than in an air traffic message to an aircraft in Europe's crowded airspace giving it clearance for descent. Furthermore, immunity can often be improved by accepting reduced performance, or by system sophistication requiring greater bandwidth, which again is very requirement specific, calling for expert judgement on acceptability. Overall, in AES terms, immunity is a difficult parameter to assess and quantify and must remain as an unknown in terms of meeting the EMC requirements in these Directives.

12.4 Protection of the radio astronomy service

The RAS service is the most vulnerable, and the most difficult of any to protect from aircraft transmissions, of any other radio service in the ITU Table of Allocations. The Radio Astronomy band at 1 660 to 1 660,5 MHz is 4 MHz from the band edge for the AMS(R)S aircraft to satellite transmissions, and the RA band at 1 610,6 to 1 613,8 MHz is separated by some 34 MHz from the lower band edge (and by much less from the MSS allocation at 1 610 to 1 626,5 MHz which could be used by light aircraft at low levels). Control measures such as employed in other MES are not possible for air safety services. Hull shielding, and upward directed antenna, assist in providing attenuation, which together with minimum possible spurious levels is the extent of practical measures. Predictions of satellite use for air traffic purposes (such as in annex B), if accurate, will help to minimise the interactions.

In ITU Radio Regulation, the commitment to protect the RA service is not an absolute one (as with some other services) in the realisation that this would require impractical levels, although RR S29.12 identifies the aeronautical service as a particular case for care. A very full treatment of this subject is given in ERO Report 26, which indicates that required separation distances for out-of band products for MES must not exceed - 129 dBW / 4 kHz at 1 km which is not a practical suppression limit. The conclusion which emerges is that specifications for AES, particularly for operation in MSS bands close to RAS allocations must pay particular attention to spurious levels.

12.5 RTCA MOPS for Aeronautical Mobile Satellite Services (AMSS)

Document DO-210 is in two parts:

Part A) Purpose, Scope and Equipment Performance Requirements

Included are RF performance requirements for:

(i) Transmitter: output power stability, harmonics, spurious and noise, intermodulation, frequency stability, signal spectrum, Doppler correction plus other parameters;

(ii) Receiver: spurious response, adjacent channel rejection, intermodulation distortion plus other parameters.

Part B) Equipment verification procedures and installed operational characteristics

Part B also includes comprehensive measurement procedures for type approval or other purposes.

DO-210 is compliant with ICAO SARPS and is organised in a pattern suitable for adoption for regulatory purposes. The three changes (including the present draft) to this document, which have been made since the 1992 publication have addressed, amongst other parameters, the levels of spurious emissions. A statement of these values appears at annex I.

12.6 Comparison of AES specifications with other MES

When interpreted with care a comparison of this kind can yield useful information. Annex I has been prepared and the following observations can be made:

- several differences of significance in content, are apparent between the aeronautical specifications and the quoted ETS. The former have been developed to specify system functioning, including as necessary the classical protective elements emanating primarily from ITU practices. ETS deal only with spectrum "hygiene" parameters, and additionally include protective measures for the Radio Astronomy Service. Third party conformance testing and public consultation are obligations under EU legislation, which would not normally appear in a world-wide aviation specification;

- compliance with the EMC, TTE, and SES Directives, in the terms of the comparison above, appears not to be confirmed absolutely, although technically the two specific aeronautical specifications could be judged satisfactory if the spurious limits were examined against equivalent requirements.

12.7 Summary

The conclusions which emerge from this analysis of the specific EU legislation in the context of AES specifications for the AMS(R)S are:

a) Compliance with the aviation legislation in CR 3922/91/EEC [9] and CD 65/93/EEC is assured by virtue of the agreement under airworthiness and JAA rules to use RTCA and EUROCAE MPS;

b) In the context of AES compliance with the SES, EMC, and TTE Directives, these are principally concerned with three aspects of performance viz. effective use of spectrum, unwanted emission levels, and EMC;

c) Effective use of the spectrum is a subjective conclusion following the analysis of the total system design against the operational requirement. Aeronautical services have features not present in many other services which must be taken into account. Confirmation of compliance is not possible without such examination;

d) Unwanted emissions in aeronautical specifications have high importance due to their interference potential, which warrant particular attention;

e) Receiver immunity is an intrinsic system design feature which depends on system characteristics and receiver design. Specifying immunity is only realistic against particular interfering signals, although generalised parameters such as adjacent frequency rejection and intermodulation performance must be included as a minimum. Study in conjunction with effective use is outside the scope of this survey;

f) It is clearly necessary that steps are taken to adequately address the protection of the Radio Astronomy Service. Present aeronautical specifications do not contain specific provisions for RAS protection.

g) Comparison with similar specifications can yield useful information, but must be interpreted with care. The results at annex I indicate that several elements in ETS for MES do not appear in present aeronautical specifications;

h) Further examination by suitably qualified experts is necessary to classify and quantify the parameters for effective utilisation and immunity appropriate for the AMS(R)S to permit specification preparation;

i) With the exception of the matters of effective spectrum use and immunity, the above would appear to apply equally to the AMSS for non-safety communications, and to MSS in aircraft.

13 Interested parties and interfaces to ETSI - external bodies

In addition to those parties currently active in the preparation of ETSI standards, this review has identified other special interests, who should be represented in such work.

13.1 AES for AMS(R)S

These include the following:

- JAA (and direct CAA representation);
- IATA (and direct airline representation);
- EUROCONTROL;
- AECMA (and direct membership representation);
- EUROCAE (and its members);
- Equipment manufacturers (Racal is already a member of ETSI);
- CEN (through its interest and contribution to ITAEG-Air);
- CENELEC (through its interest and contribution to ITAEG-Air);
- European Commission
  (exploitation of technology, regulatory matters and Air Traffic Management);
- RTCA (liaison with American interests);
- ARINC (liaison with American interests).

13.2 MES for MSS or AMSS

Include the following:

- Equipment manufacturers;
- JAA (and direct CAA representation);
- EUROCONTROL;
- EUROCAE (and its members);
- IATA (and direct airline representation);
- CEN;
- CENELEC;
- European Commission
  (exploitation of technology, regulatory matters and Air Traffic Management)

14 Future actions

Aviation is characterised by a strong global network of co-operation and agreement between all concerned players. At its highest level, Governmental agreements, through the ICAO Convention, imposes binding conditions through the provisions of its Annexes. These now contain the Standards for the AMSS operating on frequencies allocated by ITU to the AMS(R)S. For AES specifications, a voluntary network of manufacturers, airlines and regulatory interests, mostly based in the USA, carry out the detailed development of Minimum Performance Standards.

These documents form the basis of the airworthiness approval processes both in the USA and in Europe. The European bodies JAA and EUROCAE have an important function, in which they utilise the accumulated expertise of Europe in this area to arrive at meaningful and practical conclusions which then are embodied in EU legislation.

In the broader area of general air traffic standards, the ITAEG-Air group operating under a European Commission mandate, with membership drawn from CEN/CENELEC/ETSI and aviation interests has carried out a review of existing standards, to develop and propose a programme of standardization, including standards for satellite telecommunications, to the EC.

In any future actions on preparation of ETS(s) for installation or use of MESs in aircraft, it is of vital importance that appropriate European aviation organisations are consulted. Bodies directly concerned with standards, such as the JAA and EUROCAE should also be invited to participate. In the case of AES for the AMS(R)S a full appreciation of the total world situation is advised and appropriate decisions made must take account of present structures and procedures.

In particular, co-ordination should take place between ETSI and those other bodies which are concerned with standards and specifications for Aircraft Earth Stations. Given the international nature of aviation, and the necessity to be effective, this must not be limited to European interests alone. Consequently, it is recommended that ETSI should establish formal relations and liaison with at least the following as a minimum: JAA, EUROCAE, RTCA, EUROCONTROL, AECMA, ICAO, IATA and AEA. In particular, the membership of ETSI's Technical Committee SES should be expanded to include additional expertise.

It is further necessary to avoid placing European Manufacturers or airlines, at any disadvantage in an industry where international competition is fierce and unrelenting and operating margins often very slim. Such adverse situations could arise with specifications or standards, which require mandatory compliance in Europe only, with no practical benefit. In this connection, it is important to note (annex C) that only a relatively small proportion of AMS(R)S AESs are affected by European specifications. This arises as only European carriers are directly subject to European requirements and of these, only those aircraft certified in Europe and fitted with European manufactured equipment would need to comply with European Standards.

If it emerges that AMS(R)S equipment presents a significant problem to other services, then it should be noted that the protection of these other services can only be effectively achieved by addressing the problem on a world-wide basis. ITU-R is the forum where all service interests meet and where inter-service conflicts are studied and solutions identified. A chain of actions would follow from this forum, eventually leading to the incorporation of performance adjustments to all equipment, whether of European origin or elsewhere.

15 Summary of findings and recommendations

15.1 Summary of findings

For the airworthiness, it is a basic requirement that all radio, or electronic equipment, installed or taken on board an aircraft is intrinsically safe, and will not interfere with aircraft systems, whether the aircraft system is used for air navigation or for flight control. This airworthiness process is a national responsibility, exercised by national civil aviation authorities, and is also an international obligation for signatories to the Convention on International Civil Aviation (ICAO Convention), which includes nearly all world countries.

The Airworthiness approval process differs significantly for radio systems for air navigation (which includes communications) from those for other purposes, such as public correspondence communications. The Aircraft Earth Station (AES) operating on frequencies from the AMS(R)S bands at 1,5/1,6 GHz is exclusively for flight safety and regularity (RR 3630), although exceptionally public correspondence may be authorised by administrations (RR 729A). However, such communications must cease immediately, if necessary, to permit messages with priority 1 to 6 as in Article 51 of the Radio Regulations. For this equipment world-wide inter-operability is achieved through the adoption of ICAO Standards and Recommended Practices, detailed in Annex 10 to the Convention, which include necessary ITU regulatory requirements.

For these AESs, de facto standards already exist in the RTCA Minimum Performance Specification DO-210, which is the basis for the manufacture and airworthiness type approval of aircraft equipment. However, RTCA DO-210 does not contain clauses to the same extent on parameters regarding the use of the frequency spectrum as required by the TTE, EMC and SES Directives, compared with those contained in relevant existing ETSs for land and maritime mobile earth stations.

For MESs in aircraft, whether installed or portable, which operate on frequencies allocated to the AMSS or MSS providing public correspondence services, there is no obligation arising from air safety or airworthiness requirements other than that of physical safety and freedom from interference effects to mandatory carriage aircraft systems. Specifications for such systems may therefore be agreed on the basis of system requirements alone and be responsive to any commercial and other imperative consideration. Airworthiness approval is therefore granted on the basis of "no hazard to the aircraft".

Within the EU countries, Council Regulation 3922/91/EEC [9], which is obligatory without the need for national law, empowers the European Commission, assisted by the specialist body, the Joint Aviation Authorities (JAA), to adopt common technical requirements and procedures (Article 3) for air safety purposes. Annex II to this Regulation lists JAR TSOs which encompass aircraft radio systems. The list of JTSOs does not yet contain a JTSO for AESs. Such a JTSO may be created, as is common practice, by a normative reference to the relevant EUROCAE or RTCA document.

The use of satellite communications for air traffic purposes, shortly commencing in Pacific areas and later on the North Atlantic, may require the imposition of mandatory carriage for aircraft flying in these areas. Joint (Aviation Authority) Technical Standards Order (JTSO) for AES type approval (in the aeronautical sense) will be required for the certification of European registered aircraft operating in this region. These specifications may only be modified on the basis of world-wide agreement. In this approval process, the AESs must always meet the air safety requirements and be certified by the State of aircraft registry.

Aircraft may carry radio systems operating in up to 18 different frequency bands, with as many as 25 separate antennas, creating a compatibility situation of considerable complexity. Regulatory and technical provisions limiting unwanted emissions are essential. The airworthiness process, working sympathetically with aircraft design personnel, must arrive at an acceptable solution. Radio authorities would require reasonable safeguards, such as specification and conformance testing, to an agreed standard to ensure radio spectrum interests are safeguarded. Attention to the levels of unwanted emissions as compared to other mobile earth stations would appear desirable before their incorporation.

The majority of aircraft and aircraft radio certification occurs in the USA, which is followed by transfer under mutual recognition agreement to the State of registry. Estimates of European air safety certifications of AESs for new aircraft in the years ahead appear to be of the order of 40 per year (annex C). The probability of the use of satellite communications for air traffic purposes in European airspace is considered to be minimal. The use of satellite communications for public correspondence purposes by civil transport aircraft is expected to be low. For public correspondence purposes, the continuing and increasing competition offered by TFTS is a factor which could be decisive in limiting the use of AMS(R)S. The overall level of AMS(R)S activity, created by these separate but related events, in European airspace is expected to be small and the interference threat to other services also correspondingly low.

For MESs operating in the AMSS and MSS bands, the spread of the use could be extensive, particularly when smaller and cheaper equipment appear on the market e.g. that for S-PCN. Europe supports a present population of some 45 000 general aviation (i.e. light) aircraft together with many additional thousands of micro-light aircraft, balloons, gliders, etc. The use in larger passenger aircraft also presents possible hazards which may demand measures to control, although the use of such equipment in aircraft is currently banned by airlines. As a minimum these measures should include the development of specifications containing adequate provisions for unwanted emissions. Installation in aircraft will, additionally, require the application of airworthiness checks to ensure that protection of the aircraft and its systems is preserved.

The very demanding protection requirements of some users, such as the Radio Astronomy Service, may be difficult to satisfy in many circumstances. Nevertheless, it is clearly necessary that steps are taken to address the protection of the Radio Astronomy Service, when required.

Aviation is characterised by a strong world-wide network of formal international agreement, supported by specialist voluntary bodies. Safety and inter-operability are fundamental and essential objectives in the process. World-wide harmonisation of standards, specifications and operational procedures is the means adopted in the achievement of these objectives. In any proposed ETSI work, collaboration with concerned aviation bodies is essential for the production of acceptable and appropriate standards.

15.2 Recommendations

15.2.1 AES operating in AMS(R)S frequency bands

The specifications for AMS(R)S available from aviation sources and presently in the public domain, do not appear to cover to the same extent those parameters affecting spectrum use, as required by the TTE, EMC and SES Directives, such as currently contained in existing ETSs for Land and Maritime Mobile Earth Stations. Furthermore, the decision on whether an ETS is necessary, is dependant on the policy and interpretation of EU Council Regulation 3922/91/EEC. It is recommended therefore that, as a first step, ETSI should review the issue with the Joint Aviation Authorities, and other concerned parties, to establish the best solution before a final decision on an ETS is taken. This collaborative process is considered to be essential and unavoidable.

15.2.2 MES operating in the AMSS and MSS frequency bands

There is a requirement for a European Telecommunication Standard to be produced by ETSI for Mobile Earth Stations operating in the bands allocated to the AMSS, or the MSS, which are intended for use in aircraft, installed or carried on board, for public correspondence purposes. To ensure the safety aspects and the compatibility with other radio and electronic systems on the aircraft, the preparation of the ETS must be undertaken in collaboration with the Joint Aviation Authorities, supported as necessary by other interested organisations.

15.2.3 ETSI co-ordination with other bodies

To ensure that aviation interests are properly represented and that the necessary expertise is available in the development of an ETS, ETSI should include these interests. It is recommended that ETSI should seek co-operation with international aviation bodies (JAA, EUROCAE, RTCA, EUROCONTROL, AECMA, ICAO, IATA and AEA).

15.2.4 Clarification of legal aspects

ETSI should seek clarification from the European Commission regarding the need for an ETS on MES/AES that may form the basis for regulation, considering the TTE and SES Directives. Additionally it should seek clarification of the relationship of such a possible ETS with other legislation, such as EU Council Regulation 3922/91/EEC, the Air Traffic Management Directive 93/65/EEC etc.

Annex A: European membership of international bodies

Table 1: European membership of organisations, including affiliated members

Organisation / State	EU	EFTA	NATO	ICAO	EUROCONTROL	ECAC	JAA	ITU	CEPT	CEN	CENELEC	ETSI	INMARSAT	IATA	AEA
Albania								✓	✓						
Austria	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Belgium	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bulgaria				✓		✓		✓	✓			✓	✓		✓
Croatia				✓		✓			✓			✓			
Cyprus				✓	✓	✓	✓	✓	✓			✓			✓
Czech Republic				✓	✓	✓			✓		✓	✓			✓
Denmark	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Estonia				✓		✓									
Finland	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
France	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Germany	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Greece	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hungary				✓	✓	✓		✓	✓			✓		✓	✓
Iceland		✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓
Ireland	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Italy	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Latvia				✓		✓									
Lithuania				✓		✓			✓						
Luxembourg	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Malta			✓	✓	✓	✓			✓			✓			✓
Monaco				✓		✓	✓	✓	✓						
Netherlands	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Norway		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	
Poland				✓	✓	✓	✓	✓	✓		✓	✓			
Portugal	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Romania				✓		✓		✓	✓		✓	✓	✓		
Russia				✓				✓				✓	✓	✓	
San Marino				✓				✓	✓						
Slovakia				✓		✓			✓		✓	✓			
Slovenia				✓	✓	✓	✓				✓	✓			
Spain	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sweden	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Switzerland		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Turkey			✓	✓	✓	✓		✓	✓		✓	✓	✓		✓
Ukraine				✓				✓							
Vatican								✓	✓						
United Kingdom	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Annex B: Overview of European aspects of aeronautical satellite communications

B.1 Use of satellites for Air Traffic Control (ATC)

The possibility of utilising satellite based communications for air traffic control, became evident in the sixties. Communication with aircraft over desert and oceanic areas of the world employed HF - which suffered from variable propagation, black-outs and poor quality voice. In 1971, the ITU World Conference agreed an allocation of 15 MHz in each direction to the Aeronautical Mobile Satellite (R) Service (AMSS) adjacent to, and with the same spacing of 101,5 MHz between up and down links as the Maritime Mobile Satellite Service. ICAO preparations commenced and early survey work was carried out.

The rapid increase in fuel costs in the seventies placed the worlds airlines in commercial difficulties, which effectively made the use of satellite communications unjustifiable on economic grounds at that time. Difficulties with practical antenna designs for aircraft further accelerated the decline in support. Maritime satellite communications, with its proven technical and commercial possibilities, achieved the introduction of a practical service. Adjustments made to the frequency allocations - effectively reducing the AMSS to 10 MHz in each direction - whilst simultaneously increasing the maritime and land satellite allocations, reflected the situation which applied in the seventies and early eighties.

B.2 ICAO's Future Air Navigation System (FANS)

In the eighties, the ICAO Future Air Navigation Systems (FANS) Committee study on the future system for air navigation for the years up to 2010 and beyond, accepted that space systems of navigation and communications provided the only long term solution for civil aviation over many world areas. Air traffic had progressively increased throughout the period since 1945, and predictions for the years ahead foresaw a doubling of traffic in many areas shortly after the year 2000 and a trebling by 2010. Technological improvement across the broad front of air traffic management systems and techniques would be required to cope with the situation.

The findings of the FANS Committee were accepted and endorsed as official ICAO policy by the ICAO Tenth Air Navigation Conference held in 1991. They provided a number of operational scenarios for application, as necessary, to suit conditions in particular world areas. Global Navigation Satellite Systems (GNSS) were foreseen to become the standard for all en-route navigation, and some landing operations. Satellite based communications would replace HF in desert and ocean areas, and provide a possible alternative in developed continental airspace.

The ICAO machinery, in pursuance of these policy decisions has developed and agreed system Standards and Recommended Practices (SARPs) for incorporation in their telecommunications document Annex 10. These standards are a comprehensive set of parameters laying down limits for RF characteristics, specifying modulations, signal formats, procedural rules and other essential features necessary to provide an operational service.

B.3 European air traffic communications

Most of Europe is presently well covered by many hundreds of VHF air/ground terrestrial communications stations provided by States, for en-route and airport communications with aircraft within their territory. The 760 channels (at 25 kHz spacing) between 118 to 136,975 MHz is to be expanded to a possible 2 280 channels, by a reduction of channel width. This is likely to provide sufficient capacity to absorb all the anticipated increase in demand for additional channels, which will result from increasing air traffic activity.

The present communication system based largely on direct pilot-controller voice will, at the end of this decade, evolve to a predominately data mode - as Automatic Dependant Surveillance (ADS) becomes the main data gathering mechanism and the operational basis for ground control decisions and instructions. Standardized formats for position reports have been proposed internationally and technical standards for the data link are under concerted study on a world-wide basis. These efforts are expected to culminate in ICAO agreements later in the decade. The heavy investments made in Mode S radar, with its limited data link capability, may slow the process but should not act as a permanent barrier.

For Aviation, with its strong emphasis on operational safety and requirements for communications service availability of 0,9995, a system such as terrestrial VHF has many benefits to the planner and to the user. It has increased flexibility and immediate response to changing operational requirements. The redundancy provided by many ground stations and available channels, and its excellent and predictable propagation characteristics are prime factors in its support. The economics of both ground and aircraft systems are, at the moment, well ahead of equivalent satellite figures.

The carriage of VHF radio is a well established requirement by all aircraft, large and small and is accepted by all providers and users, who would have to face the difficult transition of re-equipment for satellite systems. Such a procedure in present and foreseeable technology would only be practicable for larger aircraft. Finally, and very importantly, the total service (apart from land line connections) is within the full control of aviation organisations: whether public, corporate or private.

B.4 Future expectations for satellite communications

In oceanic areas, particularly in the Pacific, plans for satellite communications to take over much of the HF communications, are well advanced. The most significant growth of air activity in the future is predicted to occur in trans-Pacific routes. Pacific and North Atlantic routes are flown predominantly by larger aircraft, some already fitted with satellite systems. Additional incentives, such as favoured tracks and faster clearances from ground control, will produce an easily manageable transition. Nevertheless, it may take a number of years for a majority of aircraft to be converted - at a conservative estimate, perhaps 7 years or more. Precise estimates of the number of aircraft which may be involved on a world-wide basis are generally not available, but a first order approximation would be 3 000 as a maximum.

The simultaneous capability of the AMSS to handle public correspondence, passenger or airline originated, provides an added impetus to the air operator, who must compete in a highly competitive regime, to complete conversion in the shortest possible time. The 4 or 5 years in which a passenger telephone capability, through a major international space system provider, has helped to generate confidence in its technical merits and provides a solid base of operational expertise from which the service can grow with confidence.

The European air traffic situation, with its particular characteristics and problems, are quite different from that of other world areas. Many diverse intersecting air routes exist, with many descending and ascending aircraft of all types and capability, creating a myriad network of great complexity and diversity. The ATLAS study, carried out by the European Commission [3] foresaw overall traffic expansion and changes in the pattern of air traffic flows - with considerably greater East-West and inter-state regional airport involvement - creating an air traffic problem of considerable magnitude.

In this environment, satellite communications would have to present very compelling operational, technical and economic arguments to replace, in part or in whole, the convenience and suitability of terrestrial means. In such a situation, the most likely course of events is that the status quo will prevail. The probability of the emergence of satellite communications, in anything other than specialised support roles, must therefore be seen as of a low order.

B.5 Public correspondence services

Public correspondence is not permitted in bands allocated exclusively to the Aeronautical Mobile Service and the Aeronautical Mobile Satellite Service under RR 3633 of the ITU Radio Regulations, as a special rule relating to the use of these frequencies. The general rule is exceptionally waived in the case of the bands at 1 500/1 600 MHz allocated to satellite services (RR 729A) and in the bands 1 670 to 1 675 MHz and 1 800 to 1 805 MHz under RR 55.381 These changes to the long established prohibition of RR 3633 were made by the 1987 World Radio Conferences on the Mobile Services. Public correspondence with aircraft using satellites commenced in 1986 and is now well established through a large multi-national space provider.

Terrestrial Flight Telephone System (TFTS) services are in operation and becoming established throughout Western Europe. The full system specification is contained in ETS 300 326 (adopted as ARINC Characteristic 752 [2]). The TFTS operates as a separate independent system on board the aircraft and has no interconnection with any of the other radio systems. The TFTS is presently the only radio system on aircraft covered by an agreed ETS. It is hoped that TFTS will achieve a wider acceptance and become established on the world scene. In European airspace it is possible that TFTS, with its economic advantages, may become a serious competitor to satellite based public correspondence.

B.6 Summary

This overview has examined a possible scenario for the use of satellite communications by aircraft in European airspace. Based on the best evidence available the likely scenario for Europe is one where:

(a) Use of satellite communications in core European airspace is unlikely to become a significant proportion of the communications for air traffic purposes. It is probable that its application will be minimal and restricted to fringe specialised support roles;

(b) Airline and passenger satellite public correspondence using satellite is possible for aircraft without other means, such as TFTS. This is also not likely to be of a great magnitude unless there are significant changes in the economics and pricing of satellite communications;

(c) Most aircraft using satellite communications are likely to be larger aircraft operating at higher flight levels and en-route to destinations outside Europe, or originating from outside Europe. The interference potential to ground radio systems, taking into account antenna directivity, could be less than expected.

Annex C: Projections for European aircraft use of satellites

C.1 Introduction

This study is concerned with the need for standards and ultimately an approval system for Aircraft Earth Stations in aircraft. It is necessary that an appreciation of the context and scope of European registered aircraft use is obtained from which the magnitude of the activities to be recommended would emerge.

In general the concern will be with larger aircraft, and in particular the long range types capable of stage lengths of 3 000 km or more. Smaller aircraft may fit satellite communications but this is much less predictable and will depend on the economics of fitting, maintenance and use.

At present some 300 aircraft world-wide are equipped for voice, and some 250 for voice and data, of which European airlines aircraft account for some 21%, or 115. Some 70% of the main components of installations have originated from a single European manufacturer.

C.2 Existing European fleets

European airlines own or operate around 2 200 commercial jets and 500 turboprop aircraft based on 1991 figures [4]. This amounts to about 23% of world fleets. Of these 1 300 are operated by member airlines of the Association of European Airlines (AEA) which includes most national flag carriers. Another 600 or more are operated by members of the European Regional Airlines Association (ERA). European General Aviation at 45 000 is the second largest in the world but well behind the USA which has 240 000. Only a relatively small number, typically executive and privately owned jets, can be confidently expected to fit and use satellite communications.

Figures provided by AEA and ERA as part of the European Commission ATLAS study have indicated the situation which applied in 1992/93. For trans-oceanic use it would be assumed that all aircraft will have to be fitted with satellite terminals. Later in the decade some will be replaced by B777 with perhaps an increase in overall numbers. An estimate of the total numbers of long range aircraft operated by European scheduled and charter airlines is less than 500 in 1994/1995. A majority are of USA manufacture and have invariably received their Certificate of Airworthiness (including the radio fit) against FAA standards and were then transferred to the national register under bilateral agreement.

C.3 Projected aircraft numbers

Projections made by ICAO [8] indicate in the next 10 years a reducing proportion of the worlds air transport activity will be operated by European airlines. In the past air transport growth has been linked with economic growth but passenger, and passenger kilometre, increases have been much greater. Freight traffic has similarly grown at rates twice or three times the Gross Domestic Product (GDP). For the next ten years world economic growth (GDP) is expected to increase at an average annual rate of 2,8% in real terms. Asia/Pacific airlines are expected to show much greater passenger traffic growth at 8,5% per annum, while Africa, Europe and Latin America may achieve 3,5 to 4%. North America and Middle East are expected to return world average figures of 6%. The approximate numbers of aircraft (figures provided from airline sources) for the years ahead have been estimated in table 2:

Table 2: Projected aircraft numbers

Year	Air Transport world-wide	Long haul world-wide	Long range European airlines
1995	8 900	2 500	575
2015	16 000	7 000	1 400

These estimates tend to show new long-range aircraft registrations in Europe of 40 per year. The proportion of this total which will be of USA manufacture (including satellite terminal) is likely to be substantial.

C.4 AES type approval implications

Looking at the situations where the need for type approval of the AES could conceivably arise, the following appear relevant:

(i) where a European manufactured aircraft with European AES is supplied to a European airline;

(ii) where a European manufactured aircraft with European AES is exported with its "C of A" transferred under bilateral agreement.

A requirement for European type approval would appear to arise in both of these cases. Other cases where the commitment is not clear are:

(iii) where a European manufactured AES is provided to a non-European aircraft manufacturer for delivery to a European airline.

No requirement would appear to arise in the following cases:

(iv) where a European airline imports new aircraft with a transfer of the "C of A" under bilateral arrangements;

(v) wet lease where crew are provided;

(vi) dry lease where the aircraft remains on its original state register;

(vii) purchase of used aircraft where the "C of A" is transferred under bilateral agreement;

(viii) other aircraft transfers of a temporary nature.

The number of equipment offered for airworthiness type approval to European national authorities is therefore likely to be quite small over the 20 countries in the Joint Airworthiness Authorities area of interest. This figure could, however, be greater if smaller aircraft fit and use satellite terminals for private, or company, purposes. Such equipment would not necessarily have to meet the same performance standards as those used in commercial, passenger carrying operations (see annex D).

Annex D: Overview of airworthiness approval process

D.1 Introduction

This annex reviews in brief terms the airworthiness processes applied to all civil aircraft to ensure their safe operation. The review is made in the context of the requirement as it exists in EC Member States and with particular reference to the approval of Aeronautical Earth Station (AES) used in the Aeronautical Mobile Satellite Services.

D.2 Basis of airworthiness

Airworthiness is the process of certifying that an aircraft is safe to fly, and is the responsibility under Article 31 of the ICAO Convention of the State of Registry of the aircraft. Article 33 of that Convention requires mutual recognition of other states certificates, provided that the requirements under which they were issued are equal to or above the minimum standards laid down at any time. Article 29 requires every aircraft "engaged in international navigation" is carry (i) a certificate of registration (ii) a certificate or airworthiness (iii) a radio station license issued by the appropriate national authority (iv) licenses for all crew members plus other documents not related to this study.

Under modern conditions aircraft are frequently leased from an owner in one State to a lessee in a second State ("wet" when the crew is also leased, and "dry" when not), which is covered by Article 33 of the ICAO Convention and Radio Regulation RR 2030 for the radio license. The Certificate of Airworthiness ("C of A") requires that all aircraft components, including all of the safety radio systems must meet their laid down requirements.

D.3 Radio system approval process

The total radio systems approval to the level required for the award of a "C of A" to an aircraft type has three main elements:

(i) type approval of the radio through bench tests to confirm that it meets the MPS performance and environmental requirements;

(ii) incorporation with antenna, cabling, indications and control of the aircraft to meet aerodynamic, structural, EMC, and physical safety requirements;

(iii) proof that the overall installation operates and performs in flight to required MPS standards.

In the case where the radio system manufacturers is co-located in the same country as the aircraft manufacturer, its type approval will automatically be accepted. Where a second country is concerned mutual recognition under Article 33 of the ICAO Convention is granted to the import and certification. Some larger airlines favour radio systems constructed elsewhere than the country of manufacture of the aircraft. Delivery and transfer of the complete aircraft to an operation in a country other than that of manufacture is normally made under Article 33 through the transfer of the "C of A".

Approval is primarily by self certification, and does not usually involve conformance testing by an independent third party. Radio systems which are not used for flight or navigation (such as TFTS) only need to comply with (ii) above.

D.4 EMC considerations

Modern aircraft carry radio systems operating in up to 12 different frequency bands. With satellite communications, satellite navigation and in some cases with TFTS, the number increases to 15 or more. Important systems such as ILS, MLS and Communications have 2, or 3 separate sets each with their own antenna amounting often to 26 or more separate antennas. Some systems must have their antenna in a position where aircraft body screening does not adversely affect performance e.g. satellite antenna are on the top surface and landing systems on the nose surface.

This produces an EMC system of great complexity which must be solved at the point of aircraft construction, i.e. by the aircraft designer. Limits for unwanted emissions laid down in the performance specification provide the first, general assurance of freedom from interaction but cannot address individual lay outs. Careful aircraft system design and placement of antenna, utilising the accumulated expertise gained over many years, must be applied to resolve final problems. On occasions, the radio system causing the interaction must be modified.

The increasing volume of electronic based systems on aircraft, e.g. digitised (fly by wire) flight and engine controls, passenger telephones and fax, in flight cabin entertainment etc. present the designer with an EMC problem of rapidly increasing magnitude. The imperatives of flight safety have to remain as the prime consideration for aircraft designers, users and regulators. The economics of the modern airline competitive regime must also be a consideration of first importance.

D.5 Aircraft Earth Station (AES) aspects

Figures published in September 1995 by INMARSAT, indicate a present total of some 600 aircraft fitted with satellite communications, of which around 90 are in the aircraft of European airlines. In contrast with other aircraft radio a high proportion (about 70%) have been provided to the USA or European aircraft manufacturer from a single European source.

At present such systems have no mandatory participation in the safety of the aircraft (although the satellite distress and safety frequencies may be used with GMDSS if occasion arises) and are not required to meet airworthiness requirements. The basis of their installation is that of "no hazard" to other systems on board, or to the aircraft itself.

Overall, the European AES population and its growth in the context of type approval, or airworthiness certification, is of a small order, and could well be only in the scale of 6 to 10 per year (see annex C). Unless satellite communications becomes a requirement in European airspace (see annex B), it may be predominately only aircraft used on inter continental routes (B747 and equivalent) which will be affected.

D.6 EU rules relating to airworthiness

Council Regulation 3922/91/EEC [9] imposes in its Article 3 the obligation for member states in their national policies to apply the Joint Airworthiness Requirements Technical, Standing Orders (JAR TSOs) produced by the Joint Aviation Authority (JAA) an associated body of ECAC. Article 7 requires mutual recognition of certification made by another Member State, or by a body acting on its behalf, or to bodies or persons placed under its jurisdiction and under its territory. The objectives of Council Regulation 3922/91/EEC [9] are clearly stated in the 9 "Whereas" clauses which precede the main text, where within the general objective of "harmonisation" and "single market" the word "safety" receives mention in six out of the nine. JAA TSOs are normally aligned with those laid down by the FAA in the USA automatically achieve harmonisation.

D.7 Non-safety radio systems

Radio systems which do not support the navigation or communication needs of the aircraft for safety purposes, e.g. TFTS public correspondence facilities, do not have to conform to the full Airworthiness requirement. In these cases a lesser standard, relating to physical safety and interference aspects (often described as a "no-hazard approval"), is applied. In essence only the element in annex D.3 (ii) above would apply. However, in cases of conflict with safety systems, there is general recognition within ITU and regulatory practice that the needs of the safety systems take precedence. Therefore, provided these criteria are met, no requirement for the functional and system elements of the specification to be agreed by national aviation authorities. Nevertheless, it makes good sense to consult with, and invite the participation of, aviation bodies in all the stages of system evaluation and specification to ensure its safe integration into the aircraft.

Annex E: Table of relevant EU legislation

The following table lists those EU Directives, Council Regulations and Council Decisions reviewed that have a direct bearing of the subject of this report. Undoubtedly, this list is not exhaustive but it does include those that were considered the most significant. Other less formal documents, such as position papers, were also considered and are referenced elsewhere.

Table 3: relevant EU legislation

EC Reference	Title	Refers to
83/189/EEC	Procedure for the Provision of Information in the Field of Information Technology	
85/C 136/01	New Approach to Technical Harmonisation	
86/361/EEC	Mutual recognition & type approval of TTE	
87/95/EEC	European Standardization in IT & Telecommunications	
88/182/EEC	Procedure for the Provision of Information in the Field of Information Technology	83/189/EEC
88/301/EEC	Competition in Telecommunications Terminal Equipment	
89/336/EEC	EMC Directive	
90/387/EEC	Internal Market for Telecommunications Services	
90/388/EEC	Competition in Market for Telecommunications Services by Implementing Open Network Provision	
3922/91/EEC	Harmonisation of Technical Requirements and Administrative Procedures in Civil Aviation	
91/263/EEC	Approximation of the Laws of the Member States concerning Telecommunications Terminal Equipment	86/361/EEC, 87/95/EEC
92/31/EEC	Approximation of Laws in EU on EMC	89/336/EEC
93/65/EEC	Definitions and Use of Compatible Specifications for the Procurement of ATM Equipment	
93/68/EEC	CE Marking	89/336/EEC, 91/263/EEC et al
93/97/EEC	Satellite Earth Stations	91/263/EEC
94/10/EC	Harmonisation of Technical Requirements and Administrative Procedures in Civil Aviation	83/189/EEC
94/46/EC	Satellite Communications	88/301/EEC, 90/388/EEC
94C 108/06	Mutual Recognition of Licensing of Telecommunications Services	

Annex F: European Telecommunication Standards (ETSs)

The following is only a brief summary of standards included in the survey. Not all of these documents are directly relevant to civil aviation, but are of interest to the survey for other purposes. Note that there are over 600 European Telecommunication Standards (ETSs) published by ETSI in total. Many ETSs contain several parts, addressing various aspects of telecommunications equipment and systems.

ETS 300 019 (1994): "Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment".

ETS 300 066: "Radio Equipment and Systems (RES); Float-free maritime satellite Emergency Position Indicating Radio Beacons (EPIRBs) operating on 406,025 MHz; Technical characteristics and methods of measurement".

ETS 300 086 (1991): "Radio Equipment and Systems (RES); Land mobile group; Technical characteristics and test conditions for radio equipment with an internal or external RF connector intended primarily for analogue speech".

ETS 300 113: "Radio Equipment and Systems (RES); Land mobile service; Technical characteristics and test conditions for radio equipment intended for the transmission of data (and speech) and having an antenna connector".

ETS 300 119 (1994): "Equipment Engineering (EE); European telecommunication standard for equipment practice".

ETS 300 127 (1994): "Equipment Engineering (EE); Radiated emission testing of physically large telecommunication systems".

ETS 300 152 (1991): "Radio Equipment and Systems (RES); Maritime Emergency Position Indicating Radio Beacons (EPIRBs) intended for use on the frequency 121,5 MHz or the frequencies 121,5 MHz and 243 MHz for homing purposes only; Technical characteristics and methods of measurement".

ETS 300 162 (1993): "Radio Equipment and Systems (RES); Radiotelephone transmitters and receivers for the maritime mobile service operating in VHF bands; Technical characteristics and methods of measurement".

ETS 300 194 (1995): "Satellite Earth Stations and Systems (SES); The interconnection of Very Small Aperture Terminal (VSAT) systems to Packet Switched Public Data Networks (PSPDNs)".

ETS 300 220: "Radio Equipment and Systems (RES); Short range devices; Technical characteristics and test methods for radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW".

I-ETS 300 225 (1994) : "Radio Equipment and Systems (RES); Technical characteristics and methods of measurement for survival craft portable VHF radiotelephone apparatus".

ETS 300 254 (1994) : "Satellite Earth Stations and Systems (SES); Land Mobile Earth Stations (LMESs) operating in the 1,5/1,6 GHz bands providing Low Bit Rate Data Communications (LBRDCs)".

ETS 300 255 (1994): "Satellite Earth Stations and Systems (SES); Land Mobile Earth Stations (LMESs) operating in the 11/12/14 GHz bands providing Low Bit Rate Data Communications (LBRDCs)".

ETS 300 282 (1994): "Satellite Earth Stations and Systems (SES); Network Control Facilities (NCFs) for Land Mobile Earth Stations (LMESs) operating in the 1,5/1,6 GHz bands and 11/12/14 GHz bands providing Low Bit Rate Data Communications (LBRDCs)".

ETS 300 326: "Radio Equipment and Systems (RES); Terrestrial Flight Telephone System (TFTS)".

ETS 300 329 (1994): "Radio Equipment and Systems (RES); Electro-Magnetic Compatibility (EMC) for Digital European Cordless Telecommunications (DECT) equipment".

ETS 300 330: "Radio Equipment and Systems (RES); Short Range Devices (SRDs); Technical characteristics and test methods for radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz".

ETS 300 332 (1994): "Satellite Earth Stations and Systems (SES); Transmit/receive Very Small Aperture Terminals (VSATs) used for data communications operating in the Fixed Satellite Service (FSS) 6 GHz and 4 GHz frequency bands".

Draft prETS 300 339: "Radio Equipment and Systems (RES); General Electro-Magnetic Compatibility (EMC) for radio equipment".

ETS 300 341 (1995): "Radio Equipment and Systems (RES); Land mobile service; Technical characteristics and test conditions for radio equipment using an integral antenna transmitting signals to initiate a specific response in the receiver".

ETS 300 372 (1995): "Radio Equipment and Systems (RES); Technical characteristics and methods of measurement for maritime float-free satellite Emergency Position Indicating Radio Beacon (EPIRB) operating in the 1,6 GHz band through geostationary satellites".

ETS 300 373 (1995): "Radio Equipment and Systems (RES); Technical characteristics and methods of measurements for maritime mobile transmitters and receivers for use in the MF and HF bands".

ETS 300 385 (1996): "Radio Equipment and Systems (RES); ElectroMagnetic Compatibility (EMC) standard for digital fixed radio links and ancillary equipment with data rates at around 2 Mbit/s and above".

ETS 300 386 (1994): "Equipment Engineering (EE); Public telecommunication network equipment Electro-Magnetic Compatibility (EMC) requirements".

ETS 300 387 (1994): "Private Telecommunication Network (PTN); Method for the specification of basic and supplementary services".

ETS 300 390 (1996): "Radio Equipment and Systems (RES); Land mobile service; Technical characteristics and test conditions for radio equipment intended for the transmission of data (and speech) and using an integral antenna".

ETS 300 392 (1996): "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Voice plus Data (V+D)".

ETS 300 406 (1995): "Methods for Testing and Specification (MTS); Protocol and profile conformance testing specifications; Standardization methodology".

ETS 300 423 (1995): "Satellite Earth Stations and Systems (SES); Land Mobile Earth Stations (LMESs) operating in the 1,5 / 1,6 GHz bands providing voice and/or data communications".

ETS 300 424 (1995): "Satellite Earth Stations and Systems (SES); Network Control Facilities (NCFs) for Land Mobile Earth Stations (LMESs) operating in the 1,5/1,6 GHz bands providing voice and/or data communications".

ETS 300 440: "Radio Equipment and Systems (RES); Short range devices; Technical characteristics and test methods for radio equipment to be used in the 1 GHz to 25 GHz frequency range".

ETS 300 441 (1996): "Radio Equipment and Systems (RES); Technical characteristics and methods of measurement for maritime radiotelephone watch receivers for the distress and calling frequency 2 182 kHz".

ETS 300 445 (1995): "Radio Equipment and Systems (RES); Electro-Magnetic Compatibility (EMC) standard for wireless microphones and similar Radio Frequency (RF) audio link equipment".

ETS 300 454 (1995): Radio Equipment and Systems (RES); Wide band audio links; Technical characteristics and test methods".

ETS 300 456 (1995): "Satellite Earth Stations and Systems (SES); Test methods for Very Small Aperture Terminals (VSATs) operating in the 11/12/14 GHz frequency bands".

ETS 300 459: "Satellite Earth Stations and Systems (SES); Network Control Facilities (NCF) for Maritime Mobile Earth Stations (MMESs) operating in the 1,5/1,6 GHz and 11/12/14 GHz bands providing Low Bit Rate Data Communications (LBRDCs)".

ETS 300 460: "Satellite Earth Stations and Systems (SES); Maritime Mobile Earth Stations (MMESs) operating in the 1,5/1,6 GHz bands providing Low Bit Rate Data Communications (LBRDCs) for the Global Maritime Distress and Safety System (GMDSS); Technical characteristics and methods of measurement".

ETS 300 487: "Satellite Earth Stations and Systems (SES); Receive-Only Mobile Earth Stations (ROMESs) operating in the 1,5 GHz band providing data communications; Radio Frequency (RF) specifications".

ETS 300 506 (1995): "European digital cellular telecommunications system (Phase 2); Security aspects (GSM 02.09)".

Annex G: List of JTSOs referring to EUROCAE RTCA documents

The following is a list of EUROCAE RTCA documents, indicating the scope of EUROCAE's activity in this field. Many of these documents have corresponding RTCA equivalents (and are exact copies of the RTCA original).

Table 4: JTSOs referring to EUROCAE RTCA documents

Date	ED	RTCA title	JTSO number
1970	1/WG7/70	75 MHz marker beacon	2c35a
1974	WG9/1-71	SSR Transponder	c74c
1974	WG7C/1-74	Doppler radar (measuring equip.)	c65a
1974	WG7C/2-74	Doppler radar (airborne computer)	c68a
1977	ED-29	OMEGA	C84a
1983	ED-38	Weather and assisted approach	2c63c
1983	ED-51	Airborne ADF equipment	2c41d
1985	ED-18	Airborne audio interface	C50c, C57a, C58A
1986	ED-23B	VHF communications	2c37a, 2c38d
1987	ED-54	DME/N, DME/P airborne equipment	2c66b
1988	ED-22B	VOR airborne equipment	2c40c
1988	ED-46A	ILS localiser airborne equipment	C36e
1988	ED-47A	ILS glide path airborne equipment	C34e
1988	ED-58	RNAV system using multi-sensor input	2c115
1990	ED-55	Flight data recorder	c124
1990	ED-62	Emergency locator transmitter	2c91a
1995	ED-36A	MLS airborne equipment	2c104

Annex H: Survey guidelines

Purpose of Survey

The current growth of the aeronautical mobile satellite services is leading to an increasing number of equipment being offered in the market. The services are essentially international in character, so that cross-border use can be envisaged. The mutual recognition of type-approval, based on standardization work, are essential elements in the licensing of the trans-border operation of these systems and equipment.

The scope and interrelationship between existing satellite standards/specifications is complex, involving many national and international bodies. It is necessary to obtain a picture of these processes, to identify clearly the specification and type approval chain, and to establish where gaps exist, which need to be filled for regulatory reasons e.g. for protection of other services.

Survey guidelines

The Project Team will study the existence and interrelationship between aeronautical mobile satellite standards / specifications and investigate the subject as follows:

- identify the major international and regional/national specification bodies who have currently published, or are about to publish specifications for aeronautical mobile satellite systems (referred to as Identified Specification Bodies);

- establish the background and membership of the Identified Specification Bodies;

- review and summarise the scope of the Identified Specifications;

- examine and identify the inter-dependencies of the Identified Specifications;

- examine the relevance of the specifications for regulatory type approval;

- detail the regulatory requirements of the radio communications authorities;

- identify, if any, areas not covered by these specifications;

- identify the interfaces to ETSI-external bodies or fora (national and international);

- identified the bodies interested in an aeronautical ETS;

- investigate the legal necessity for an aeronautical ETS as a result of existing Directives and conditions.

Annex I: AES specification comparison

Table 5 illustrates those elements contained in the various standards and specifications which have a bearing, directly or indirectly, on the subject of this report. This table is indicative only, it does not imply whether the inclusion or the omission of a parameter or procedural requirement may be construed as being an essential element of a future ETS. Elements contained in the various documents with quantitative values, e.g. unwanted emissions, will require detailed comparison before a conclusion on the adequacy of those values could be stated.

Table 5: AES specification comparison

Element in document \ Document	ICAO annex 10 (note 4)	RTCA DO-210	ARINC Char 741	LMES LBRDC ETS 300 254/5	LMES V+D ETS 300 423
Mandatory "standard"	✓			✓	✓
Voluntary specification		✓	✓		
Transmitter parameters					
Spurious emissions:	✓	✓	✓	✓	✓
Modulation noise:		(note 5)		✓	✓
Receiver parameters					
Adjacent frequency rejection	✓	✓	✓	(note 1)	(note 1)
Intermodulation test	✓	✓	✓	(note 1)	(note 1)
EMC (specific tests)			✓ (note 2)	✓	
MES CMF (note 3)				✓	✓
Specific RAS protection				✓	✓
Test specifications		✓	✓	✓	✓
Manufacturer's self-certification		✓	✓		
3rd-party conformance testing				✓	✓
Public consultation				✓	✓

NOTE 1: Possibly included in system specification.

NOTE 2: Specific isolation requirement for other on-board radio systems (incl. TFTS).

NOTE 3: MES control may not be practicable with air safety systems.

NOTE 4: International treaty provisions.

NOTE 5: Values for spurious emission are on next page of this annex.

RTCA DO-210: permissible levels for harmonics, discrete and noise

In respect of the values for this parameter contained in DO-210, the table below displays those contained in the initial issue of the document in 1992, followed by the present proposals for amendment in the 1,5/1,6 MHz spectrum area (two changes were effected in the period between which are not shown here).

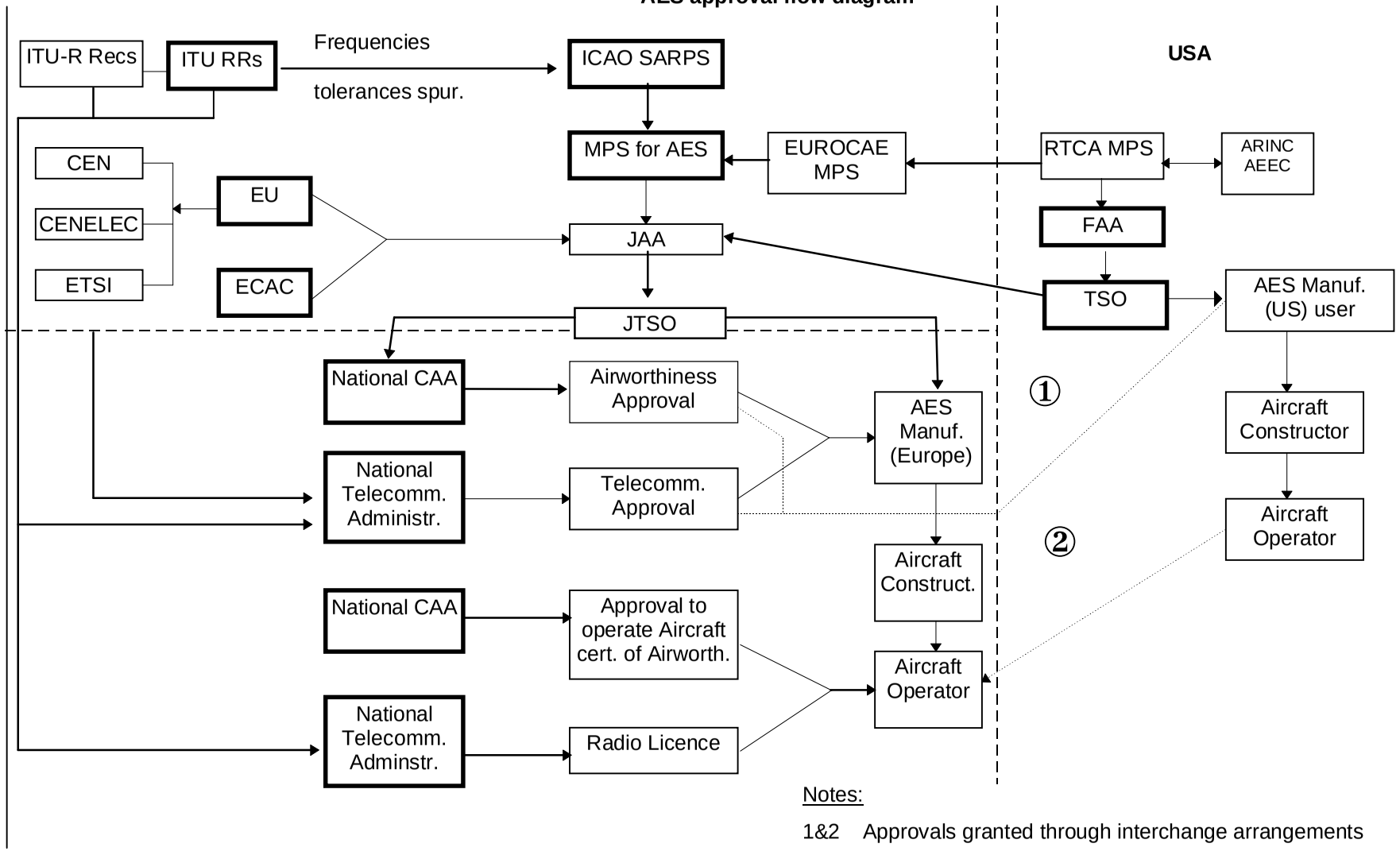
Table 6: RTCA DO-210 (permissible levels for harmonics, discrete and noise)

June 1992		**November 1995**	
Frequency (MHz)	Power density value (dBc/ 4 kHz)	Frequency (MHz)	Power density value (dBc/ 4 kHz or 1 MHz)
1 530/1 559	- 203	1 525/1 559	- 203
1 559/1 565	- 135	1 559/1 565	- 135
1 565/1 585	- 155	1 565/1 585	- 155 (1 MHz)
		1 585/1 605	- 143 (1 MHz)
		1 605/1 610	- 117 (1 MHz)
1 585/1 735	- 55	1 610/1 614	- 95 (1 MHz)
		1 614/1 735	- 55
1 735/12 000	- 105	1 735/12 000	- 105
NOTE 1: Values are attenuation in dB relative to transmitter average power (60 watts).			
NOTE 2: Measurement bandwidth is 4 kHz unless otherwise indicated.			

NOTE: TC SES is of the opinion that some of the above limits may be difficult to meet at ambient temperature.

Annex J: AES approval flow diagram

AES approval flow diagram



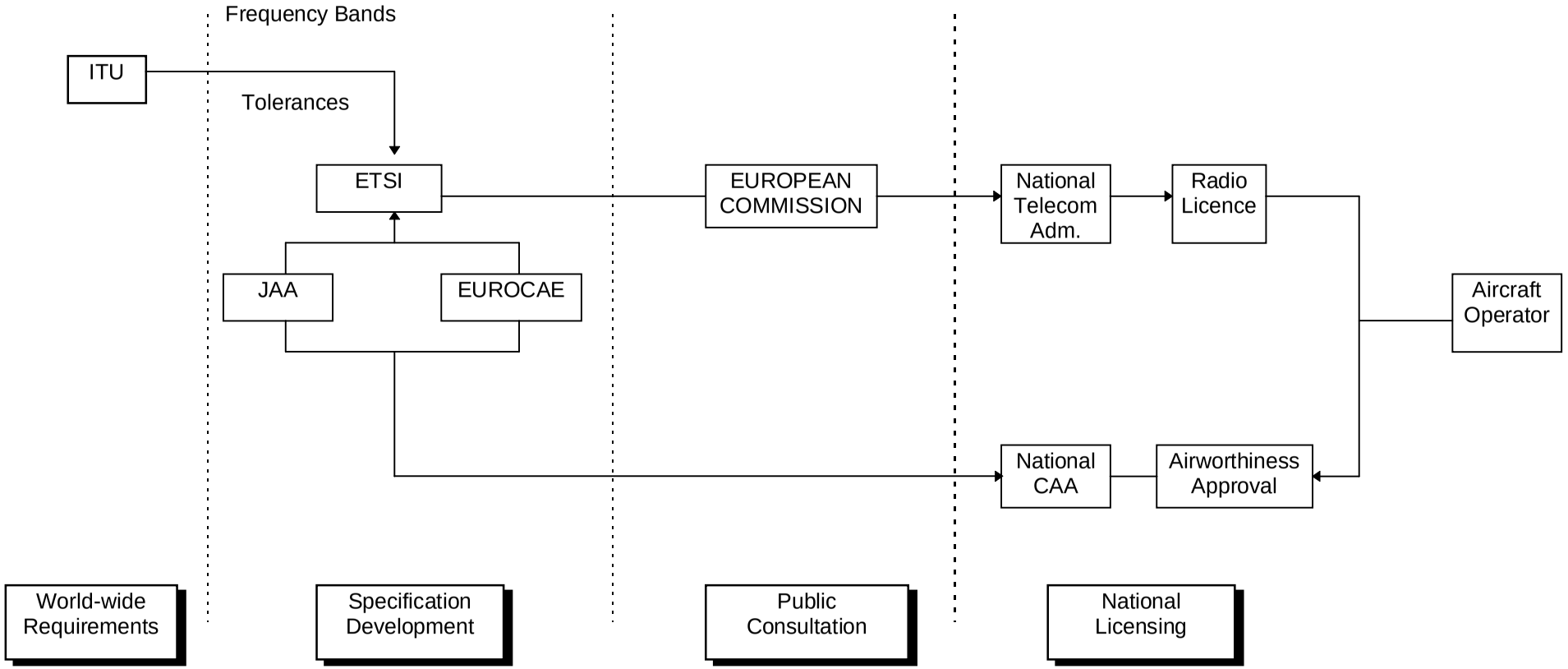
Notes:

1&2 Approvals granted through interchange arrangements

3 Bold bordered boxes contain bodies with mandatory authority

Annex K: MES type approval flow diagram (for aircraft use)

MES type approval flow diagram (for aircraft use)



History

Document history	
May 1996	First Edition

ISBN 2-7437-0673-2
Dépôt légal: Mai 1996