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HANDBOOK ON RADIO FREQUENCY SPECTRUM REQUIREMENTS FOR CIVIL AVIATION

Volume I

ICAO SPECTRUM STRATEGY, POLICY STATEMENTS and related information

DRAFT SIXTH EDITION [rev 13 September 2013]

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AMENDMENTS

The issue of amendments is announced regularly in the *ICAO Journal* and in the monthly *Supplement to the Catalogue of ICAO Publications and Audio-visual Training Aids*, which holders of this publication should consult. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by

CORRIGENDA		
No.	Date	Entered by

FOREWORD

Historical background

ICAO's Special Communications/Operations Divisional Meeting held in 1995 (Special COM/OPS/95) noted that the International Telecommunication Union (ITU) had begun to convene its World Radiocommunication Conferences (WRCs) every three to four years. While divisional-type ICAO meetings had traditionally developed positions on WRC agenda items related to aviation, it was evident that it was not feasible to convene such meetings frequently enough to keep pace with this schedule of WRCs. The Special COM/OPS/95 meeting recognized the importance of keeping up with the rapid development in telecommunications and consequently recommended that a new mechanism be developed to enable that civil aviation to record its agreed requirements for aeronautical radio frequency spectrum in an adequate and timely manner.

The meeting accordingly recommended that an ICAO radio frequency (RF) document be developed and maintained (Recommendation 7/1). The Air Navigation Commission, at its meeting on 19 June 1995 (ANC 139-10), approved the recommendation for action. Subsequently ICAO developed this *Handbook on radio frequency spectrum requirements for civil aviation* and the first edition was published in [1998]

Include the text of Recommendation 7/1 of COM/OPS/95 (and action by the ANC)

Status of the handbook

This handbook contains the ICAO Spectrum Strategy and Policy Statements relevant to the aviation requirements for radio frequency spectrum, as approved and amended by the ICAO Council.

The handbook is intended to assist States and ICAO in preparing for ITU conferences. The ICAO position on matters of interest to aviation on the agenda of ITU WRC-15 is included in Attachment F. The strategy for establishing and promoting the ICAO position for future ITU WRCs is in Attachment E.

The material in this handbook is supplementary to the Standards and Recommended Practices (SARPs) contained in Annex 10 to the Convention on International Civil Aviation — *Aeronautical Telecommunications*, which continue to have precedence and applicability for those aspects covered by their provisions.

Amendments to this handbook will be made on a regular basis so that the material will represent the latest position on the spectrum requirements for civil aviation. Towards this end, the Recommendations of divisional-type meetings and air navigation conferences as well as the findings and Recommendations of ICAO panels and other (e.g. Regional) bodies, as approved by the Air Navigation Commission and Council as appropriate, are expected to be among the main sources of information. Changes may also be necessary as a result of decisions taken at ITU WRCs.

Results of on-going activities in ICAO on spectrum management are available on the web site for the Aeronautical Communications Panel (ACP) at http://legacy.icao.int/anb/panels/acp/index.cfm. ACP Working Group F is undertaking the activities on preparation and coordination of material, including the development of the draft ICAO position, in particular for ITU WRCs, ITU-R study group meetings and meetings of regional telecommunication organizations.

Organization of the handbook

The handbook consists of two volumes:

Volume I contains the ICAO spectrum strategy and policy statements

Volume II contains technical material on the utilization of radio frequency spectrum by aviation

Volume I is laid out in the following way:

- Chapter 1 introduces the subject of radio frequency spectrum management.
- Chapter 2 defines the objectives and purpose of the handbook.
- Chapters 3 to 5 describe the institutional aspects and the relationships between the main participants (ITU, ICAO, national authorities, etc.).
- Chapter 6 contains an overview of the spectrum management process.
- Chapter 7, which is divided into four sections, contains the principal elements of the handbook. Each frequency band and its uses are described in detail, together with the approved ICAO policy statements for the civil aviation spectrum requirements in that band. Also included are relevant provisions (Regulations), Resolutions and Recommendations which are contained in the ITU Radio Regulations.

— Chapter 8 contains the ICAO spectrum strategy and addresses future requirements of frequencies for civil aviation.

— Chapter 9 describes the elements of a framework of rules and preventative measures for the regulation and control of interference.

— Attachment A provides a selection of relevant ITU definitions.

— Attachment B contains acronyms and abbreviations used in the handbook.

— Attachment C gives an overview of the regulatory aspects of radio equipment in aircraft.

— Attachment D addresses the processes and sequence of actions for the review and updating of the handbook.

— Attachment E contains the ICAO strategy for improving support for the ICAO position.

— Attachment F contains the ICAO position for ITU WRC-15, as approved by the Council on 27 May 2013.

— Attachment G contains technical information and frequency sharing criteria.

— Attachment H references relevant ITU Resolutions and Recommendations which are incorporated in the ITU Radio Regulations.

— Attachment I contains a list of relevant ITU R Recommendations and Reports as well as the hyperlinks to download this material. ITU-R Recommendations and Reports are freely available from the ITU web site.

Action by Member States and ICAO

States are requested to use the material in this policy document, as it is necessary and opportune, in their national discussions on matters relating to the use of the radio frequency spectrum by international civil aviation. In particular, the ICAO spectrum strategy, the ICAO policy statements and the ICAO position for ITU World Radiocommunication Conferences (WRC) should be utilized and incorporated in proposals from States for ITU WRCs, meetings of the ITU-R sector

(ITU-R Study Groups) and meetings of Regional Telecommunication organizations as the up-to-date agreement within ICAO on the reference subject. ICAO observers at these conferences and meetings may also, as necessary, use the material from the document as the agreed ICAO policy for international civil aviation purposes.

The complete volume(s) of the ITU material from which the texts are reproduced in this handbook can be obtained from:

International Telecommunication Union (ITU)
Publication Sales
Place des Nations
1211 Geneva 20 (Switzerland)
Telephone: +41 22 730 61 41 (English)
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Fax: + 41 22 730 51 94
E-mail: sales@itu.int / http://www.itu.int/publications

Note 1.— Although this handbook includes relevant provisions from the ITU Radio Regulations, these extracts are not complete and the handbook should therefore be used in conjunction with the full text of the ITU Radio Regulations and the relevant ITU-R Recommendations.

Note 2.— Throughout this handbook, extracts from the ITU Radio Regulations are presented against a shaded background.

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Chapter 1

INTRODUCTION

1.1 The radio frequency spectrum is a scarce natural resource with finite capacity limits and for which demand is constantly increasing. Predictions of future demand for spectrum indicate a continuing rate of increase for all users and radio services and facilities that utilize radio waves as the world economies progressively expand. The competition among all users for the spectrum available is hence expected to intensify in the years ahead. In this competitive situation, even a user holding a spectrum allocation will not have an automatic right to retain that radio frequency spectrum, as a decision by an International Telecommunication Union (ITU) conference may require that spectrum be removed from any radio service to meet a superior justified demand for other radio services. Aviation is only one of many such competitors, albeit with the significant benefit of a worldwide cooperative forum, namely the International Civil Aviation Organization (ICAO), to coordinate and support its case.

1.2 Aeronautical services are recognized internationally to be prime users of radio frequencies without which aircraft operations would not be capable of meeting the global demand for safe, efficient and cost-effective transport. The prominent safety-of-life element, present during all phases of an aircraft's flight, is accorded special treatment internationally and is granted protection from harmful interference through agreed measures. Aeronautical spectrum use in the main frequency bands amounts to around 14 per cent of the total available and is divided into two main functions: air-ground communications and radionavigation. The future will also see the gradual introduction of satellite-based services in accordance with the communications, navigation and surveillance/air traffic management (CNS/ATM) policies agreed at the Tenth Air Navigation Conference (1991) and approved by the ICAO Council.

1.3 Radio frequency spectrum congestion imposes on all users the duty of spectrum-efficient operation. The process of channel splitting, as employed in some aeronautical communication and navigation frequency bands, is an example of technological development helping to achieve spectrum-efficient operation and meeting future requirements without requiring additional spectrum. Modern sophisticated systems employing complex modulations are another facet of efficient spectrum use when transmitting more information within the same bandwidth. Extending radio services and systems into higher frequency bands is yet another. These measures will continue for the foreseeable future.

1.4 The process of international competition between expanding radio services obliges all existing users (i.e. aeronautical and non-aeronautical) to continually defend and justify the retention of frequency bands or the addition of new bands to those already allocated to their service, subject to the same conditions as apply in other services, civil aviation operations are expanding globally, requiring more navigation and communication facilities and thus creating additional pressures on the already stressed and limited spectrum availability. The civil aviation community must accordingly develop and present, as necessary, its agreed policies and its quantified and qualified statements of requirement for radio frequency spectrum so as to ensure the continuing availability of adequate radio spectrum and, ultimately, the on-going viability of air navigation services throughout the world.

1.5 This document contains a balanced and justified presentation of aviation needs, and it will be made available to all aviation interests involved in the frequency management process. It will be updated through regular amendments based on technological developments in communication, navigation and surveillance systems for aviation, changing operational requirements on the utilization of these systems. These updates also consider the decisions in the ITU, including amendments to the ITU Radio Regulations and the development of relevant ITU-R Recommendations and Reports.

Chapter 2

OBJECTIVES AND PURPOSE

2.1 The ITU is the specialized agency of the United Nations for telecommunication matters where international agreements are made on the use of the radio frequency spectrum. At World Radiocommunication Conferences (WRCs), convened about every three - four years, changes are made to the ITU Radio Regulations, including the Table of Frequency Allocations (Article 5 of the ITU Radio Regulations), on the basis of proposals made by States. This mechanism was introduced in 1992 in order to better adapt the Table of Frequency Allocations to rapid technological developments and spectrum requirements for all users of the radio frequency spectrum.

2.2 A consequence of this process is that a coordinated aeronautical position (the ICAO position) must be established for every ITU World Radiocommunication Conference and finalized well in advance of the ITU conference itself, in order to be of maximum use to aviation authorities. The ICAO position is intended to be used by civil aviation authorities in their national discussions with the radio regulatory authorities when developing proposals for submission by their administrations to meetings of Regional Telecommunication Organizations which prepare Regional positions for ITU Conferences as well as to the ITU Conferences themselves and to brief the delegations at these meetings. In addition, it is to be used by aviation experts at these conferences and is submitted by ICAO to the ITU conferences in the form of an information paper. The ICAO position contains the agreed radio frequency allocation requirements for aeronautical radio services, including the necessary protection from harmful interference, that are provided to support safety critical aeronautical communication, navigation and surveillance systems. The ICAO position, the ICAO spectrum strategy and the ICAO policy statements in this handbook are developed by the Air Navigation Commission, with the assistance of the Aeronautical Communications Panel (ACP) Working Group F and the Navigation System Panel (NSP), and approved by the ICAO Council. In developing the ICAO position, all ICAO Member States and relevant international organizations are consulted.

2.3 With this background, the prime objectives of this document are:

a) to provide a consolidated and up-to-date statement of agreed spectrum requirements for aeronautical services and the ICAO policy in the frequency bands used by international civil aviation for the communication, navigation and surveillance systems that are to be provided for air traffic purposes, taking into account all future needs;

b) to provide a source of reference for relevant ITU regulations, resolutions, recommendations and associated ITU-Radiocommunication Sector (ITU-R) material;

c) to provide a convenient record for important frequency management material, such as the criteria applied in the planning of radio frequency assignments, and the protection from interference; and

d) to provide background information on the international spectrum management institutional framework and the main ITU elements.

Chapter 3

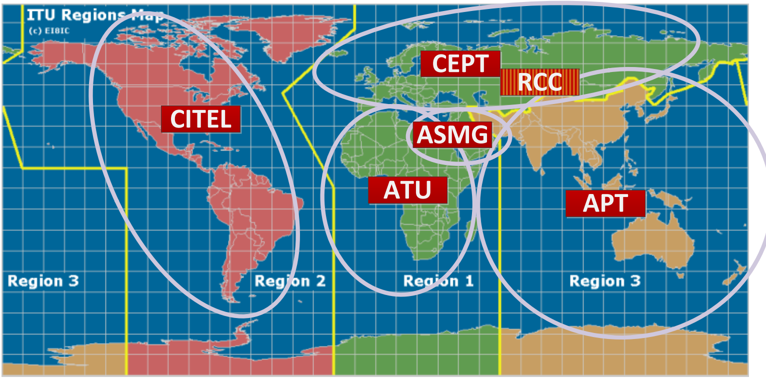
THE INTERNATIONAL TELECOMMUNICATION UNION

3.1 The ITU was created in 1932 by the fusion of the International Telegraph Union and the International Radio Telegraph Union, both international organizations of long-standing. In August 1947, the United Nations recognized the ITU as a specialized agency in the field of telecommunications, while acknowledging also that other specialized agencies, such as ICAO, would not be barred from any kind of work touching upon aeronautical telecommunications including standardization activities. The recognized competence of the ITU embraces all aspects of telecommunications, whether by line or by radio transmission, for which it has authority to set standards for systems, technical parameters and procedures. A prime and highly important area for aviation concerns the regulation and use of the radio frequency spectrum for which ITU is the recognized international body. The agreements made under its auspices for these matters and incorporated in the Final Acts of World Radiocommunication Conferences (which prior to 1993 were known as World Administrative Radio Conferences) are accorded treaty status and have full mandatory force without any possibility for variation in regard to their scope or their substance except by agreement at a further conference.

3.2 The basic treaty documents of the ITU (the ITU Constitution and the ITU Convention) are amended at Plenipotentiary Conferences which are held at intervals of four to six years. Between these conferences, the Administrative Council, with a membership not exceeding 25 per cent of the total number of members of the Union, performs a policy and management function. The Administrative Council normally meets once per year for a duration of two weeks. The representation from member administrations to ITU conferences and meetings is drawn from national telecommunication authorities representing all the radio services and users in their State. Consequently, policy and decisions at a national level are matters for these authorities.

3.3 The internationally agreed regulation of the radio frequency spectrum is provided in the ITU Radio Regulations, parts of which are reviewed at WRCs. Within the Radio Regulations the finite useable radio spectrum, from approximately 8.3 kHz to 275 GHz is allocated to user services (se Figure 3-3) in response to their recognized demands, and among three world regions (see Figure 3-1) in accordance with the major regional spectrum requirements for these services in the relevant Region. The allocations are contained in Article 5 of the Radio Regulations.

Together with other provisions on licensing, interference resolution, safety and distress procedures and other aspects, the Radio Regulations are the treaty requirements to be observed at all times by all radio services.



Approximate coverage of ITU Regions by regional telecommunication organizations

Figure 3-1. Map of ITU world regions

3.4 Within ITU Member States, the telecommunication authorities (or telecommunication administrations) normally control and operate the mechanism which develops the national proposals for amending the Radio Regulations for submission to the ITU WRCs. National and international (regional) preparatory committees function as the coordination medium to which the aviation requirements, either ICAO coordinated or nationally derived, are presented by the national aviation authorities for consideration. National policies which take into account all of the competing interests of radio frequency spectrum users to determine the States' proposals to the conference. It is essential that aeronautical participation in these activities be ensured in order to support and defend aviation requirements.

3.5 Aviation services are recognized important users of radio spectrum to create safe and expeditious conditions to support air operations. The aeronautical mobile (route) service (AM(R)S), the aeronautical radionavigation service (ARNS) and their satellite service counterparts are important components in the mobile and radiodetermination families of users (see Figure 3-3) with (normally) exclusive allocations made on a worldwide basis to ensure global harmonization. A summary overview of the use of spectrum by aviation is in Figure 3-2. World-wide allocations enable international standardization of equipment and systems to support safe and global air traffic. The Radio Regulations are used as the framework for the relevant ICAO Annexes and the Standards and Recommended Practices (SARPs) contained therein.

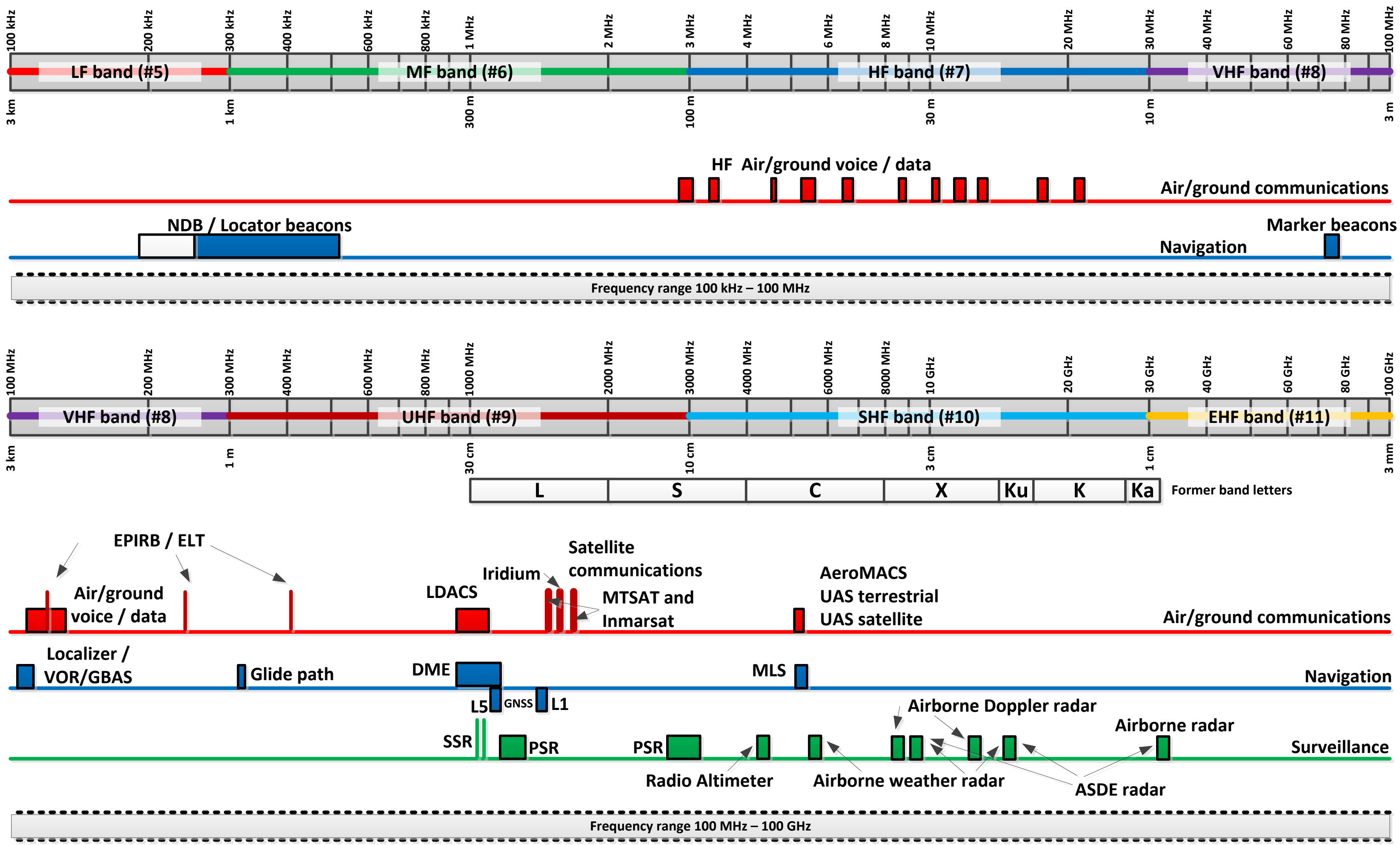
3.6 The Radio Regulations also regulate the prevention and removal of interference, whether between services, countries or regions, between frequency assignments, or from other sources of radiation such as industrial or medical equipment. Particular attention is accorded to services which have a predominant critical safety-of-life function, such as aeronautical services. This is reflected in special measures for rapid elimination of interference by national telecommunication authorities or, in case interference is affecting two or more States, through bilateral negotiations with authorities in these States. Other special measures such as the use of radio in distress and emergency situations or for search and rescue operations, in collaboration with maritime and land services as necessary, are also given prominent treatment.

3.7 In the radio field, the technical work of the ITU is performed on an on-going basis by the Radiocommunication Assembly, which is supported by the ITU Radiocommunication Sector (ITU-R) and the ITU Radiocommunication Study Groups (ITU-R SG). The ITU-R Study Groups support this technical work through the development of relevant ITU-R Recommendations or ITU-R Reports. Most aviation related issues are addressed in ITU_R Study Group 5 which deals with **all** mobile and mobile-satellite matters and with radionavigation. This work is important to aviation, particularly in relation to the development of ITU-R Recommendations addressing compatibility between aeronautical and non-aeronautical services with the view to prevent harmful interference to aeronautical use of radio frequency spectrum. In addition, the detailed technical preparations for the WRCs which are undertaken under the auspices of the Radiocommunication Bureau by the Conference Preparatory Meeting (CPM) is delegated to these Study Groups. The CPM functions as a permanent body using material developed by the ITU-R study groups or presented by administrations in developing the CPM Report to the WRC. The CPM Report provides information on the technical, operational and regulatory/procedural issues relevant to the WRC agenda items.

3.8 In response to its specialized responsibility and competence in civil aviation, ICAO has been accorded observer status (*"Observer in an advisory capacity"*, see Section 7-III.2) at all conferences and meetings held under ITU auspices, including ITU-R meetings. This enables ICAO to submit its internationally agreed statements on telecommunication policies and frequency use and ensures that the ICAO position and policy is propagated at these conferences and meetings and, to the maximum extent possible, to ensure that aeronautical allocations and frequency use, including future requirements, are safeguarded.

3.9 In order to coordinate frequency use and spectrum requirements within specific regions of the world, a number of regional bodies have been set up in a cooperative arrangement between telecommunication administrations. These are: the European Conference for Posts and Telecommunications (CEPT) for Europe, the Asia-Pacific Telecommunity (APT) for the Asia-Pacific region, the Comisión Interamericana de Telecomunicaciones (CITEL) for the Americas region, the African Telecommunications Union (ATU) for Africa, the Regional Commonwealth in the field of Communication (RCC) for Eastern Europe, and the Arab Spectrum Management Group (ASMG) for the Arab countries in the Middle East and North Africa. These Regional bodies have the capability, where agreed and necessary, to present joint proposals to ITU conferences, which would include, where appropriate, proposals addressing aeronautical allocations. A trend is appearing also where these bodies exercise joint influence on policies to promote their regional interest, often with a strong commercial motivation.

3.10 The ITU forum is of great importance to civil aviation interests and is increasing in importance with the emergence of new philosophies on spectrum sharing between different services and on jointly operated services, such as mobile-satellite services. In order to secure adequate spectrum for aviation, it is essential that the aviation position be rational, well considered and well presented in discussions that are becoming increasingly diverse, complex and commercial in their character and scope. The ITU, for its part, is expected to give due consideration to the globally coordinated civil aviation requirements and positions submitted by ICAO and to act accordingly in order to ensure the continued safety of the air transport operations worldwide.



Notes:
Drawing not to scale
Not all Regional or sub-Regional allocations are shown
Band identification (e.g. VHF) and band # per Radio Regulations
The satellite communication bands used by MTSAT and Inmarsat are not allocated the the Aeronautical Mobile Satellte (R) Service

Figure 3-2. Overview of spectrum allocation to aeronautical services

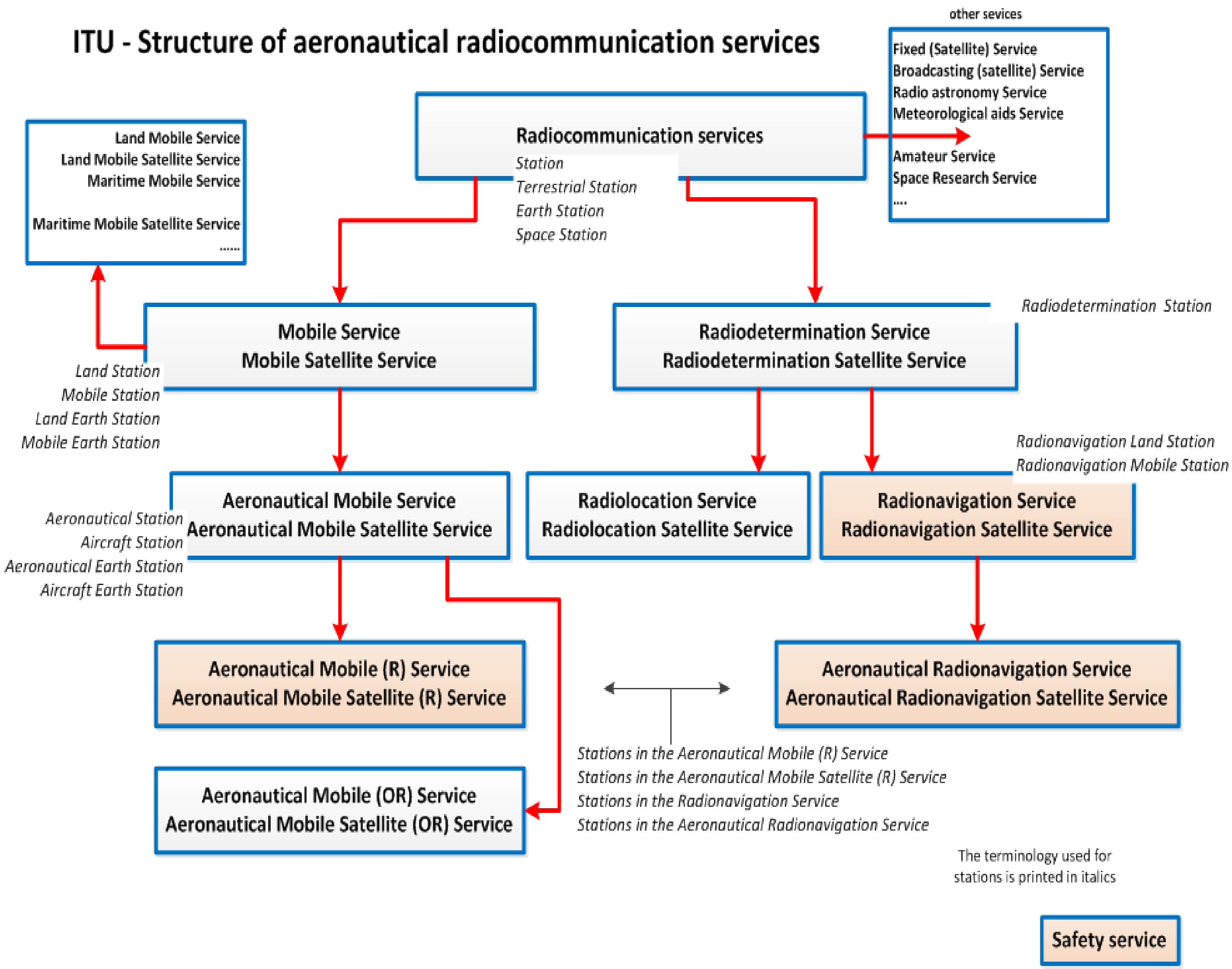


Figure 3-3 Radio services

Note: Allocations are made to services; Frequency assignments are made to stations

Chapter 4

THE ITU REGULATORY FRAMEWORK FOR AERONAUTICAL RADIO SERVICES

4.1 THE ITU RADIO REGULATIONS

4.1.1 The ITU Radio Regulations recognize aeronautical mobile and radionavigation services as separate services within the mobile services family and the radiodetermination family, respectively (see Figure 3-3). The distress and safety provisions in Chapter VII (Article 30) and the regulatory and operational aspects of the aeronautical mobile service in Chapter VIII (dealing with aeronautical services), as well as various other regulations of the Radio Regulations, establish aeronautical services as a distinct and important component within the radio service hierarchy with a high importance being placed on safety aspects.

4.1.2 For the purpose of allocating spectrum, three regions are defined in the Radio Regulations as in Figure 3-1. Allocations in the Table of Frequency Allocations (Article 5 of the Radio Regulations) can be made on a worldwide or regional basis. Sub-regional or country allocations are normally made through footnotes to this table. These "footnote" allocations have the same status as allocations appearing in the Table of Frequency Allocations.

4.1.3 A distinctive designation has been created between aeronautical mobile services provided for safety and regularity of flight (aeronautical mobile route (R) services) and those for other (non-safety) purposes (aeronautical mobile off-route (OR) services) to ensure the necessary protection of air traffic operations (safety and regularity). The convention employed in the Radio Regulations of according worldwide exclusive allocations to these services facilitates and promotes the development of globally agreed system specifications and interoperability as required in Article 37 of the ICAO Convention on International Civil Aviation. The ICAO SARPs, notably those in Annex 10, are the practical realization of this requirement.

4.1.4 This section of the handbook identifies elements of the Radio Regulations which define the context and status of aeronautical services incorporated in the Radio Regulations. Reference should be made, as appropriate, to the hierarchical organization of radio services at Figure 3-3 and to the extracts in Attachment A (definitions and terms used in the Radio Regulations).

4.2 COMMUNICATIONS

4.2.1 Aeronautical communications services are classified as:
Aeronautical communications services according to article 44 of the Radio Regulations are classified into 1 of 10 orders of priority where those in priority order 1-6 are regarded as safety and the remaining 4 non-safety. In practical terms this relates to the following:

a) safety communications requiring high integrity and rapid response:

   1) safety-related communications carried out by the air traffic services (ATS) for air traffic control (ATC), flight information and alerting; and

   2) communications carried out by aircraft operators, which also affect air transport safety, regularity and efficiency (AOC); and

b) non-safety related communications:

   1) private correspondence of aeronautical operators (aeronautical administrative communications (AAC)); and

   2) public correspondence (aeronautical passenger communications (APC)).

4.2.2 Allocations in the Table of Frequency Allocations (Article 5 of the Radio Regulations) are made to the:

a) aeronautical mobile service (AMS) defined in RR 1.32, this service is not appropriate for safety of life operations and is not considered further in this handbook;

b) aeronautical mobile (route) service (AM(R)S) defined in RR 1.33, with allocated band segments in the frequency range 2850 – 22000 kHz, and the frequency bands 108-117.975, 117.975-137 MHz, 960-1 164 MHz, 5 030-5 091 & 5 091-5 150 MHz ;

c) aeronautical mobile (off-route) service (AM(OR)S) defined in RR 1.34, this service is not appropriate for safety of life operations and is not considered further in this handbook;

d) no allocations have been made to the aeronautical mobile satellite service

(AMSS) defined in RR 1.32; this service is not appropriate for safety of life operations and is not considered further in this handbook; instead, the AMSS may operate under the (generic) mobile satellite service

e) aeronautical mobile-satellite (route) service (AMS(R)S) defined in RR 1.36 in the frequency bands 1610 – 1626.5 MHz and 5000 – 5150 MHz;

f) aeronautical mobile satellite (off-route) service (AM(OR)S) defined in RR 1.37, this service is not appropriate for safety of life operations and is not considered further in this handbook;

Note: No allocation to the Aeronautical Mobile Satellite (Route) Service in the band 1545 – 1555 MHz and 1646.5 – 1656.5 MHz has been made. For further information see Section 7-II, mobile satellite bands 1525 – 1559 MHz and 1626.5 – 1660.5 MHz.

4.2.3 All voice and data communications between aircraft and ground stations, with priority 1 to 6 as defined in RR 44.1, use frequencies from the bands under b) and e) above. The (R) designation (see RR 43.1) signifies the use along national and international civil air routes. The (OR) designation (see RR 43.2) signifies uses other than along national or international civil air routes and typically includes national defense. Public correspondence is not permitted in bands allocated exclusively to the aeronautical mobile service or the aeronautical mobile satellite service

4.2.4 In the 1 545–1 555 MHz and 1 646.5–1 656.5 MHz bands, the spectrum requirements of the AMS(R)S (i.e. all aeronautical communications with priorities between 1 and 6 in Article 44) shall be given priority in accommodating the spectrum requirements of the AMS(R)S. These categories of messages are the same as those in Annex 10, Volume II, Chapter 5, 5.1.8 a) to f). These AMS(R)S communications also have priority and immediate access over any other mobile-satellite communication operating within a network in these bands (see RR 5.357A and RR 5.362A, as well as Chapter 7-II (1 525–1 660.5 MHz) on mobile-satellite bands).

4.2.5 Chapter VIII of the Radio Regulations deals with certain licensing, regulatory and service operation aspects of the aeronautical mobile service and applies to all of the aeronautical mobile-satellite services, including the (R) and the (OR) components. A special mention at RR 35.1 and RR 35.1.1 recognizes the role which ICAO carries out through the SARPs in Annex 10 by according these superior status to that of the regulations mentioned in RR 35.1 which they may replace.

4.2.6 Appendix 27 to the Radio Regulations contains the Frequency Allotment Plan for the AM(R)S in the HF bands between 2 850 kHz and 22 000 kHz. This appendix contains the plan for HF frequency allotments to major world air route areas and to regional and domestic air route areas as well as VOLMET areas. It also includes worldwide frequency allotments, which are for the use of aircraft operating agencies for aeronautical operational control (AOC), to be assigned in accordance with provision 27/194A.

4.2.7 Article 39 of the Radio Regulations requires the operators of aircraft to produce, on request, the radio license for the installations on board an aircraft and the operator's certificate of competency. These regulations are in line with Article 30 of the ICAO Convention.

4.3 NAVIGATION & SURVEILLANCE

4.3.1 Allocations in the Table of Frequency Allocations (Article 5 of the Radio Regulations) for navigation and surveillance purposes are made to the:

— Radiodetermination-satellite service: defined in RR 1.41. This service is not appropriate for safety of life operations and hence is not considered further in this handbook

— Radionavigation service: defined in RR 1.42

— Aeronautical radionavigation service: defined in RR 1.46

— Radionavigation-satellite service: defined in RR 1.43

— Aeronautical radionavigation-satellite service: defined in RR 1.47

4.3.2 The definition for radionavigation services also includes those systems, such as radar, which contribute to the navigation of aircraft for ATC or which support other air navigation functions, such as radio altimeters and airborne weather radar.

4.3.3 Radionavigation services receive specific mention in the definition of harmful interference at RR 1.169, and in that of a safety service at RR 1.59. Radio Regulation 4.10 ensures that such harmful interference to radionavigation services receives the highest priority in measures to control and clear its effects.

4.3.4 Radiodetermination services, the generic service which includes radionavigation, are the subject of Article 28 of the Radio Regulations. Protection requirements for the planning of aeronautical radio beacons operating in the LF and MF bands are contained in Appendix 12 of these Regulations.

4.3.5 The practice in the aeronautical service of removal of the station identification to indicate a failure of service is expressly provided for in RR 19.10, and the requirements for call signs, including the formation of call signs, are contained in Article 19, Sections III and IV. These call signs are also use in aviation for the registration of aircraft.

4.4 RELATIONSHIP BETWEEN ITU RADIO REGULATIONS AND OTHER MATERIAL AND ICAO SARPS

4.4.1 Under its Constitution and Convention, the ITU is recognized as the authorative international body for telecommunications. The Radio Regulations are the instrument through which this specialization is expressed in internationally agreed terms for radio matters. These Radio Regulations, as presently constituted, lay down the agreed apportionment of the radio frequency spectrum to the various user services, including the aeronautical services. The Radio Regulations also define maximum radiation limits (e.g. for spurious or unwanted emissions) to support an interference-free radio environment. When necessary, this material is supplemented by ITU-R Recommendations. These, together with a broad regulatory framework covering, in particular, licensing of radio stations, personnel, provisions for inspection on demand, and procedures for safety and distress, create the basis for a universal system of order in the use of radio frequencies.

4.4.2 The Radio Regulations have treaty status, and there is an inherent obligation on States to comply, unless an exception is stated and embodied in the Final Acts of the Conference which created the regulation. Such statements appear in the published version of the Final Acts. Aeronautical services are obliged to operate within the framework established by the Radio Regulations.

4.4.3 The ICAO SARPs in Annex 10 are developed in accordance with Article 37 of the ICAO Convention for the purpose of ensuring the safety and regularity of air navigation. In addition to the Radio Regulations, the SARPs specify interface and performance standards for internationally agreed aeronautical systems which have been developed by aviation to meet the specific operational requirements of aeronautical services. ICAO is recognized internationally as the competent international body to carry out this work and to coordinate a worldwide policy for the operational use of the specified systems. Furthermore, the ICAO Annexes contain procedures for regular and emergency communications that are specifically developed for aviation purposes, taking account of the operational conditions. These procedures supplement the basic requirements of the Radio Regulations for procedures in aeronautical communications.

4.4.4 The Radio Regulations and ICAO SARPs together thus form a complementary set of regulatory provisions without any overlap. The Radio Regulations must evolve within the general telecommunications environment with its many and diverse users of the radio frequency spectrum, while the ICAO SARPs respond to the operational safety aspects of air navigation and are developed and agreed by aviation within the ICAO organizational framework.

4.5 FREQUENCY COORDINATION AND REGISTRATION

The coordination and registration of frequency assignments is the prerogative of the ITU and must be performed in accordance with procedures laid down in the Radio Regulations. Frequencies are registered in the Master International Frequency Register (MIFR) maintained at ITU Headquarters in Geneva. With the increasing practice of the sharing of frequency bands by more than one service, coordination assumes an increasing importance in ensuring compatible use.

In exclusive aeronautical bands, actual (day-to-day) coordination of frequency assignments is being undertaken by ICAO, through the ICAO Regional Offices. To support this coordination, the ICAO Regional Offices have developed the necessary procedures, including the relevant frequency assignment planning criteria. A global frequency assignment plan, based on the frequency assignment planning in the ICAO Regional Offices is being developed. Coordination of frequency assignments is taking place (in most cases) with the national civil aviation authorities.

This procedure, however, does not dispense with the more general requirement for the coordination of a frequency assignment within the ITU and the registration of this frequency assignment in the MIFR, if international protection of that assignment is necessary. Such coordination and registration needs to take place through the radio regulator authorities in each country. Although in some cases aeronautical frequency assignments, notably those in HF and LF/MF bands, are registered by the countries operating these services, other frequency assignments,— particularly those in bands above 100 MHz — tend to be recorded only in national registers or in the ICAO Regional Air Navigation Plans. Because of this, de facto, the ICAO frequency register is the authorative internationally agreed (within ICAO) list of coordinated frequency assignment for aviation in the following frequency bands:

255 – 526.5 MHz	NDB, Locator
108 – 117.975 MHz	ILS localizer, VOR, GBAS, VDL Mode 4
117.975 – 137 MHz	Air/ground voice (DSB/AM), VDL Mode 2 and 4
960 – 1215 MHz	DME (SSR)
5030 – 5091 MHz	MLS

Coordination and registration of frequency assignments in the HF bands (between 2850 – 22000 kHz) is only taking place through the ITU. However, ICAO is considering developing in parallel, a relevant ICAO list of HF frequency assignments.

Coordination and registration of frequency assignments for radar stations and on-board autonomous radionavigation systems is however NOT being coordinated through ICAO

Note: see also Chapter 5

4.6 ITU STANDARDS

In the case of system and equipment standards, those contained in ICAO Annexes are obligatory (although a difference is allowable in matters of non-major detail). On the other hand, ITU standards, as published in ITU-R or ITU-T specification documents, exist as recommendations only, except for the very few instances where a linked reference is placed in the Radio Regulations and compliance is mandatory. The technical characteristics for HF aviation equipment in Appendix 27 of the Radio Regulations, since they form part of the Radio Regulations, enjoy the same status as compulsory treaty obligations.

4.7 ITU RESOLUTIONS AND RECOMMENDATIONS

ITU Resolutions form part of the Radio Regulations and normally express a mandatory agreement among all of the ITU members to follow a particular course of action. ITU Recommendations, which are also part of the Radio Regulations, have no mandatory force and usually address matters of limited concern.

4.8 RADIO EQUIPMENT IN AIRCRAFT

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

Chapter 5

ICAO INVOLVEMENT IN FREQUENCY AND SPECTRUM PLANNING

5.1 ICAO is the United Nations specialized agency with recognized competence in matters related to aviation safety. Under Article 37 of the Convention on International Civil Aviation, ICAO is empowered to adopt and amend international SARPs for all aviation matters including aeronautical communications systems and air navigation aids. Under Article 37, the highest practicable degree of uniformity is seen as essential to facilitate and improve the safety of air navigation. Characteristics for radio communication and navigation systems are laid down in Annex 10 to the ICAO Convention, and the requirement for interoperability of systems on a global basis demands that frequency allocations be available worldwide and, preferably, also exclusive.

5.2 ICAO coordinates the input to ITU discussions on aeronautical radio frequency spectrum matters. In pursuance of this role, ICAO is accorded observer status at relevant ITU WRCs and also participates at meetings of the ITU-R study groups, including the Conference Preparatory Meetings which prepare the technical basis for WRCs. The range of this involvement includes aspects of common system technical standards, maximum levels of tolerable interference and measures to control and resolve interference incidents, frequency planning criteria, the preparation of frequency plans, and distress and safety procedures. The outcome of these discussions normally results in material being incorporated in the ITU Radio Regulations or in ITU-R Recommendations and subsequently being applied through national regulation by national telecommunication authorities.

5.3 Within ICAO, the necessary activity to support these ITU-generated functions exists at two levels:

a) at the worldwide level, through the work of the Air Navigation Commission, with the assistance of the ACP (Working Group F) and the NSP (and communication divisional meetings or air navigation conferences, as required), to prepare the coordinated ICAO policies, spectrum estimates and technical inputs for ITU conferences and ITU-R study groups. The ICAO spectrum strategy, policy statements and the ICAO position for WRCs are approved by the Council; and

b) at the regional level, by the ICAO Regional Offices, through coordination of frequency assignment plans with States, using agreed ICAO planning criteria. This activity is supported by the Regional Planning and Implementation Groups (PIRG).

5.4 Aviation representatives are generally included in States' delegations to ITU conferences where they have the important role of safeguarding the aviation position during the conference discussions. States' cooperation in this supporting role is an essential factor in securing the aviation requirements.

5.5 The repetitive (now three to four-year) cycle for ITU WRCs means that the ICAO position on the Conference agenda must be prepared within same time frame as national / Regional inputs to the Conference. This process is described in Attachment D to this handbook.

5.6 This handbook, which is updated through a rolling system of amendment action, provides the record of agreed ICAO policies, including the ICAO Spectrum Strategy and the ICAO Policy Statements.

5.7 The relationship between the radio regulatory activities and those of ICAO and Civil Aviation Authorities (CAAs) is given in Figure 5-1.

5.8 The strategy to improve States' support to the ICAO position at WRCs has been approved by the ICAO Council. This strategy is in Attachment E.

5.9 The ICAO position for WRC-15, as approved by the Council on xxxx, is in Attachment F and is to be considered at WRC-15.

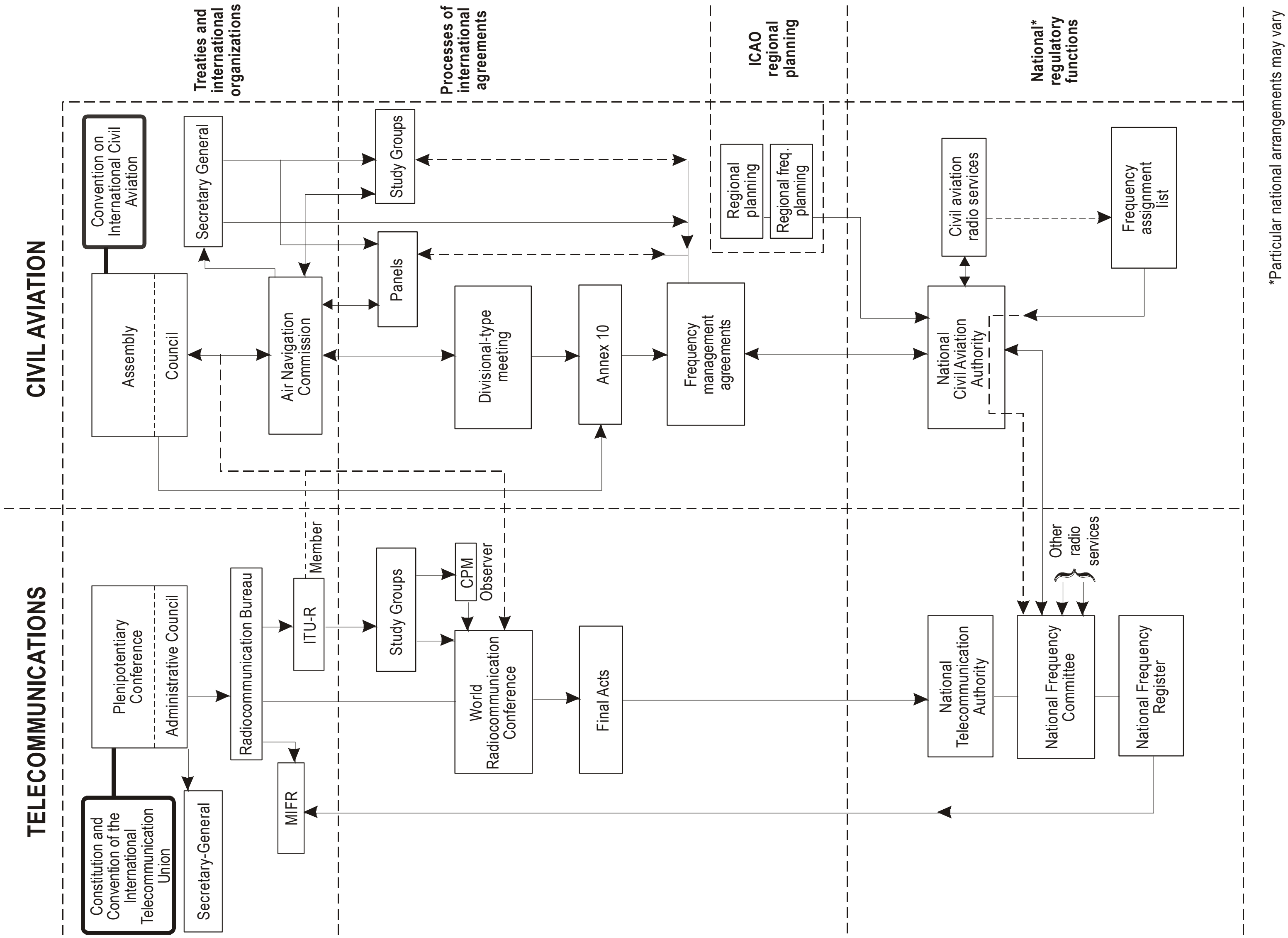


Figure 5-1. Frequency management institutional relationships

Chapter 6

OVERVIEW OF THE SPECTRUM MANAGEMENT PROCESS

6.1 GENERAL ASPECTS OF THE PROCESS

6.1.1 Civil aviation use of the radio frequency spectrum accounts for less than 14 per cent of the total, comparable to maritime use, but considerably less than other uses such as broadcast or national defense. The spectrum management process is designed to make the optimum use of this scarce spectrum resource. One of its main objectives is to create a universally agreed framework in which the demands for radio frequencies from individual countries are balanced with the interests of different service users to produce a planned radio environment incorporating an effective and efficient spectrum use. It has a necessary international dimension, which must be flexible and responsive to changing patterns of demand or to new technology, having scope for additional forms of transmissions and modulation methods.

6.1.2 With new technology, the useable spectrum expands over time, particularly in the higher frequency region, creating new possibilities and options. Spectrum expansion has limitations of scale and scope, however. Demand for spectrum continues to increase at a much faster rate than the frequency availability created from either extended spectrum boundaries or improved efficient use of the spectrum that is available (e.g. through reduced channel spacing). In its essentials, spectrum management combines separate disciplines, such as regulatory and control measures and technical (frequency assignment) planning, to achieve a reasonable compromise in dealing with the increasing demand for more spectrum. The current decade is expected to see this increase in demand rise sharply, particularly for broadband mobile applications and spectrum management problems will hence increase in complexity and scale.

6.1.3 In the context of this handbook, the management of the spectrum may be characterized by four main domains or areas of activity: the regulatory domain, the technical domain, the licensing domain and the registration domain, which are described below.

The regulatory domain

6.1.4 In this domain, the international agreements made within the ITU lay down a set of principles, rights and procedures, together with an institutional framework for their effective operation, which create the basis for an orderly international use of radio frequencies. The mechanism of the ITU (periodic radiocommunication conferences, the Radio Regulations Board and the Radiocommunication Bureau) maintains the permanent documents responsive to, and in line with, modern conditions.

6.1.5 The Radio Regulations, which have treaty status, are the cornerstone of the process. They contain the internationally agreed Table of Frequency Allocations and the agreed rules for its implementation, as well as the important international obligations for the operation of radio stations, licensing and other control measures for ensuring an effective regime of operation within the framework of the Radio Regulations.

6.1.6 The Radio Regulations primarily address regulatory aspects; technical material, usually of a more volatile character, is relegated to the Appendices to the Radio Regulations or to ITU-R Recommendations. Amendments to the Radio Regulations can only be made through a WRC, the Final Acts of which are agreed and signed at the conference, with the instrument of ratification to be deposited within the given time as specified in the Final Acts themselves. This regulatory basis, as contained in the ITU Constitution, Convention and Radio Regulations, is the starting point for the existence of a framework of stable international order and practical utility which is adhered to by all countries of the world.

The technical domain

6.1.7 In the final analysis, the effective use of the radio frequency spectrum is dependent on the expert technical planning of the frequency assignments used by the various services and systems. The main technical tools at the disposal of the spectrum manager are those in the hierarchical order of allocation planning, service sharing planning and, at the station level, the planning of assignments to particular locations.

6.1.8 The processes here are quantitative and exact, requiring careful examination and agreement between countries and service users. The concepts of acceptable interference and harmful interference, as contained in the regulatory rules, must be translated into practical limits and applied to achieve a service which meets all of its operational requirements. Different services require different amounts of bandwidth and can tolerate different levels of interference. Also, propagation conditions vary widely throughout the useable spectrum. Careful assessment and balancing of these degrees of freedom have to be applied to achieve optimum results. The ITU-R is the focus for the studies which lead to refined and workable criteria for sharing among services and for the development of international and national frequency plans.

6.1.9 Due to safety implications, however, civil aviation is, through ICAO, developing and planning most of the use of worldwide exclusive aeronautical frequency bands within its organizational structures, utilizing technical standards that have been adopted or approved within ICAO.

The licensing domain

6.1.10 Implementation of the basic ITU obligations for certification of system and personnel, licensing of stations, monitoring the observance of licence conditions and clearing interference are functions carried out at the national level under national law. These duties are normally exercised by national telecommunication administrations, which also provide the spectrum management expertise for national frequency planning and participate in international discussions on spectrum matters. Coordination among administrations is the usual mechanism for bilateral and multilateral discussions. The licensing actions generally also include equipment type approval against national or other specifications. The parameters checked include those having an effect on other users, such as frequency stability and spurious emissions, and system interoperability features. In the case of aviation equipment, conformity with Annex 10 may also be a licensing condition.

6.1.11 The licensing process is the controlling mechanism for the use and change of use of frequency bands, or for the exercise of sanctions in the case of license infringements. It also provides the opportunity to levy such charges as are necessary to support the spectrum management and regulation activity or to control demand.

6.1.12 Article 18 of the Radio Regulations requires that all stations be licensed by the government having authority over their operations. For aircraft, dispensations are granted in 18.8 for the specific instance of first delivery, and in 18.11 for wet and dry lease. Article 39 requires the station license to be available for inspection on demand at any time. Article 37 addresses operators' certificates for personnel in the aeronautical services. These basic telecommunications requirements have been included in Articles 29, 30 and 32 of the ICAO Convention.

The registration domain

6.1.13 The registration by countries of their assignments in an internationally agreed document is fundamental to the ITU principle of prior rights gained by earlier registration (first come – first serve), and the important obligation not to derogate the protection of existing registered assignments of other countries. The procedural rules are laid down in the Radio Regulations and the process of consultation and recording in the Master International Frequency Register (MIFR) is administered by the Radiocommunication Bureau. A comprehensive procedure for coordination, especially for space services, is a particular feature of these important provisions which have been developed and refined over many years.

6.1.14 The MIFR thus serves the dual purpose of a formal record and a planning guide for new assignments.

6.1.15 The predominant emphasis in all of these processes is that of the freedom of countries to use frequencies as they wish provided they do not affect other existing services and uses which have been established in accordance with the Regulations and registered in the MIFR. In keeping with these liberal principles, the ITU Convention contains no provisions for arbitration or for the referral of disputes to international adjudication. The settling of problems is hence treated as a matter for bilateral or multilateral resolution in the first instance, calling on informal assistance from the permanent organs of the ITU should this fail. Cases of failure, however, remain an insignificant proportion of the millions of operating radio services.

For the role of ICAO in frequency coordination and registration (in ICAO) see paragraph 4.5 and Chapter 5 above

6.2 ELEMENTS OF THE TECHNICAL DOMAIN

6.2.1 The technical planning of frequency assignments is the single most important element in the use of the spectrum. Advances in technology supporting more efficient use of the available radio frequency spectrum and in planning methods such as the use of computers) enable a more effective and efficient use of radio frequencies. Frequencies are technically managed and planned in accordance with a hierarchical process that involves the planning of allocations to radio services, the, determination of sharing conditions (with other services operating in the same or adjacent frequency bands) co-frequency and the actual frequency assignment planning.

Planning of frequency allocations

6.2.2 At the highest level is the planning of allocations of frequency bands to radio services, which are agreed internationally within ITU at WRCs and incorporated in the Table of Frequency Allocations (Article 5 of the Radio Regulations; see also Section 7-II). Allocations in the form of frequency bands are made to “services”, with the choice of grouping of services adopted in ITU (see Figure 3-3). Allocations are classified as primary or secondary, with the primary allocation taking precedence at all times over a secondary allocation should a conflict arise in registration or in implementation (see Section 7-II).

6.2.3 Allocations may be worldwide, as is the case with the majority of aeronautical services, or made to one or two of the three ITU world Regions (see Figure 3-1). Countries may make specific requests for sub-regional or country allocations, usually coordinated in advance with their neighbors. These allocations are normally incorporated in footnotes to the Table of Frequency Allocations.

6.2.4 Allocations may exceptionally also be translated by specific ITU conferences into frequency allotment or assignment plans and incorporated in ITU documents, e.g. Appendix 27 for the AM(R)S in HF bands, or Appendix 30 for broadcasting-satellite services. or the Final Acts of a conference that is developing a frequency assignment plan. It is more usual, however, for allocations to provide the basis for regional, area (sub-regional) or national frequency assignment planning.

6.2.5 Frequency assignment plans for aeronautical communications and navigation systems (with the exception of the HF bands) are usually developed and agreed regionally within ICAO, through the ICAO Regional Offices, using the planning criteria contained in the attachments to ICAO Regional Air Navigation Plans (see also paragraph 4.5).

Service sharing

6.2.6 Increasing pressure on the spectrum has led to an increased sharing of frequency bands by compatible primary services to the extent that sharing has become commonly used. ITU-R studies, which determine the sharing conditions between different services, may include a technical procedure for coordination purposes. Sharing between low-signal-level space services and other services, including on occasion aeronautical services, is often proposed. The results of the ITU-R studies are normally published in ITU-R Recommendations or ITU-R Reports.

Planning of frequency assignments

6.2.7 This activity follows on from allocation planning or sharing studies. Its purpose is to prepare frequency assignment plans between cooperating countries for their region or area, or by countries for application within national boundaries, or to identify individual assignments on a case-by-case basis. For terrestrial services, it employs the dimensions of frequency, distance and time separation in calculations which would use some or all of the following parameters:

- location of required service
- frequency of operation and transmission bandwidth
- power and directive gain of antenna
- propagation characteristics
- protection required by proposed service
- protection required by other existing services on same or adjacent frequencies
- time of day, season or year of operation.

A frequency assignment can be made when each new (or modified) frequency assignment simultaneously satisfies the protection requirement for each direction of transmission (the new/modified frequency assignment will not cause harmful interference to existing frequency assignments and in turn, existing frequency assignments shall not cause harmful interference to the new/modified frequency assignment). The task of creating and maintaining a frequency assignment plan for a region is usually extensive, requiring computer based tools. Assignments are made to transmitting stations subject to the requirement to protect the received signal in a given area (designated operational coverage) from harmful interference.

6.2.8 For space services, Article 9 of the Radio Regulations lays down comprehensive coordination procedures operated by the Radiocommunication Bureau. Acceptability is assessed using calculation methods and criteria contained in agreed ITU-R Recommendations. ICAO is normally not involved in the coordination of frequency assignments for space services.

6.2.9 Further guidance on frequency assignment planning and other technical material is in Volume II of this handbook.

6.3 THE ROLE OF TECHNOLOGY IN SPECTRUM MANAGEMENT

6.3.1 Technology plays a vital role in spectrum management in two ways:

a) it provides automated (computer based) assistance to the frequency assignment planning process, facilitating better analysis, performing more complex or repetitive calculations, maintenance and access to information and data on frequency use, and many other applications; and

b) through system improvements, it leads to improved utilization of radio frequency (RF) spectrum.

6.3.2 Modern communication and navigation systems, employing sophisticated RF modulation techniques, tighter system design parameters and improved interference rejection circuitry, promote more efficient frequency use and are now commercially available at economical prices. For example, the actual spectral occupancy of a single VHF communication channel in the AM(R)S band has been significantly improved by channel splitting on four occasions in the past fifty years; and has resulted in the availability of many extra channels in that band. The use of digital modulation techniques to replace analogue modulations may provide for another practical system improvement measure which, coincidentally, may lead to more efficient spectrum use.

6.3.3 Technology improvements remain the best possibility for meeting the anticipated demand for frequencies in the future.

6.4 AERONAUTICAL SERVICES

6.4.1 Aeronautical services are subject to all of the processes described above in the same general way as any other radio service. The allocations to the aeronautical mobile and aeronautical radionavigation services are part of the common spectrum resource for aviation and are required to be justified on a continuous basis, requesting additions when necessary and releasing frequencies which are no longer required.

6.4.2 The areas where the special role of radio in air operations is fully recognized, as noted above, are:

a) the technical control and management of the exclusive allocations to aeronautical services is carried out by aeronautical experts, both internationally and nationally, in a majority of countries. In these activities, ICAO performs a central coordinating function, providing the international forum for the review of needs for spectrum, the development of technical planning standards, and the registration of global use. National aviation experts participate fully in these activities.

b) equipment and system approval by aviation authorities, recognizing that ground systems must meet operational standards based on safety, and aircraft equipment must obtain type approval and airworthiness certification also based on safety requirements under national responsibilities emanating from the ICAO Convention; and

c) cases of interference to aeronautical radio services are treated in the Radio

Regulations as requiring special measures. National telecommunications administrations are required to take particular care in the licensing and operation of other services and industrial processes using radio waves which have the potential to endanger safety-of-life functions. In cases where harmful interference is experienced, ICAO can offer assistance in eliminating the interference.

6.5 SPECTRUM MANAGEMENT IN THE FUTURE

6.5.1 The worldwide demand for frequencies continues to increase, placing considerable pressures on the spectrum management process. Growth patterns vary between world regions, with developed economies experiencing expansion in (generic) mobile communications, both terrestrial and satellite, and in sound and television broadcasting. Elsewhere, fixed links for point-to-point communications are important in areas without an extensive ground-based (cable) infrastructure, or where radio services in large areas with difficult terrain have to be developed. Bandwidth efficient technologies can provide substantial gains in the amount of information processed per unit of bandwidth. Attention is also strongly focused on the release of spectrum no longer needed, or inefficiently used, or where the service concerned fails to argue the case for retention.

6.5.2 A result of this new trend is that spectrum earmarked for use at some point in the future, or where no plans exist for use, can no longer be retained, effectively creating a situation in which it may never be possible to successfully reinstate a claim. In this process, the aeronautical industry, with its long timescales for international agreement and coordination, is at a serious disadvantage compared to other users, particularly to those users where commercial considerations are prime. Instances of arbitrary forcible release of spectrum to such commercial services are expected to increase.

6.5.3 Demand is unlikely to be satisfied solely by the application of the procedures of administrative negotiation and agreement used in the past, in which majority support at ITU conferences has been the criterion for change. Further, there are practical limits to the technical sharing of frequencies between services (i.e. shared allocations) which in the final analysis often merely advances eventual saturation. Spectrum managers are therefore seeking fresh initiatives to provide more effective ways of awarding and recovering frequencies.

6.5.4 In some countries, procedures are being introduced in which the recognition of economic forces would play a controlling role. Spectrum award to the highest bidder and licensing costs are the parameters in which market forces will be applied to restrict demand, ration allocations, and affect the speedy return of frequencies no longer needed. While this is initially applicable to high-profile services, such as land mobile and broadcasting, and in congested areas, it will in the longer term affect aeronautical allocations, increasing the cost of licences and applying pressure to release under-used frequencies. Although there is some recognition that for any methodology to be completely viable it must take into account essential social and community services and protect their interests, this reasoning has not yet been extended to include aviation, which spectrum managers are coming to regard as just another type of commercial operation, albeit with some special safety connotations. Spectrum pricing, which is a levy on the use of radio frequency spectrum, is in some countries being extended to aeronautical spectrum.

6.5.5 Future aeronautical radio services are anticipated to make much greater use of bandwidth efficient systems through the application of modern technology for reduction of channel spacing, and increased channel capacity and digital technology. The overall effect of these technological improvements is to meet the expected increase in air traffic around the world in the years ahead, which in some areas is expected to double, and perhaps up to and beyond the year 2030 without any significant increase in spectrum. Introduction of new aeronautical systems or services may require additional frequency bands to be made available for aviation.

6.6 SPECTRUM MANAGEMENT SUMMARY

The objective of radio frequency spectrum management is to create a rational, controlled regime whereby the scarce radio frequency resource is planned in such a manner as to meet the competing and conflicting demands of all of the radio services intending to make use of it. It is characterized by an international treaty agreement within the ITU on the principles and objectives to be adhered to in pursuance of agreed international policies, which include, in particular, the following:

a) a complementary set of domains addressing the separate aspects of allocations, supporting regulations, technical planning, service licensing and frequency registration, embodied within an enabling set of agreed Radio Regulations;

b) the application of these agreed principles and measures within national territories by national telecommunication authorities. This process also includes the national coordination role for both implementation of international agreements and for the development of coordinated national proposals for the purpose of international negotiation and agreement;

c) the recognition that radio plays a vital role in the safe operation of aircraft, and the acceptance that aviation, through ICAO, may create standards for equipment and for frequency plans; and

d) the realization that technical and regulatory measures alone cannot meet all future demands of radio services for access to scarce frequencies. Present trends are leading to consideration of other means, including in particular the restriction of demand through the application of economic measures, such as administrative pricing and auction of frequency bands to the highest bidder.

Chapter 7

STATEMENT OF FREQUENCY ALLOCATIONS, TECHNICAL DETAILS AND ICAO POLICY

This chapter addresses the main subject matter in detail, structured as follows:

Section 7-I. List of frequency bands.

Section 7-II. Civil aviation frequency allocations — ICAO policies and related information (including a composite statement for each frequency band):

- allocation table;
- footnotes;
- ICAO policy;
- aviation use; and
- commentary.

Section 7-III. Radio Regulations and other ITU material of importance to aeronautical services including:

- identification of Regulations of importance to civil aviation; and
- ICAO policy.

Section 7-IV. Review of ITU Resolutions and Recommendations, including:

- reference to all Resolutions and Recommendations of the Radio Regulations affecting aeronautical services; and
- ICAO policy for each Resolution and Recommendation of the Radio Regulations.

SECTION 7-I. LIST OF FREQUENCY BANDS

Band	*Service*	*Aviation use*	*Section 7-II page no.*
*130–535 kHz	ARNS	NDB/locator	7-19
*2 850–22 000 kHz	AM(R)S	Air-ground communications (HF voice and data)	7-29
3 023 and 5 680 kHz	AM(R)S	Search and rescue	7-39
74.8–75.2 MHz	ARNS	Marker beacon	7-41
*108–117.975 MHz	ARNS AM(R)S	VOR/ILS localizer/ GBAS/VDL Mode 4	7-43
*117.975–137 MHz	AM(R)S	Air-ground and air-air communications (VHF voice and data)	7-51
121.5, 123.1 and 243 MHz	AM(R)S	Emergency frequencies	7-57
328.6–335.4 MHz	ARNS	ILS glide path	7-59
406–406.1 MHz	MSS	Search and rescue	7-61
*960–1 164 MHz	ARNS/RNSS AM(R)S	Air-ground communications/DME/UAT/ GNSS	7-65
1 030 and 1 090 MHz	ARNS	SSR/ACAS/ADSB	7-65
*1164–1 215 MHz	ARNS/RNSS	DME/GNSS	7-65
*1 215–1 400 MHz	RLS/RNSS ARNS	GNSS Primary surveillance radar	7-73
*1 525–1 559 MHz	MSS (s-E)**	Satellite communications	7-79
*1 610–1 626.5 MHz	AMS(R)S (s-E, E-s)	Satellite communications	7-79
*1 626.5–1 660.5 MHz	MSS (E-s)**	Satellite communications	7-79
*1 559–1 626.5 MHz	ARNS/RNSS/ MSS	GNSS	7-91
*2 700–3 300 MHz	ARNS/RNS/RLS	Primary surveillance radar	7-103
*4 200–4 400 MHz	ARNS	Radio altimeter	7-109

Band	*Service*	*Aviation use*	*Section 7-II page no.*
*5 000–5 250 MHz	ARNS AM(R)S AMS(R)S	MLS/UAS command and non-payload communication/airport surface communication/	7-111
*5 350–5 470 MHz	ARNS	Airborne weather radar	7-121
8 750–8 850 MHz	ARNS/RLS	Airborne Doppler radar	7-125
9 000–9 500 MHz	ARNS/RNS	Precision approach radar ASDE	7-127
13.25–13.4 GHz	ARNS	Airborne Doppler radar	7-131
15.4–15.7 GHz	ARNS/RLS	ASDE/other systems	7-133
24.25–24.65 GHz	RNS	ASDE	7-139
31.8–33.4 GHz	RNS	ASDE/Airborne radar	7-141

AM(R)S: Aeronautical mobile (route) service
AMS(R)S: Aeronautical mobile-satellite (route) service
ARNS: Aeronautical radionavigation service
MSS: Mobile-satellite service
RLS: Radiolocation service
RNS: Radionavigation service
RNSS: Radionavigation-satellite service

* A graphical presentation of the allocations of the aeronautical services, together with other services and relevant footnotes to which these bands are also allocated is in Figures 7-1 to 7-7.

** In the frequency bands 1 545–1 555 MHz and 1 646.5– 1 656.5 MHz, priority is supposed to be given to accommodating the spectrum requirements of the aeronautical mobile-satellite (R) service providing transmission of messages with priority 1 to 6 as defined in Article 44; no allocation to AMS(R)S has been made in this frequency band

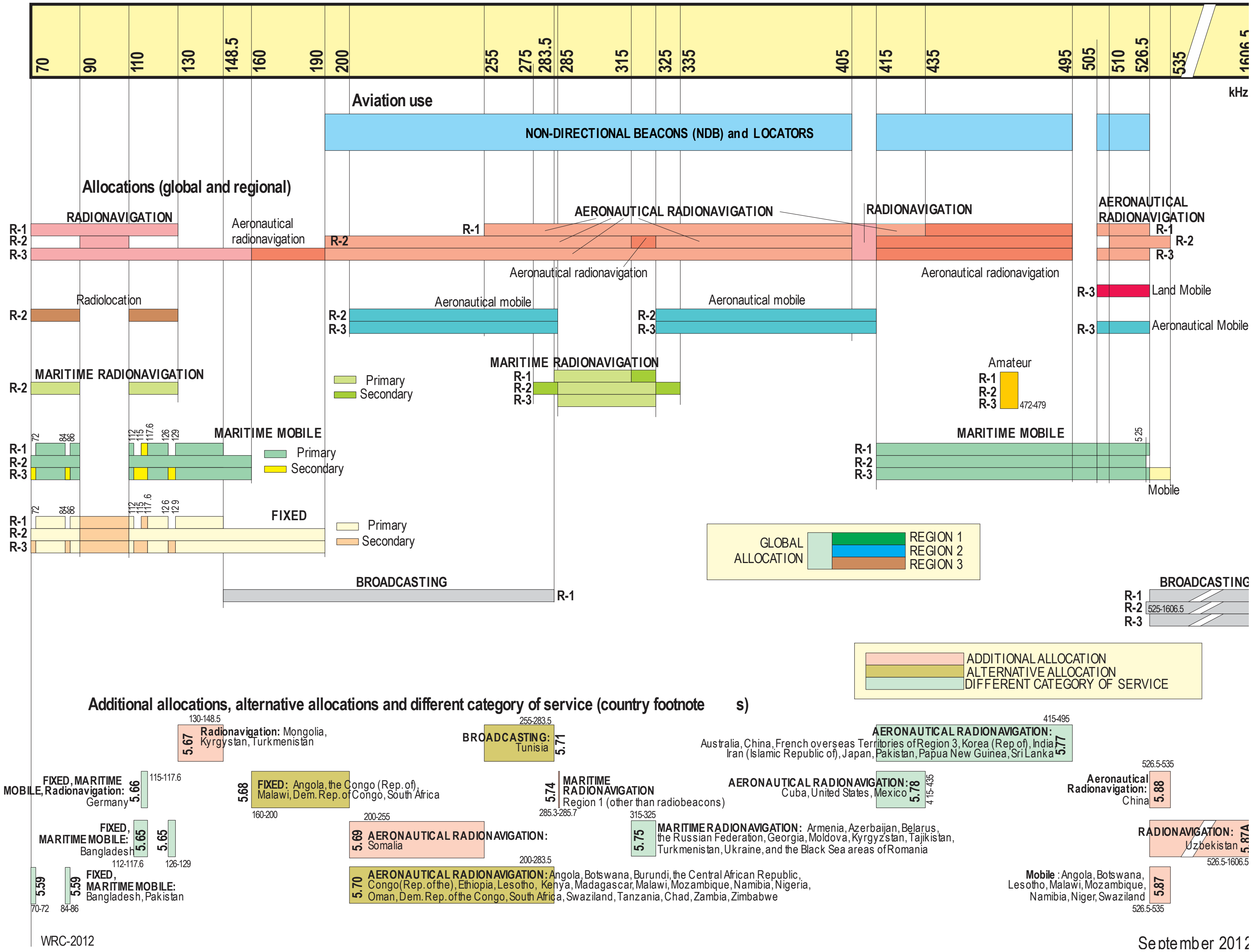


Figure 7-1. 70–1 606.5 kHz

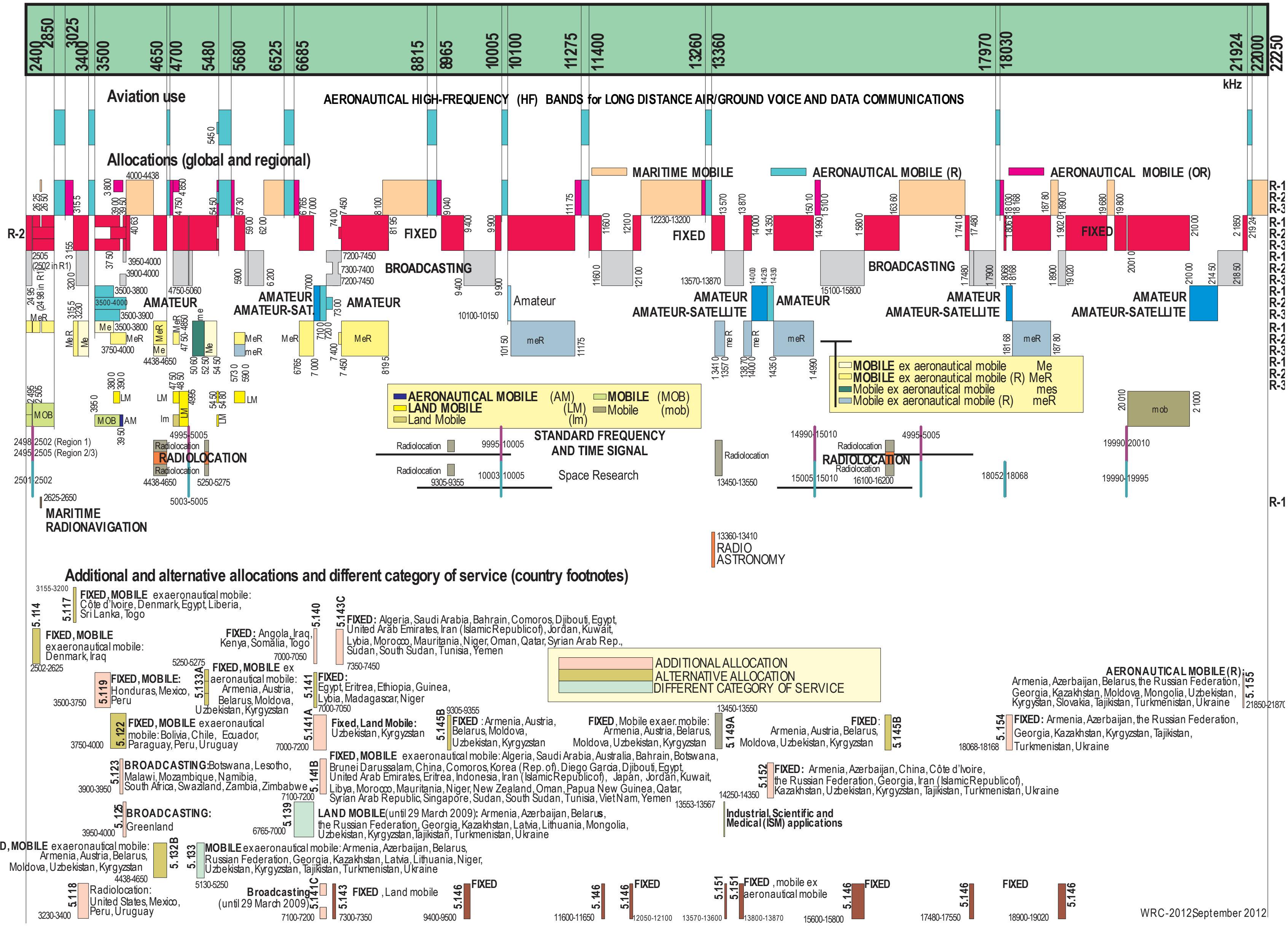


Figure 7-2. 2 400–22 250 kHz

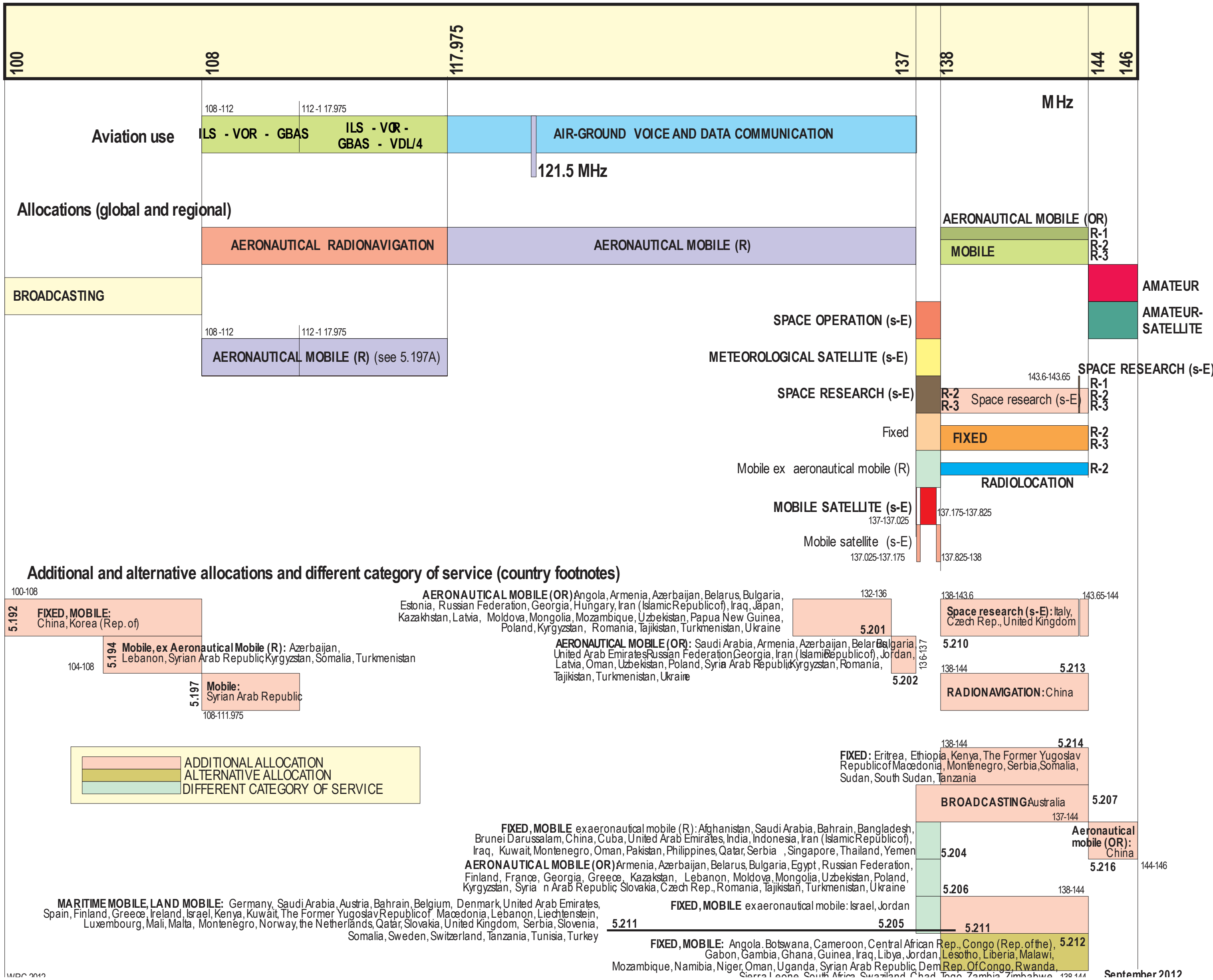


Figure 7-3. 100–146 MHz

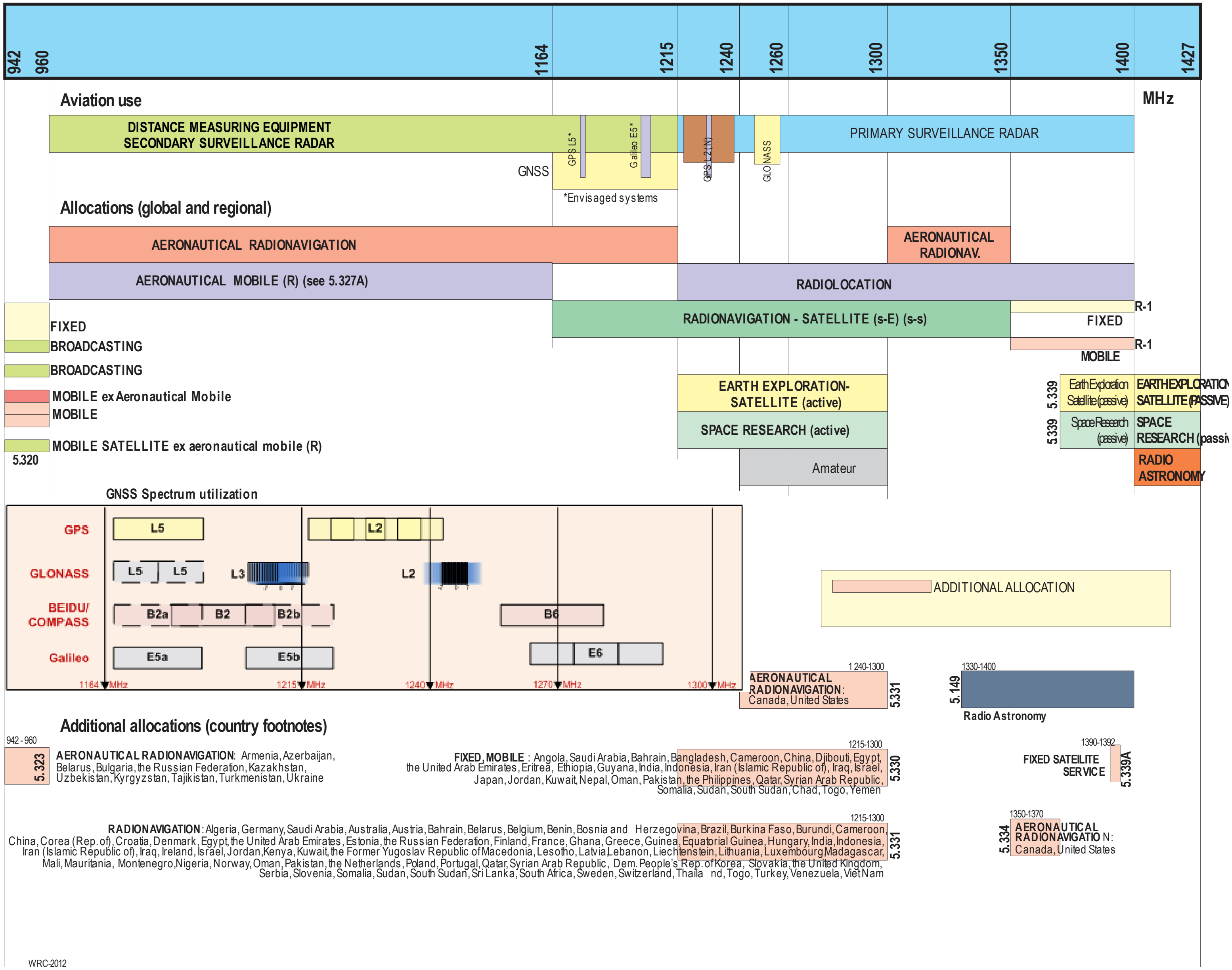


Figure 7-4. 942–1 427 MHz

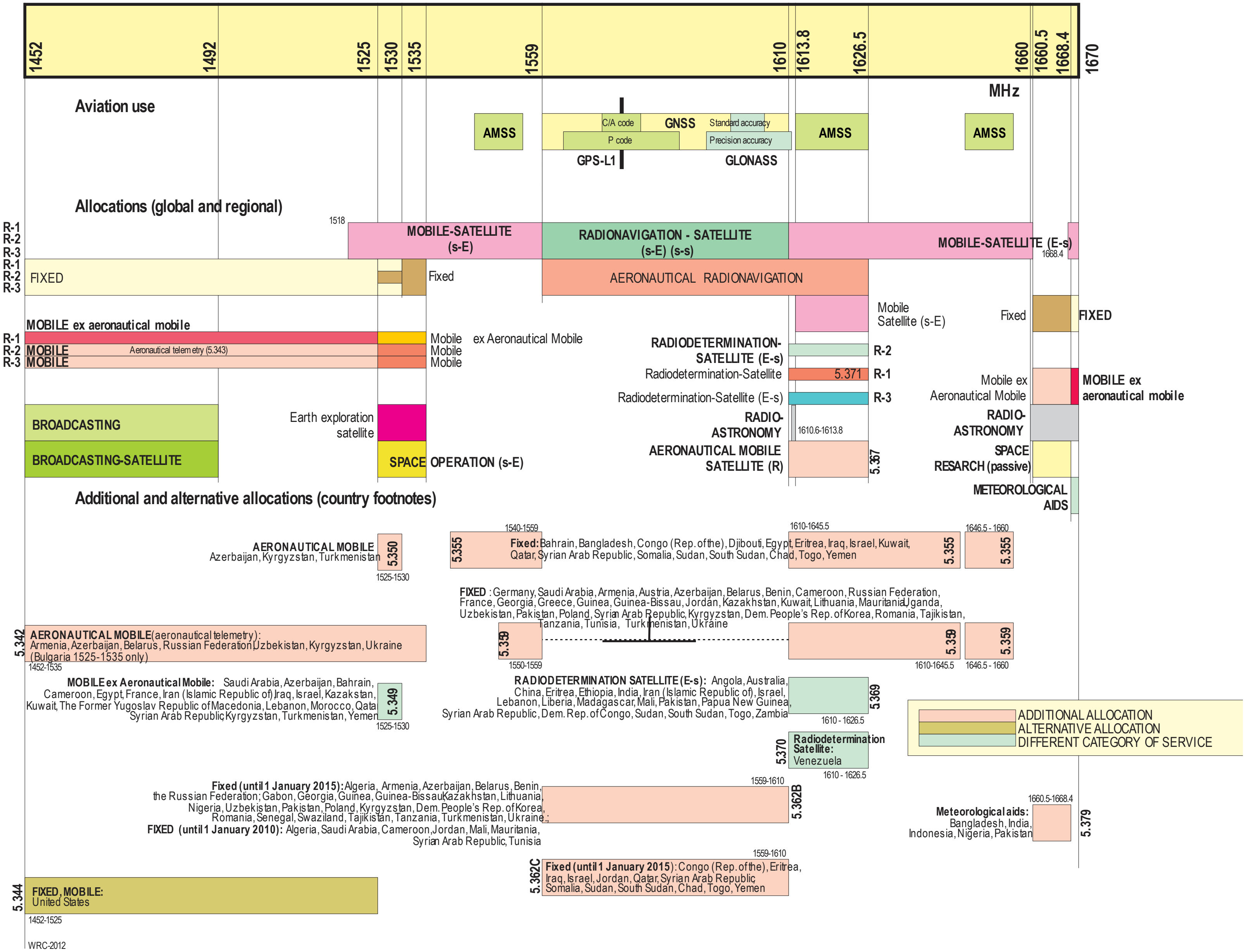


Figure 7-5. 1 452–1 670 MHz

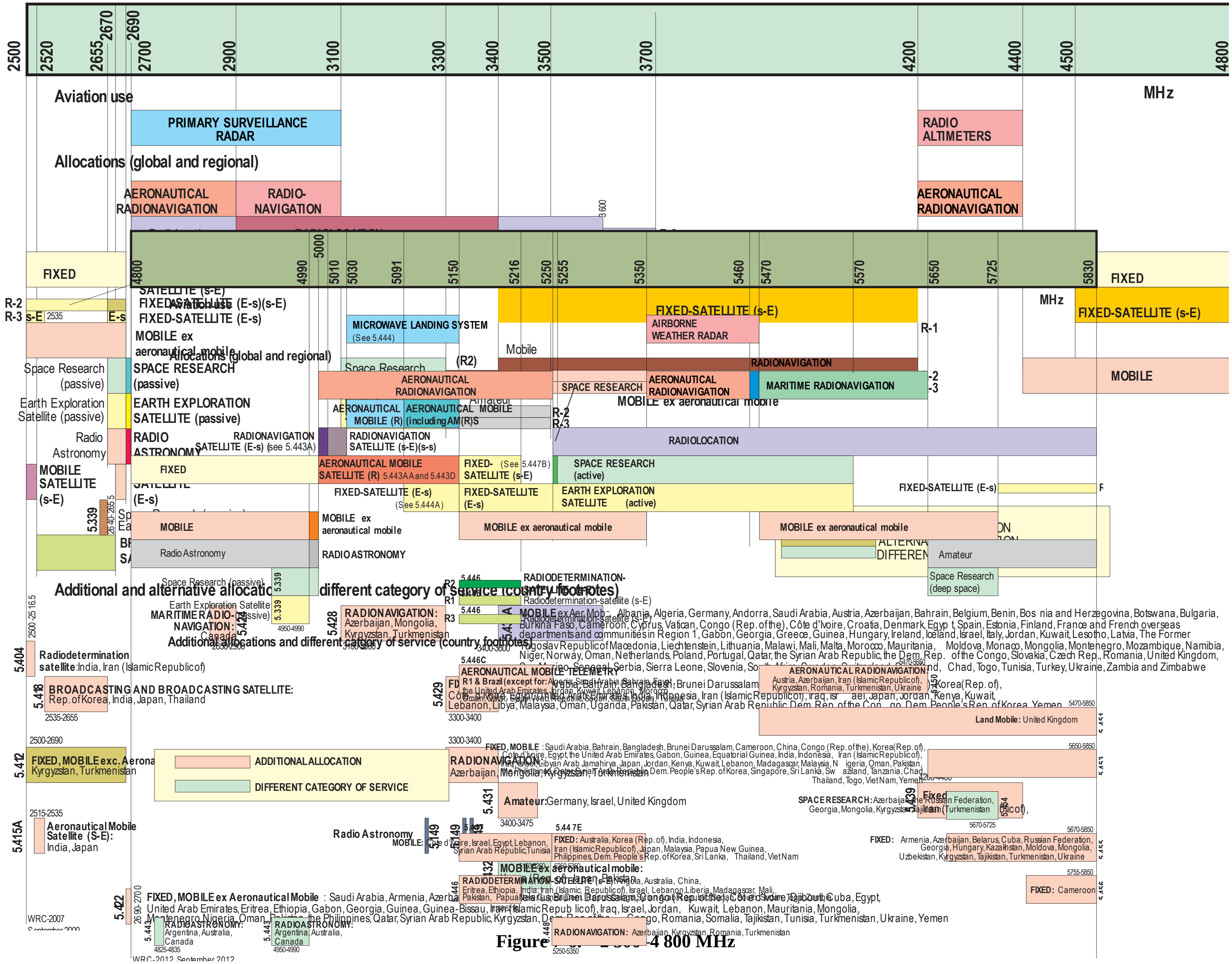


Figure 7-9. 2 500–4 800 MHz

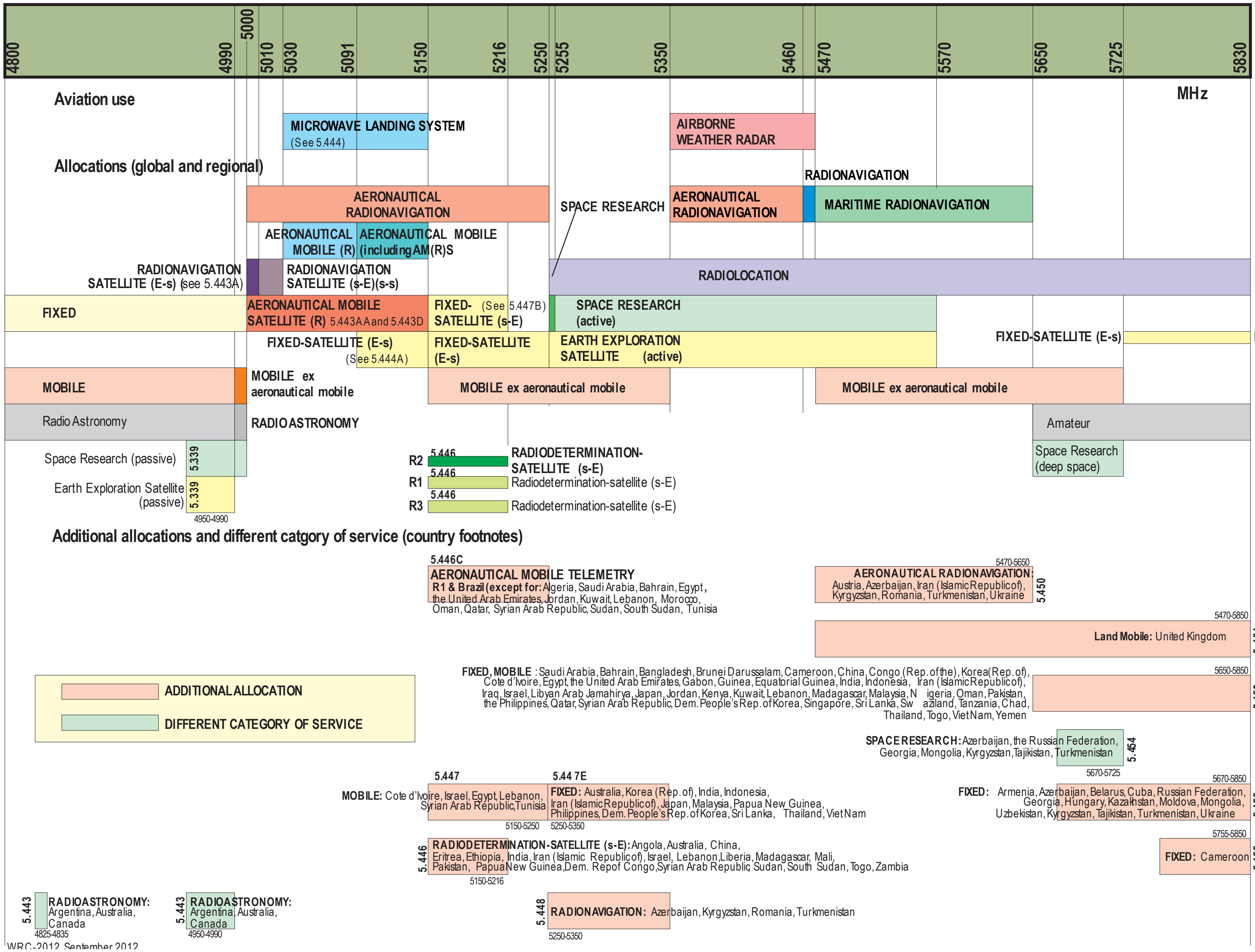


Figure 7-7. 4 800–5 830 MHz

SECTION 7-II. CIVIL AVIATION FREQUENCY ALLOCATIONS — ICAO POLICY STATEMENTS AND RELATED INFORMATION

(including a composite statement for each frequency band)

The following material is reproduced from Article 5 of the ITU Radio Regulations to provide necessary information on the regulatory basis of the Table of Frequency Allocations.

Note 1.— Extracts from the ITU Radio Regulations are presented against a shaded background.

Note 2.— This edition incorporates the changes to the Radio Regulations adopted at WRC-07.

ARTICLE 5
FREQUENCY ALLOCATIONS

5.1 In all documents of the Union where the terms allocation, allotment and assignment are to be used, they shall have the meaning given them in Nos. **1.16** to **1.18**, the terms used in the three working languages being as follows:

Frequency distribution to	French	English	Spanish
Services	Attribution (attribuer)	Allocation (to allocate)	Atribución (atribuir)
Areas or countries	Allotissement (allotir)	Allotment (to allot)	Adjudicación (adjudicar)
Stations	Assignation (assigner)	Assignment (to assign)	Asignación (asignar)

Section I. Regions and Areas

5.2 For the allocation of frequencies the world has been divided into three Regions* as shown on the following map and described in Nos. 5.3 to 5.9.

Note 1.— The map is reproduced in Figure 3-1 of this handbook.

Note 2.— 5.3 to 5.22 are not included in this handbook.

*5.2.1 It should be noted that where the words “regions” or “regional” are without a capital “R” in these Regulations, they do not relate to the three Regions here defined for purposes of frequency allocation.

. . .

Section II. Categories of Services and Allocations

5.23 *Primary and secondary services*

5.24 1) Where, in a box of the Table in Section IV of this Article, a band is indicated as allocated to more than one service, either on a worldwide or Regional basis, such services are listed in the following order:

5.25 a) services the names of which are printed in “capitals” (example: FIXED); these are called “primary” services;

5.26 b) services the names of which are printed in “normal characters” (example: Mobile); these are called “secondary” services (see Nos. **5.28** to **5.31**).

5.27 2) Additional remarks shall be printed in normal characters (example: MOBILE except aeronautical mobile).

5.28 3) Stations of a secondary service:

5.29 a) shall not cause harmful interference to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date;

5.30 b) cannot claim protection from harmful interference from stations of a primary service to which frequencies are already assigned or may be assigned at a later date;

5.31 c) can claim protection, however, from harmful interference from stations of the same or other secondary service(s) to which frequencies may be assigned at a later date.

5.32 4) Where a band is indicated in a footnote of the Table as allocated to a service “on a secondary basis” in an area smaller than a Region, or in a particular country, this is a secondary service (see Nos. **5.28** to **5.31**).

5.33 5) Where a band is indicated in a footnote of the Table as allocated to a service “on a primary basis”, in an area smaller than a Region, or in a particular country, this is a primary service only in that area or country.

5.34 *Additional allocations*

5.35 1) Where a band is indicated in a footnote of the Table as “also allocated” to a service in an area smaller than a Region, or in a particular country, this is an “additional” allocation, i.e. an allocation which is added in this area or in this country to the service or services which are indicated in the Table (see No. **5.36**).

5.36 2) If the footnote does not include any restriction on the service or services concerned apart from the restriction to operate only in a particular area or country, stations of this service or these services shall have equality of right to operate with stations of the other primary service or services indicated in the Table.

5.37 3) If restrictions are imposed on an additional allocation in addition to the restriction to operate only in a particular area or country, this is indicated in the footnote of the Table.

5.38 *Alternative allocations*

5.39 1) Where a band is indicated in a footnote of the Table as “allocated” to one or more services in an area smaller than a Region, or in a particular country, this is an “alternative” allocation, i.e. an allocation which replaces, in this area or in this country, the allocation indicated in the Table (see No. **5.40**).

5.40 2) If the footnote does not include any restriction on stations of the service or services concerned, apart from the restriction to operate only in a particular area or country, these stations of such a service or services shall have an equality of right to operate with stations of the primary service or services, indicated in the Table, to which the band is allocated in other areas or countries.

5.41 3) If restrictions are imposed on stations of a service to which an alternative allocation is made, in addition to the restriction to operate only in a particular country or area, this is indicated in the footnote.

5.42 *Miscellaneous provisions*

5.43 1) Where it is indicated in these Regulations that a service or stations in a service may operate in a specific frequency band subject to not causing harmful interference to another service or to another station in the same service, this means also that the service which is subject to not causing harmful interference cannot claim protection from harmful interference caused by the other service or other station in the same service.

5.43A 1 *bis*) Where it is indicated in these Regulations that a service or stations in a service may operate in a specific frequency band subject to not claiming protection from another service or from another station in the same service, this means also that the service which is subject to not claiming protection shall not cause harmful interference to the other service or other station in the same service.

5.44 2) Except if otherwise specified in a footnote, the term “fixed service”, where appearing in Section IV of this Article, does not include systems using ionospheric scatter propagation.

5.45 Not used.

Section III. Description of the Table of Frequency Allocations

5.46 1) The heading of the Table in Section IV of this Article includes three columns, each of which corresponds to one of the Regions (see No. **5.2**). Where an allocation occupies the whole of the width of the Table or only one or two of the three columns, this is a worldwide allocation or a Regional allocation, respectively.

5.47 2) The frequency band referred to in each allocation is indicated in the left-hand top corner of the part of the Table concerned.

5.48 3) Within each of the categories specified in Nos. **5.25** and **5.26**, services are listed in alphabetical order according to the French language. The order of listing does not indicate relative priority within each category.

5.49 4) In the case where there is a parenthetical addition to an allocation in the Table, that service allocation is restricted to the type of operation so indicated.

5.50 5) The footnote references which appear in the Table below the allocated service or services apply to more than one of the allocated services, or to the whole of the allocation concerned.

5.51 6) The footnote references which appear to the right of the name of a service are applicable only to that particular service.

5.52 7) In certain cases, the names of countries appearing in the footnotes have been simplified in order to shorten the text.

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Band: 130–535 kHz
Service: Aeronautical radionavigation (NDB)
Allocation:

<table>
<tr><th colspan="3">kHz
130–255</th></tr>
<tr><td colspan="3">Allocation to services</td></tr>
<tr><td>Region 1</td><td>Region 2</td><td>Region 3</td></tr>
<tr><td>130–135.7
FIXED
MARITIME MOBILE

5.64 5.67</td><td>130–135.7
FIXED
MARITIME MOBILE

5.64</td><td>130–135.7
FIXED
MARITIME MOBILE
RADIONAVIGATION
5.64</td></tr>
<tr><td>135.7–137.8
FIXED
MARITIME MOBILE
Amateur 5.67A

5.64 5.67 5.67B</td><td>135.7–137.8
FIXED
MARITIME MOBILE
Amateur 5.67A

5.64</td><td>135.7–137.8
FIXED
MARITIME MOBILE
RADIONAVIGATION
Amateur 5.67A
5.64 5.67B</td></tr>
<tr><td>137.8–148.5
FIXED
MARITIME MOBILE

5.64 5.67</td><td rowspan="2">137.8–160
FIXED
MARITIME MOBILE

5.64</td><td rowspan="2">137.8–160
FIXED
MARITIME MOBILE
RADIONAVIGATION

5.64</td></tr>
<tr><td rowspan="3">148.5–255
BROADCASTING

5.68 5.69 5.70</td></tr>
<tr><td>160–190
FIXED</td><td>160–190
FIXED
Aeronautical Radionavigation</td></tr>
<tr><td colspan="2">190–200
AERONAUTICAL RADIONAVIGATION</td></tr>
</table>

<table>
<tr><th colspan="3">kHz
255 (200)–405</th></tr>
<tr><th colspan="3">Allocation to Services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td></td><td rowspan="2">200–275
AERONAUTICAL
RADIONAVIGATION
Aeronautical Mobile</td><td rowspan="4">200–285
AERONAUTICAL
RADIONAVIGATION
Aeronautical Mobile</td></tr>
<tr><td rowspan="2">255–283.5
BROADCASTING
AERONAUTICAL
RADIONAVIGATION

5.70 5.71</td></tr>
<tr><td rowspan="2">275–285
AERONAUTICAL
RADIONAVIGATION
Aeronautical Mobile
Maritime radionavigation
(radiobeacons)</td></tr>
<tr><td rowspan="2">283.5–315
AERONAUTICAL
RADIONAVIGATION
MARITIME
RADIONAVIGATION
(radiobeacons) 5.73

5.72 5.74</td></tr>
<tr><td colspan="2">285–315
AERONAUTICAL RADIONAVIGATION
MARITIME RADIONAVIGATION
(radiobeacons) 5.73</td></tr>
<tr><td>315–325
AERONAUTICAL
RADIONAVIGATION
Maritime radionavigation
(radiobeacons) 5.73

5.72 5.75</td><td>315–325
MARITIME
RADIONAVIGATION
(radiobeacons) 5.73
Aeronautical
radionavigation</td><td>315–325
AERONAUTICAL
RADIONAVIGATION
MARITIME
RADIONAVIGATION
(radiobeacons) 5.73</td></tr>
<tr><td rowspan="2">325–405
AERONAUTICAL
RADIONAVIGATION

5.72</td><td>325–335
AERONAUTICAL
RADIONAVIGATION
Aeronautical mobile
Maritime radionavigation
(radiobeacons)</td><td rowspan="2">325–405
AERONAUTICAL
RADIONAVIGATION
Aeronautical mobile</td></tr>
<tr><td>335–405
AERONAUTICAL
RADIONAVIGATION
Aeronautical mobile</td></tr>
</table>

Editorial notes: The Provisional Final Acts show that 5.72 is suppressed; however, this footnote was not deleted from the Table of Frequency Allocation

kHz 405–505		
Allocation to Services		
Region 1	Region 2	Region 3
405–415 RADIONAVIGATION 5.76 5.72	**405–415** RADIONAVIGATION 5.76 Aeronautical mobile	
415–435 MARITIME MOBILE 5.79 AERONAUTICAL RADIONAVIGATION	**415–472** MARITIME MOBILE 5.79 Aeronautical radionavigation 5.80 5.77 5.78 5.82	
435–472 MARITIME MOBILE 5.79 5.79A Aeronautical Radionavigation 5.77 5.82		
472-479 MARITIME MOBILE 5.79 Amateur 5.80A Aeronautical radionavigation 5.77 5.80 5.82 5.80B		
479–495 MARITIME MOBILE 5.79 5.79A Aeronautical radionavigation 5.77 5.82	**479–495** MARITIME MOBILE 5.79 5.79A Aeronautical radionavigation 5.80 5.77 5.82	
495–505	MARITIME MOBILE	

<table>
<tr><th colspan="3">kHz
505–535</th></tr>
<tr><th colspan="3">Allocation to Services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td rowspan="3">505–526.5
MARITIME MOBILE
5.79 5.79A 5.84

AERONAUTICAL
RADIONAVIGATION</td><td>505–510
MARITIME MOBILE
5.79</td><td rowspan="3">505–526.5
MARITIME MOBILE
5.79 5.79A 5.84

AERONAUTICAL
RADIONAVIGATION
Aeronautical Mobile
Land Mobile</td></tr>
<tr><td>510–525
MOBILE 5.79A 5.84

AERONAUTICAL
RADIONAVIGATION</td></tr>
<tr><td rowspan="2">525–535
BROADCASTING 5.86

AERONAUTICAL
RADIONAVIGATION</td></tr>
<tr><td></td><td>526.5–535
BROADCASTING
Mobile

5.88</td></tr>
</table>

Footnotes:

5.64 Only classes A1A or F1B, A2C, A3C, F1C or F3C emissions are authorized for stations of the fixed service in the bands allocated to this service between 90 kHz and 160 kHz (148.5 kHz in Region 1) and for stations of the maritime mobile service in the bands allocated to this service between 110 kHz and 160 kHz (148.5 kHz in Region 1). Exceptionally, class J2B or J7B emissions are also authorized in the bands between 110 kHz and 160 kHz (148.5 kHz in Region 1) for stations of the maritime mobile service.

5.67 *Additional allocation*: in Mongolia, Kyrgyzstan and Turkmenistan, the band 130–148.5 kHz is also allocated to the radionavigation service on a secondary basis. Within and between these countries this service shall have an equal right to operate. (WRC-07)

5.67A Stations in the amateur service using frequencies in the band 135.7–137.8 kHz shall not exceed a maximum radiated power of 1 W (e.i.r.p.) and shall not cause harmful interference to stations of the radionavigation service operating in countries listed in No. **5.67**. (WRC-07)

5.67B The use of the band 135.7–137.8 kHz in Algeria, Egypt, Iran (Islamic Republic of), Iraq, Lebanon, Syrian Arab Republic, Sudan, South Sudan and Tunisia is limited to the fixed and maritime mobile services. The amateur service shall not be used in the above-mentioned countries in the band 135.7–137.8 kHz, and this should be taken into account by the countries authorizing such use. (WRC-12)

5.68 *Alternative allocation*: in Angola, Congo (Rep. of the), Malawi, the Dem. Rep. of the Congo, and South Africa, the band 160–200 kHz is allocated to the fixed service on a primary basis. (WRC-12)

5.69 *Additional allocation*: in Somalia, the band 200–255 kHz is also allocated to the aeronautical radionavigation service on a primary basis.

5.70 *Alternative allocation*: in Angola, Botswana, Burundi, the Central African Rep., Congo (Rep. of the), Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Nigeria, Oman, the Dem. Rep. of the Congo, South Africa, Swaziland, Tanzania, Chad, Zambia and Zimbabwe, the band 200–283.5 kHz is allocated to the aeronautical radionavigation service on a primary basis. (WRC-12)

5.71 *Alternative allocation*: in Tunisia, the band 255–283.5 kHz is allocated to the broadcasting service on a primary basis.

5.72 (SUP – WRC-12)

5.73 The band 285–325 kHz (283.5–325 kHz in Region 1), in the maritime radionavigation service may be used to transmit supplementary navigational information using narrow-band techniques, on condition that no harmful interference is caused to radiobeacon stations operating in the radionavigation service.

5.74 *Additional allocation*: in Region 1, the frequency band 285.3–285.7 kHz is also allocated to the maritime radionavigation service (other than radiobeacons) on a primary basis.

5.75 *Different category of service*: in Armenia, Azerbaijan, Belarus, the Russian Federation, Georgia, Moldova, Kyrgyzstan, Tajikistan, Turkmenistan, Ukraine and the Black Sea areas of Romania, the allocation of the band 315–325 kHz to the maritime radionavigation service is on a primary basis under the condition that in the Baltic Sea area, the assignment of frequencies in this band to new stations in the maritime or aeronautical radionavigation services shall be subject to prior consultation between the administrations concerned. (WRC-07)

5.76 The frequency 410 kHz is designated for radio direction-finding in the maritime radionavigation service. The other radionavigation services to which the band 405–415 kHz is allocated shall not cause harmful interference to radio direction-finding in the band 406.5–413.5 kHz.

5.77 *Different category of service*: in Australia, China, the French Overseas Communities of Region 3, Korea (Rep. of), India, Iran (Islamic Republic of), Japan, Pakistan, Papua New Guinea and Sri Lanka, the allocation of the frequency band 415–495 kHz to the aeronautical radionavigation service is on a primary basis. In Armenia, Azerbaijan, Belarus, the Russian Federation, Kazakhstan, Latvia, Uzbekistan and Kyrgyzstan, the allocation of the frequency band 435-495 kHz to the aeronautical radionavigation service is on a primary basis. Administrations in all the aforementioned countries shall take all practical steps necessary to ensure that aeronautical radionavigation stations in the frequency band 435–495 kHz do not cause interference to reception by coast stations of transmissions from ship stations on frequencies designated for ship stations on a worldwide basis. (WRC-12)

5.78 *Different category of service*: in Cuba, the United States of America and Mexico, the allocation of the band 415–435 kHz to the aeronautical radionavigation service is on a primary basis.

5.79 The use of the bands 415–495 kHz and 505–526.5 kHz (505–510 kHz in Region 2) by the maritime mobile service is limited to radiotelegraphy.

5.79A When establishing coast stations in the NAVTEX service on the frequencies 490 kHz, 518 kHz and 4 209.5 kHz, administrations are strongly recommended to coordinate the operating characteristics in accordance with the procedures of the International Maritime Organization (IMO) (see Resolution **339 (Rev. WRC-07)**). (WRC-07)

5.80 In Region 2, the use of the band 435–495 kHz by the aeronautical radionavigation service is limited to non-directional beacons not employing voice transmission.

5.80A The maximum equivalent isotropically radiated power (e.i.r.p.) of stations in the amateur service using frequencies in the band 472-479 kHz shall not exceed 1 W. Administrations may increase this limit of e.i.r.p. to 5 W in portions of their territory which are at a distance of over 800 km from the borders of Algeria, Saudi Arabia, Azerbaijan, Bahrain, Belarus, China, Comoros, Djibouti, Egypt, United Arab Emirates, the Russian Federation, Iran (Islamic Republic of), Iraq, Jordan, Kazakhstan, Kuwait, Lebanon, Libya, Morocco, Mauritania, Oman, Uzbekistan, Qatar, Syrian Arab Republic, Kyrgyzstan, Somalia, Sudan, Tunisia, Ukraine and Yemen. In this frequency band, stations in the amateur service shall not cause harmful interference to, or claim protection from, stations of the aeronautical radionavigation service.

5.80B The use of the frequency band 472-479 kHz in Algeria, Saudi Arabia, Azerbaijan, Bahrain, Belarus, China, Comoros, Djibouti, Egypt, United Arab Emirates, the Russian Federation, Iraq, Jordan, Kazakhstan, Kuwait, Lebanon, Libya, Mauritania, Oman, Uzbekistan, Qatar, Syrian Arab Republic, Kyrgyzstan, Somalia, Sudan, Tunisia and Yemen is limited to the maritime mobile and aeronautical radionavigation services. The amateur service shall not be used in the above-mentioned countries in this frequency band, and this should be taken into account by the countries authorizing such use.

5.82 In the maritime mobile service, the frequency 490 kHz is to be used exclusively for the transmission by coast stations of navigational and meteorological warnings and urgent information to ships, by means of narrow-band direct-printing telegraphy. The conditions for use of the frequency 490 kHz are prescribed in Articles **31** and **52**. In using the frequency band 415–495 kHz for the aeronautical radionavigation service, administrations are requested to ensure that no harmful interference is caused to the frequency 490 kHz. In using the frequency band 472-479 kHz for the amateur service, administrations shall ensure that no harmful interference is caused to the frequency 490 kHz. (WRC-12)

5.84 The conditions for the use of the frequency 518 kHz by the maritime mobile service are prescribed in Articles **31** and **52**. (WRC-07)

5.86 In Region 2, in the band 525–535 kHz the carrier power of broadcasting stations shall not exceed 1 kW during the day and 250 W at night.

5.87 *Additional allocation*: in Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Niger and Swaziland, the band 526.5–535 kHz is also allocated to the mobile service on a secondary basis. (WRC-03)

5.87A *Additional allocation:* in Uzbekistan, the band 526.5–1 606.5 kHz is also allocated to the radionavigation service on a primary basis. Such use is subject to agreement obtained under No. **9.21** with administrations concerned and limited to ground-based radiobeacons in operation on 27 October 1997 until the end of their lifetime.

5.88 *Additional allocation*: in China, the band 526.5–535 kHz is also allocated to the aeronautical radionavigation service on a secondary basis.

ICAO POLICY:

- No change to 5.70, 5.80 and 5.86.
- In regions where the global navigation satellite system (GNSS) is implemented and non-directional radio beacon (NDB) assignments are withdrawn from international and national usage, aviation requirements for spectrum in these bands may be reduced.
- Until NDBs have been phased out, the current allocations to the aeronautical radionavigation service must be safeguarded.

On a global basis, the use of NDB beacons is expected to continue in the medium term and the long term subject to Regional or sub-Regional requirements. The use in general is stabilized and may be reduced over time as a result of on-going GNSS and RNAV implementation. However, the use of NDB and Locator beacons will continue subject to regional requirements (e.g. to provide a backup network to GNSS). No (significant) increase in frequency requirements for NDB and Locator beacons is expected; the aeronautical requirements can be met in the currently available frequency bands. Outer locators which are used in conjunction with the ILS and Marker Beacons are in a number of cases being replaced with DME. Parts of the bands used for NDB/Locator systems are shared with the amateur, broadcasting, maritime radionavigation and the maritime mobile services.

AVIATION USE: These bands support NDBs for short- and medium-range navigation. NDBs transmit non-directional signals in the low and medium frequency (LF/MF) bands, normally between 190 and 535 kHz. With appropriate automatic direction finder (ADF) equipment on board an aircraft, the pilot can determine the bearing of the station or can "home" on the station. The ADF receiver tuning range is normally between 190 and 1 750 kHz. NDBs are mainly used as a non-precision instrument approach aid, either in conjunction with an instrument landing system (ILS) (then designated as a "locator"), or to define air routes/airways. NDBs are extensively deployed at aerodromes for general aviation. Although NDBs are comparatively inexpensive navigation aids and relatively simple to install and maintain, bearing information derived from NDBs is not very precise and lightning, precipitation static, etc., cause intermittent or unreliable signals resulting in erroneous bearing information and/or large oscillations of the radio compass needle. NDBs are assigned frequencies on the basis of daytime propagation conditions.

Frequencies used for NDB are prone to night effects, whereby, due to ionosphere propagation (reflection), significant errors due to the reception of signals from distant NDBs may occur. This night effect increases with assigned frequency of operation.

Aeronautical NDBs at coastal locations are also used by the maritime service, and in the reverse sense, beacons provided for maritime purposes are potentially usable by aviation.

Frequency scarcity in ITU Region 1 (Europe and Africa) has been a cause for concern in the past. The 1979 ITU World Administrative Radio Conference (WARC-79) hence recognized a demand in Europe and Africa and allocated in ITU Region 1 the frequency band 415–435 kHz to the aeronautical radionavigation service, shared with the maritime mobile service, at that time on a permitted basis. An ITU frequency assignment plan for Region 1 was prepared for this band in 1985 giving priority access to the aeronautical radionavigation service (re. Final Acts of the Regional Administrative Radio Conference for the planning of the MF Maritime Mobile and Aeronautical Radionavigation Service (Region 1), Geneva, 1985). At present, the need for NDBs has stabilized and aviation can meet its requirement from the current allocations. Allocations made on a permitted basis were removed from the Radio Regulations in WRC-95 and replaced with an allocation on a primary basis.

Interference from broadcasting in the band 255–283.5 kHz has been reported, which renders parts of this band unusable in much of Region 1. (This band is not allocated to the broadcasting service in Regions 2 and 3.)

COMMENTARY: For international purposes, the future air navigation systems (FANS) scenario foresaw a reduction in the role of NDBs in the future due to, *inter alia,* the emergence of GNSS as the future system for a range of navigation services, including those for oceanic and low-density continental airspace.

At a national level where the majority of NDB services are provided, frequency demand for NDBs will depend to a large extent on national policies. The last worldwide ICAO review in 1985 (Appendix C to Agenda Item 8 of the *Report of the Communications/Operations (COM/OPS) Divisional Meeting (1985)* (Doc 9464)) considered the retention of NDB allocations essential, including the need for assignments for national purposes. General aviation use of NDBs is expected for at least the medium term (2035)

Recent developments include the need to retain NDB systems on a larger scale to provide back-up for GNSS failures in areas where alternative back-up systems such as VOR/DME or DME-DME navigation is technically or economically not practicable.

Footnotes:

Footnotes to the table of frequency allocations of particular importance are:
5.76: Designation of 410 kHz for radio direction finding
5.80: The prohibition of the use of voice on NDB frequencies in Region 2 in the band 435–495 kHz
5.84: Designation of 518 kHz for special use in the maritime mobile service

More information on the use of spectrum for NDB as well as frequency assignment planning of these beacons relating to the provisions of Article 28 and Appendix 12 of the Radio Regulations is in paragraphs 7-III.6 and 7-III.4.2 of this Handbook. Attachment G contains technical information on and sharing criteria for NDB.

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Band: 2 850–22 000 kHz
Service: AM(R)S (air-ground communications (HF voice and data))
Allocation: In several sub-bands

kHz 2 850–22 000		
Allocation to Services		
Region 1	Region 2	Region 3
2 850–3 025	AERONAUTICAL MOBILE (R) 5.111 5.115	
3 400–3 500	AERONAUTICAL MOBILE (R)	
4 650–4 700	AERONAUTICAL MOBILE (R)	
5 450–5 480 FIXED AERONAUTICAL MOBILE (OR) LAND MOBILE	**5 450–5 480** AERONAUTICAL MOBILE (R)	**5 450–5 480** FIXED AERONAUTICAL MOBILE (OR) LAND MOBILE
5 480–5 680	AERONAUTICAL MOBILE (R) 5.111 5.115	
6 525–6 685	AERONAUTICAL MOBILE (R)	
8 815–8 965	AERONAUTICAL MOBILE (R)	
10 005–10 100	AERONAUTICAL MOBILE (R) 5.111	
11 275–11 400	AERONAUTICAL MOBILE (R)	
13260-13360	AERONAUTICAL MOBILE (R)	
17 900–17 970	AERONAUTICAL MOBILE (R)	

21 850–21 870	FIXED 5.155A 5.155

21 924–22 000	AERONAUTICAL MOBILE (R)

Footnotes:

5.111 The carrier frequencies 2 182 kHz, 3 023 kHz, 5 680 kHz, 8 364 kHz and the frequencies 121.5 MHz, 156.525 MHz, 156.8 MHz and 243 MHz may also be used, in accordance with the procedures in force for terrestrial radiocommunication services, for search and rescue operations concerning manned space vehicles. The conditions for the use of the frequencies are prescribed in Article **31**.

The same applies to the frequencies 10 003 kHz, 14 993 kHz and 19 993 kHz, but in each of these cases emissions must be confined in a band of ±3 kHz about the frequency. (WRC-07)

5.115 The carrier (reference) frequencies 3 023 kHz and 5 680 kHz may also be used, in accordance with Article **31** by stations of the maritime mobile service engaged in coordinated search and rescue operations. (WRC-07)

5.155 Additional allocation: in Armenia, Azerbaijan, Belarus, the Russian Federation, Georgia, Kazakhstan, Moldova, Mongolia, Uzbekistan, Kyrgyzstan, Slovakia, Tajikistan, Turkmenistan and Ukraine, the band 21 850–21 870 kHz is also allocated to the aeronautical mobile (R) service on a primary basis. (WRC-07)

5.155A In Armenia, Azerbaijan, Belarus, the Russian Federation, Georgia, Kazakhstan, Moldova, Mongolia, Uzbekistan, Kyrgyzstan, Slovakia, Tajikistan, Turkmenistan and Ukraine, the use of the band 21 850–21 870 kHz by the fixed service is limited to provision of services related to aircraft flight safety. (WRC-07)

ICAO POLICY:

- Retain the current allocations in the HF bands to the aeronautical mobile (route) service (AM(R)S) bands and the provisions of Appendix 27 to the Radio Regulations for the foreseeable future for HF voice and data.
- Protect the use of the aeronautical HF bands in accordance with the provisions of Appendix 27.
- No change to Footnotes 5.111 and 5.115.
- Support the measures and participate in the technical studies addressed in Resolution 207 (Rev. WRC-03) concerning the unauthorized use of and interference to frequencies in the bands allocated to the AM(R)S.
- Consider technical solutions which can be implemented efficiently without changes to aircraft equipment or disruption of aeronautical services.

On a global basis, HF communications provide the main means for long distance (beyond the radio horizon) air/ground voice and data communications. Despite the introduction of satellite communication systems (to provide long distance communications as an alternative to the use of HF bands in aviation), HF communications are expected to continue to be required for the long term. The use of these bands for long distance aeronautical voice and data communications is not expected to increase significantly and the future requirements are expected to be met in the currently available frequency bands.

AVIATION USE: HF communications provide the main long-distance air-ground communication system in areas where VHF is not practicable, e.g. in oceanic and remote areas, low-level overseas paths, and area coverage where the area is large. Single sideband amplitude modulation voice is the modulation used. Data transmission over HF frequencies is permissible and has increasing applications.

Appendix 27 to the Radio Regulations contains the allotment Plan and system parameters and was agreed at the ITU WARC-Aer2 (1978). The ICAO Communications Divisional Meeting (1976) carried out the ICAO coordination prior to the ITU conference. The ICAO Communications Divisional Meeting (1981) agreed to the necessary amendments to Annex 10, which included the change of specification from double sideband (DSB) to single sideband (SSB).

Allotments in the Appendix 27 Plan are made to major world air route areas

(MWARA) for long-distance international services where more than one country is affected. Regional and domestic air route areas (RDARA) allotments are made in other cases. The structure of Appendix 27 conforms to the operational requirement for aeronautical HF voice communication for the foreseeable future.

The registration of assignments in the Master International Frequency Register (MIFR) is a requirement covered by the Radio Regulations and effected through ITU member administrations (national telecommunication administrations). Due to the provisions of the Radio Regulations, ICAO cannot play any role in this registration (see *Ref. 27/19* in the section below titled *Use of data in the HF AM(R)S*).

A number of frequencies in the HF bands have been allotted on a worldwide (WW) basis for Aeronautical Operational Control (AOC). Many airlines (aircraft operating agencies) use these frequencies intensively any, in many cases, operate their own HF network to support long distance operational control for regularity of flight and aircraft safety purposes. (RR 27/217).

> 27/217 4. The world-wide frequency allotments appearing in the Tables at No. 27/213 and Nos. 27/218 to 27/231, except for carrier (reference) frequencies 3 023 kHz and 5 680 kHz, are reserved for assignment by administrations to stations operating under authority granted by the administration concerned, for the purpose of serving one or more aircraft operating agencies. Such assignments are to provide communications between an appropriate aeronautical station and an aircraft station anywhere in the world for exercising control over regularity of flight and for safety of aircraft. World-wide frequencies are not to be assigned by administrations for MWARA, RDARA and VOLMET purposes. Where the operational area of an aircraft lies wholly within a RDARA or Sub-RDARA boundary, frequencies allotted to those RDARAs and Sub-RDARAs shall be used.

Appendix 27 designates the carrier frequencies 3 023 kHz and 5 650 kHz (RR 27/232 to RR 27/238) for common use on a worldwide basis. RR 27/236 permits these frequencies to be used by other mobile services for air-surface search and rescue operations. Footnotes 5.111 and 5.115 (WRC-07) and Appendix 15 of the Radio Regulations also specify these frequencies for specific distress and safety purposes (coordinated search and rescue operations). The relevant provisions of Appendix 27 of the Radio Regulations are reproduced below in *Section 7-II Band 2023 kHz and 5680 kHz* of this Handbook.

Appendix 27 RR27/19 specifically recognizes the coordination role of ICAO, with particular reference to the operational use of frequencies in the Allotment Plan. This activity is coordinated at Regional Air Navigation Meetings where regional requirements and frequencies for long-range communications are agreed. Such agreements need to be registered with the ITU MIFR through the national telecommunication administrations.

Appendix 27 contains provisions for adaptation of the allotment and frequency assignment procedures. These provisions allow administrations to assign frequencies which are not identified in the allotment plan under the condition that such frequency assignments will not reduce the protection of frequencies which are in the allotment plan. After proper coordination by the national telecommunication authorities of such frequency assignments with other administrations, these frequency assignments can be recorded in the ITU MIFR with the same international protection as other frequencies. These provisions provide for adequate flexibility in the regulatory procedures to implement changes in the use of the HF frequency bands by aviation, including, the accommodation of new frequency assignment

4. *Adaptation of allotment procedure*

27/20 It is recognized that not all the sharing possibilities have been exhausted in the allotment Plan contained in this Appendix. Therefore, in order to satisfy particular operational requirements which are not otherwise met by this allotment Plan, Administrations may assign frequencies from the aeronautical mobile (R) bands in areas other than those to which they are allotted in this Plan. However, the use of the frequencies so assigned must not reduce the protection to the same frequencies in the areas where they are allotted by the Plan below that determined by the application of the procedure defined in Part I, Section II B of this Appendix.

27/21 5. When necessary to satisfy the needs of international air operations Administrations may adapt the allotment procedure for the assignment of aeronautical mobile (R) frequencies, which assignments shall then be the subject of prior agreement between Administrations affected.

27/22 6. The coordination described in No. 27/19 shall be effected where appropriate and desirable for the efficient utilization of the frequencies in question, and especially when the procedures of No. 27/21 are unsatisfactory.

27/67 e) That, in accordance with the Radio Regulations, all details of the assignment(s), including the transmitting antenna characteristics shall be notified to the Radiocommunication Bureau.

COMMENTARY:

The present policy, in line with the findings of the ICAO Communications/ Meteorology/Operations (COM/MET/OPS) Divisional Meeting (1990), is that no change be made to the allocation of the bands between 2 and 22 MHz allocated to the AM(R)S (Appendix A to the report of COM/MET/OPS/90 on Agenda Item 3, paragraph 2.3 — Future aviation use — refers). Although his policy recognizes that requirements for HF frequency assignments are increasing, over the years few new frequency assignments have been made. However, as the transition to satellite-based communication occurs over an extended period, some increase of new requirements for HF frequency assignments may be necessary. Also, the coverage of Polar Regions which cannot be accommodated by satellite systems utilizing geostationary satellites would likely remain a requirement for continued use HF spectrum even after full implementation of satellite communication. Implementation of non-geostationary satellite systems (e.g. IRIDIUM) may provide for the missing coverage over polar areas.

Use of data in the HF AM(R)S

Data link on HF frequencies was considered by the Aeronautical Mobile Communications Panel (AMCP) and the Automatic Dependent Surveillance Panel (ADSP). A study on this matter, including the development of SARPs for Annex 10, was completed and relevant SARPs incorporated in Annex 10, Volume III. An estimate of the possible number of families for a worldwide HF data link service was made (six families each of six frequencies).

An HF data link system has been implemented with global coverage under the current provisions for the aeronautical HF bands and in accordance with the provisions contained in Appendix 27 to the Radio Regulations. HF data link requires that frequencies are available by multiple stations in a large geographical area. SARPs for HF data link were incorporated in Annex 10, Volume III, in 1999. A global HF data link network /system (ARINC GlobalLink) for aviation, operating in accordance with ICAO SAPRs, is currently in operation

The existing technical provisions in Appendix 27 permit data modulations, and the Rules of Procedure relating to this were approved by the ITU Radio Regulations Board at its meeting in July 1998. The text of these rules is reproduced below:

Ref. 27/15:
This provision specifies that the use of channels derived from the frequencies indicated in No. 27/18 for the various classes of emissions other than J3E and H2B will be subject to special arrangements by the administrations concerned

and affected. In this connection, and having in mind the spirit of Resolution **713** (WRC-95), the Board considers as a valid “special arrangement by the administrations concerned” any formal action by the International Civil Aviation Organization (ICAO) which results in Standards and Recommended Practices (SARPs), which are approved by the ICAO in accordance with its procedures and which are communicated to the ITU accordingly.

Ref. 27/19:
This provision specifies the role of ICAO in performing voluntary coordination (“should”) in the operational use of the frequencies. The Board considers such a coordination as an internal ICAO activity, intended to concluding operational agreements between the international operators (e.g. timesharing arrangements). Therefore the Bureau will not take into account such agreements between operators, unless they are communicated to the Bureau by their national telecommunications administration.

Ref. 27/58:
This provision lists the permissible classes of emission on the channels of Appendix 27 and stipulates, amongst other emissions, the possibility of using “other transmissions such as data transmission, single sideband, suppressed carrier”. The class of transmission listed against this latter description is JXX (former designation A9J). In this respect, the Board considers that any SSB (suppressed carrier) class of emission is authorized on the channels in Appendix 27 (e.g. J2B, J2D, J7B, J7D, J9B, J9D, etc.), provided that the following conditions are satisfied:

- the reference frequency of the concerned transmission coincides with a reference frequency listed in the list of carrier (reference) frequencies (27/18);
- the occupied bandwidth of other authorized emissions does not exceed the upper limit of J3E emissions (No. 27/12), i.e. 2 700 Hz;
- the assigned frequency is at a value 1 400 Hz above the carrier (reference) frequency (27/75).

In frequency assignment planning, it is important to realize that the geographical disposition of allotments to MWARA and RDARA may need to be adjusted to accommodate the area of application of the new data services. HF data link is anticipated to operate in a different operational configuration than that for radiotelephony. In accordance with Appendix 27, RR 27/56, the frequency assignments for data must be made so as not to cause harmful interference to the allotments in Appendix 27. While some assignments may be identified using the possibilities covered by RR 27/20 (see above), the additional requirements for dedicated families for data, as specified by the AMCP, cannot be met from the present Appendix 27 allotment Plan without affecting the provisions (allotments) for HF voice.

On the use of HF data link and to assist in the coordination and registration of frequency assignments by the ITU, Recommendation ITU-R M.1458 on the "*Use of the frequency bands between 2.8 – 22000 MHz by the aeronautical mobile (R) service for data transmission using class of emission J2D*" provides additional information.

Harmful interference to HF services in certain areas

The increase in harmful interference to air-ground communications (and to maritime communications) in the HF bands was discussed at ITU World Radiocommunication Conferences in 1997 and 2000. This problem is prevalent in some areas in the western part of the South Pacific and is believed to arise from the use of non-licensed, non-authorized equipment often installed on marine craft. The ITU discussions have encompassed both administrative measures, i.e. better control and regulation, and technical measures, which can reduce the effect. The latter are only regarded with favour in aviation if they can be implemented without changes to current operational aircraft equipment. Resolution 207 was amended at WRC-03 to draw attention to this threat and to ensure that studies by ITU-R continue.

Appendix 27 provisions: Appendix 27 can only be amended by a competent ITU WRC where this subject is placed on the agenda. There are currently no requirements for a review of the allotment Plan.

Some of the definitions, relevant to the use of frequencies from the aeronautical HF bands, as given in Appendix 27 are presented below.

Current and future use of HF frequency bands.
Current use of the HF frequency bands is still very significant. An analysis for the NAT Region showed that for flight over the North Atlantic, the distribution of contacts for all aeronautical stations was:

73 % was over HF channels
26.23 % was over general purpose VHF channels
0.14 % was over SATCOM channel

This analysis showed that the expectations from the FANS Committee towards the future use of SATCOM and the replacement of HF by satellite communications did not materialize over the years.

Future use

In the North Atlantic area, due to the traffic growth, use of HF communications is increasing with the increase in air traffic and the use of HF frequencies for long distance communications is also expected to grow. The NAT SPG (North Atlantic Systems Planning Group) has taken steps to increase the number of HF frequencies for use in the NAT Region. It is expected that the necessary frequency assignments can be found within the current HF frequency bands and within the procedures as specified in **Appendix 27** to the Radio Regulations. Similar steps (to increase the use of HF frequencies) are considered as well in other Regions. No amendments to the Radio Regulations are necessary as the current procedures include for the flexibility to make new assignments and seek their registration and protection within the ITU.

It should be noted that SATCOM voice trials conducted in 2007 showed, *inter alia*, that it could not be concluded if the existing satellite infrastructure, networks and telephone links to the radio stations have sufficient capacity to handle the volume of traffic currently supported by the NAT HF/VHF network. Furthermore, delays in establishing communication from the ground were significantly worse than what can be expected using HF under normal conditions. In this respect, HF performance exceeds SATCOM except in the worst conditions of propagation which occur very rarely. (Source: ICAO North Atlantic Satellite Voice Task Force, September 2007.)

An important feature of HF systems is to provide support for beyond line-of-sight communications. The already employed HF systems are expected to continue to be employed in the Future Communications Infrastructure (FCI). When satellite systems are available that can meet the COCR communication requirements in remote and oceanic airspace (Oceanic, Remote and Polar Regions, ORP), increased use of satellite systems in ORP airspace may be expected. The use of geostationary satellite systems however are not capable of providing full coverage in polar regions; for polar regions, HF communication system may continue to be required or, alternatively, global orbiting satellites (such as provided by IRIDIUM) may be used, subject to meeting the COCR requirements.

Definitions

27/1 1. *Frequency allotment Plan:* A Plan which shows the frequencies to be used in particular areas without specifying the stations to which the frequencies are to be assigned.

27/2 2. The terms to express the different methods of frequency distribution as used in this Appendix have the following meanings:

Services	Attribution (attribuer)	Allocation (to allocate)	Atribución (atribuir)
Areas	Allotissement (allotir)	Allotment (to allot)	Adjudicación (adjudicar)
Stations	Assignation (assigner)	Assignment (to assign)	Asignación (asignar)

27/3 3. *A Major World Air Route* is a long-distance route, made up of one or more segments, essentially international in character, extending through more than one country and requiring long-distance communication facilities.

27/4 4. *A Major World Air Route Area (MWARA)* is an area embracing a certain number of Major World Air Routes, which generally follow the same traffic pattern and are so related geographically that the same frequency families may logically be applied.

27/5 5. *Regional and Domestic Air Routes* are all those using the Aeronautical Mobile (R) Service not covered by the definition of a Major World Air Route in No. 27/3.

27/6 6. *Regional and Domestic Air Route Area (RDARA)* is an area embracing a certain number of the air routes defined in No. 27/5.

27/7 7. *A VOLMET Allotment Area* is an area encompassing all points where an HF broadcast facility might be required to operate on a family of frequencies common to the area.

27/8 8. *A VOLMET Reception Area* is an area within which aircraft should be able to receive broadcasts from one or more stations in the associated VOLMET Allotment Area.

27/9 9. *A World-Wide Allotment Area* is one in which frequencies are allotted to provide long-distance communication between an aeronautical station within that allotment area and aircraft operating anywhere in the world.

27/10 10. *Family of Frequencies in the Aeronautical Mobile (R) Service* contains two or more frequencies selected from different aeronautical mobile (R) bands and is intended to permit communication at any time within the authorized area of use (see Nos. 27/213 to 27/231) between aircraft stations and appropriate aeronautical stations.

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Band: 3 023 kHz and 5 680 kHz
Service: AM(R)S (search and rescue)
Aviation use: The frequencies 3 023 kHz and 5 650 kHz are intended for common use on a worldwide basis as indicated in Appendix 27.

27/232 1. The carrier (reference) frequencies 3 023 kHz and 5 680 kHz are intended for common use on a worldwide basis.

27/233 2. The use of these frequencies in any part of the world is authorized:

2.1 aboard aircraft for:

a) communications with approach and aerodrome control;

b) communication with an aeronautical station when other frequencies of the station are either unavailable or unknown;

2.2 at aeronautical stations for aerodrome and approach control under the following conditions:

a) with mean power limited to a value of not more than 20 W in the antenna circuit;

b) special attention must be given in each case to the type of antenna used in order to avoid harmful interference;

c) the power of aeronautical stations which use these frequencies in accordance with the above conditions may be increased to the extent necessary to meet certain operational requirements subject to coordination between the administrations directly concerned and those whose services may be adversely affected.

27/234 3. Notwithstanding these provisions, the frequency 5 680 kHz may also be used at aeronautical stations for communication with aircraft stations when other frequencies of the aeronautical stations are either unavailable or unknown. However, this use shall be restricted to such areas and conditions that harmful interference cannot be caused to other authorized operations of stations in the aeronautical mobile service.

27/235 4. Additional particulars regarding the use of these channels for the above purposes may be recommended by the meetings of ICAO.

27/236 5. Frequencies 3 023 kHz and 5 680 kHz may also be used by stations of other mobile services participating in coordinated air-surface search and rescue operations, including communications between these stations and participating land stations. Aeronautical stations are authorized to use these frequencies to establish communications with such stations.

Note: See also Footnotes 5.111 and 5.115 at the beginning of this section.

Band: 74.8–75.2 MHz
Service: Aeronautical radionavigation (marker beacon)
Allocation:

MHz 74.8–75.2		
Allocation to Services		
Region 1	Region 2	Region 3
74.8–75.2	AERONAUTICAL RADIONAVIGATION 5.180 5.181	

Footnotes:

5.180 The frequency 75 MHz is assigned to marker beacons. Administrations shall refrain from assigning frequencies close to the limits of the guardband to stations of other services which, because of their power or geographical position, might cause harmful interference or otherwise place a constraint on marker beacons.

Every effort should be made to improve further the characteristics of airborne receivers and to limit the power of transmitting stations close to the limits 74.8 MHz and 75.2 MHz.

5.181 *Additional allocation*: in Egypt, Israel, and the Syrian Arab Republic, the band 74.8–75.2 MHz is also allocated to the mobile service on a secondary basis, subject to agreement obtained under No. **9.21**. In order to ensure that harmful interference is not caused to stations of the aeronautical radionavigation service, stations of the mobile service shall not be introduced in the band until it is no longer required for the aeronautical radionavigation service by any administration which may be identified in the application of the procedure invoked under No. **9.21**. (WRC-03)

ICAO POLICY:

- No change to the current allocations.
- No change to Footnote 5.180.
- Deletion of Footnote 5.181.

Marker Beacons are used, in conjunction with ILS. On a global basis, the frequency band available for Marker Beacons satisfies the aeronautical requirements. In a number of cases, Marker Beacons (and outer Locators) are being replaced with DME. As long as Marker Beacons are in operation, the band 74.8 – 75.2 MHz needs to be available for these systems.

AVIATION USE: The frequency of 75 MHz is assigned to marker beacons for use with ILS to define specific points on the approach path. The outer marker is nominally at 7.5 km from the runway threshold, the middle marker at 1 050 m from the threshold and, where installed, the inner marker is located just prior to the threshold. In addition, markers may also be used to mark significant points on air routes.

COMMENTARY: There is a continuing and essential requirement for this allocation (see also ILS localizer in band 108–111.975 MHz and ILS glide path in the band 328.6 – 335.4 MHz).

ILS will continue to be used for the foreseeable future. Marker beacons are an indispensable element of the ILS system. Marker beacons are also used as en-route waypoint markers.

Footnote 5.181 relating to the future use of this band by the mobile service was introduced at WARC Mob-87, primarily at the initiative of the CEPT in the expectation that from 1995-1998 onwards the ILS system, including the marker beacons, would be withdrawn from use by international civil aviation due to the firm plans in ICAO to transfer from ILS to MLS. Eventually, this transition did not take place and the need for continuing ILS operations (including the marker beacons) was re-established by ICAO. At WRC-2000, the aviation community was successful in removing fifteen European and Middle Eastern country names from this footnote. With the continuing use of ILS systems and markers, this footnote is not only ineffective but carries the risk of addition of new names at future conferences and should be deleted in its entirety. Any use of this band by the mobile service is incompatible with the allocation to the aeronautical radionavigation service.

The names of many countries, initially included in this footnote, have been deleted, leaving the concerns regarding compatibility and protection of marker beacons ILS/VOR limited to the three countries currently mentioned in this footnote.

Ban d: 108–117.975 MHz
Service: Aeronautical radionavigation (VOR/ILS localizer) and Aeronautical mobile (Route) service (GBAS/VDL Mode 4)
Allocation:

MHz 108–117.975		
Allocation to Services		
Region 1	Region 2	Region 3
108–117.975	AERONAUTICAL RADIONAVIGATION 5.197 5.197A	

Footnotes:

5.197 *Additional allocation*: in the Syrian Arab Republic, the band 108–111.975 MHz is also allocated to the mobile service on a secondary basis, subject to agreement obtained under No. **9.21**. In order to ensure that harmful interference is not caused to stations of the aeronautical radionavigation service, stations of the mobile service shall not be introduced in the band until it is no longer required for the aeronautical radionavigation service by any administration which may be identified in the application of the procedures invoked under No. **9.21**. (WRC-12)

5.197A *Additional allocation:* the band 108–117.975 MHz is also allocated on a primary basis to the aeronautical mobile (R) service, limited to systems operating in accordance with recognized international aeronautical standards. Such use shall be in accordance with Resolution **413 (Rev. WRC-12)**. The use of the band 108–112 MHz by the aeronautical mobile (R) service shall be limited to systems composed of ground-based transmitters and associated receivers that provide navigational information in support of air navigation functions in accordance with recognized international aeronautical standards. (WRC-12)

ICAO POLICY:

- No change to the current allocation to the aeronautical radionavigation service and the aeronautical mobile (route) service (AM(R)S).
- Deletion of Footnote 5.197.
- Ensure conformity with ITU-R Recommendation SM.1009

> regarding compatibility with FM broadcast services in the band 87.5–108 MHz and ILS/VOR as well as with ITU-R Recommendation M.1841 for GBAS.

On a global basis the band 108 – 117.975 is used for ILS (Localizer) and VOR. Implementation of GBAS under an allocation to the AM(R)S in this band is expected to start around 2015 – 2025 and be progressively implemented from 2015 – 2030 in some areas if GBAS is technically and economically feasible. Such implementation is subject to a satisfactory safety case with specific attention to interference into GNSS signals. In the longer term, GBAS may replace ILS in some areas. The spectrum vacated by future ILS decommissioning, if any, will be re-used for GBAS systems. Some residual use of ILS is expected to continue to well beyond 2030.

On a global basis, the future use of VOR systems is expected to decline between 2015 – 2030 due to implementation of GNSS and RNAV. However, a residual number of VOR systems will continue to be in operation to meet specific requirements beyond 2030. The vacated spectrum, if any, will be re-used for GBAS and, if necessary, for the implementation of VHF air/ground communication systems.

The frequency band 108 – 117.975 is expected to meet the aeronautical requirements for ILS, VOR and GBAS until 2030 and beyond. Rationalization of GBAS technical characteristics (and frequency assignment planning criteria) may be necessary, in particular when being implemented in areas where VOR and ILS operations continue.

The frequency band 112 – 117.975 MHz can also be used for VDL Mode 4 under the allocation to the aeronautical mobile (R) service. The spectrum requirements for VDL Mode 4 until 2020 are expected to be minimal (up to a maximum of 2 to 4 channels) and can easily be implemented in most areas. This frequency band is also considered to accommodate VHF air/ground voice and data link systems, subject to spectrum availability.

AVIATION USE: ILS localizer, VOR, GBAS and VDL Mode 4.

ILS is one of the ICAO standard, non-visual aids to final approach and landing. The localizer transmitter, operating on one of the 40 ILS channels within the sub-band 108 MHz–111.975 MHz, emits signals which provide course guidance throughout the descent path to the runway threshold.

The VHF omnidirectional radio range (VOR) is the short/medium range navigation aid. The basic navigation guidance derived from a VOR is a radial line of position (magnetic) with respect to a known geographic point (the VOR site). The radial line is read in degrees of azimuth from magnetic North and is technically accurate to within approximately ±3.0 degrees. The overall system accuracy is approximately ±5.0 degrees. Bearing information may be used by aircraft to fly toward or away from the station at any azimuth selected by the pilot. The 180 degrees ambiguity in this indication is resolved by the provision of a "to/from" indicator in the aircraft avionics. A DME is a useful adjunct to, and is normally co-located with, a VOR. In such cases, the VOR is referred to as "VOR/DME". A DME provides a continuous digital readout of the slant range distance, in nautical miles, between the aircraft and the DME site. Because of the defined channel pairing scheme in Annex 10, when using a VOR/DME, the tuning of the airborne receiver to the VOR will automatically couple the DME receiver to the associated DME ground station. The VOR/DME is used to provide navigation guidance on ATS routes and specified tracks. Its accuracy allows ATS routes to be kept at reasonable widths and permits the application of comparatively small lateral separation minima between routes, resulting in a more efficient use of the airspace. The VOR/DME route structure is normally established so as to make it possible for aircraft to fly from one VOR direct to the next, or along intersecting radials of two adjacent VORs. Reporting points and/or other significant points are normally established along radials, either together with a given DME distance from an associated VOR, or by an intersection of radials from two different VORs. The VOR can also serve as a landing aid at locations where no precision approach facility is available.

The ground-based augmentation system (GBAS) monitors GNSS signals at an aerodrome and broadcasts locally relevant integrity messages, pseudo-range corrections and approach data via a VHF data broadcast to aircraft within the range depending upon intended operations.

The frequency band 112 – 117.975 MHz is also planned for use by VDL Mode 4, in accordance with the provisions of the Radio Regulations and Annex 10. Frequency assignment planning criteria for VDL Mode 4 in this band have been developed in ICAO.

Use of the frequency band 108 – 117.975 MHz by the aeronautical radionavigation service

Note: Technical details on the use of the band 108 – 117.975 MHz by systems operating in the aeronautical radionavigation service (ILS, VOR) and the aeronautical mobile (R) service (GBAS, VDL Mode 4) is in Volume II of this Handbook (in preparation). This material will also include provisions relating to harmful interference from FM broadcasting stations.

Figure 7-8 presents an overview of the channeling arrangements and use of the various aeronautical radio navigation and communication systems in the frequency band 1208 – 117.975 MHz.

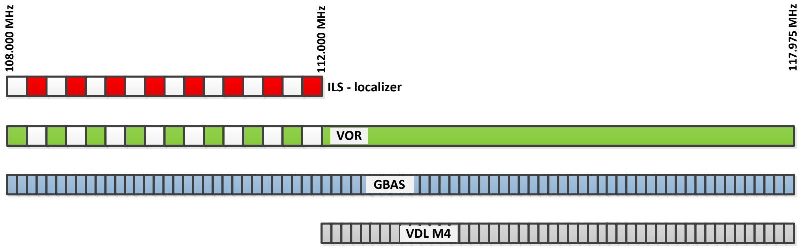

Figure 7-8 Channeling arrangements and use of systems in the frequency band 108 - 117.975 MHz

The sub-band 108–111.975 MHz is shared between ILS localizer and VOR in an interleaved frequency arrangement (108.1 and 108.15 MHz for ILS, 108, 108.05, 108.2 and 108.25 MHz for VOR, etc.). The channel spacing is either 50 kHz or 100 kHz, depending on regional agreements and requirements.

The sub-band 112–117.975 MHz is used for VOR, with 50 kHz or 100 kHz channel spacing, depending on regional agreements and requirements.

GBAS is standardized to operate in the band 108–117.975 MHz. GBAS/ILS and GBAS/VHF COM frequency planning criteria are currently under development. Until these criteria are defined and included in SARPs, GBAS frequencies should be selected from the band 112.050–117.900 MHz. The channel spacing for GBAS is 25 kHz

VDL Mode 4 is standardized to operate also in the frequency band 112 – 117.975 MHz. The channel spacing for VDL Mode 4 is 25 kHz. The expected use of this band by VDL Mode 4 is limited to a few frequency assignments.

The ILS localizer is frequency paired with the glide path frequencies from the band 328.6–335.4 MHz (see Figure 7-9) and, where possible, with the microwave landing system (MLS) from the band 5 030–5 150 MHz. The ILS localizer is also paired with DME; implementation of DME associated with the ILS is increasingly replacing the use of marker beacons and the outer locater, mainly for economic reasons. .

VOR is normally associated with DME and is frequency paired. Short-range airport VOR frequencies are usually taken from the sub-band 108–111.975 MHz.

Note: The pairing of frequencies for the ILS localizer and the ILS glide path, as well as for the ILS/VOR with DME is contained in Annex 10 (Volume I)

Interference from FM broadcasting

ILS localizer, VOR, GBAS and VDL Mode 4 receivers are vulnerable to intermodulation and saturation effects from FM broadcast transmissions from the band 87–108 MHz. Guidelines for States, when assessing compatibility between assignments for FM broadcasting and aeronautical radionavigation (ILS/VOR), have been agreed in the ITU-R (Recommendation ITU-R.SM 1009 refers). ITU-R Recommendation M.1841 addresses the issue of the compatibility between GBAS and FM sound broadcasting addresses this issue. Report ITU-R M.2147 addresses issues relevant to the compatibility between the ICAO standard VDL Mode 4 air/ground data link and FM sound broadcasting. The need to secure compatibility from the introduction of digital sound broadcasting in the frequency band 87 – 108 MHz has been addressed in Resolution 413 (WRC-12).

Note: Additional information related to the effects of interference from FM broadcasting on aeronautical use of the band 108 – 117.975 MHz is contained in Attachment G and in Volume II [in preparation] of this Handbook.

Use of the band 108 – 117.975 MHz by the aeronautical mobile (R) service

WRC-03 adopted Resolution 413 (which was amended at WRC-07 and again at WRC-12) to reflect the additional allocation to the AM(R)S as per 5.197A (WRC-07)) in the band 108 – 117.975 MHz and to provide for the conditions of using this band by the AM(R)S.

Resolution 413 (Rev WRC-12) invites ITU-R to study any compatibility issues between the broadcasting service and GBAS/VDL Mode 4 that may arise from the introduction of appropriate digital sound broadcasting systems.

Frequency congestion for ILS and VOR exists in some high-density areas, such as Western Europe and North America. This applies to ILS and VOR and arises, partially, from the frequency pairing and the frequency assignment planning constraints in the DME band (960 – 1215 MHz).

The band has been used by aviation since 1947. The channel spacing was reduced from 200 kHz to 100 kHz in 1963 and from 100 kHz to 50 kHz in 1972 (at the Seventh Air Navigation Conference).

Footnote 5.197 was introduced at WARC-87 in anticipation that ILS would be withdrawn from international service in 1998 and the use of the ILS localizer would be terminated. At WRC-03 most countries removed their names from this footnote since ILS will continue operation for the foreseeable future.

COMMENTARY (ILS): The Special COM/OPS/95 examined the future of ILS in the context of transition to MLS and to GNSS as envisaged in the FANS scenarios. The transition to MLS has effectively been cancelled and the transition to GNSS/GBAS approach and landing system has been much slower than predicted. GNSS has not yet achieved Category II and Category III. It is difficult to predict if (or when) such capabilities will be widely available.

Most States indicated an intention to retain ILS in service (report of the Special COM/OPS/95 meeting on Agenda Item 1, paragraph 1.3.4 refers) for the foreseeable future. In this regard, it is noted that Annex 10 requires all ILS and VOR receivers (globally) to comply with the (improve) immunity standards against interference from FM broadcasts as from 1998.

ILS sustainability was addressed at the Special COM/OPS/95 which agreed to a review the ILS SARPs and guidance material to ensure adequate provision for ILS beyond the year 2000. Other recommendations have called for studies and examinations of various scenarios for transition from ILS to either MLS or GNSS, with important emphasis on the economics of operation.

The introduction of the mobile service, in accordance with the provision of Footnote 5.197 (WRC-07), is not possible in the foreseeable future. In light of the above, it is clear that the ILS allocation will be needed for the long future, until well beyond 2035.

COMMENTARY (VOR): The continuing deployment of VOR is dependent on the progress, development and implementation of GNSS; the aviation community may continue to require VOR for some time after implementing GNSS. ICAO has adopted SARPs for GNSS, and will continue, through the NSP, to develop the measures and principles necessary to evolve towards the use of GNSS as a means of en-route navigation.

Different world regions will have different emphasis on their need for GNSS in the near and medium terms, and decisions will be taken at a regional level.

No definite or tentative dates have been agreed for the GNSS programmes. In addition, safety requires a backup means of en-route navigation if all GNSS service is temporarily lost. Such backup facilities may include continued use of VOR/DME, DME/DME or NDB..

COMMENTARY (GBAS): ICAO has identified the band 108–117.975 MHz to support GBASVDB (Ground Based Augmentation System/VHF Data Broadcast) operations. WRC-03 and WRC-07 reviewed this band and introduced an allocation to the AM(R)S which, in the frequency band 108 – 112 is limited to ground based systems that transmit navigational information in support of air navigation and surveillance functions. This restriction was introduced to prevent aircraft systems using this frequency band which may cause interference to FM broadcast receivers. These systems shall not cause harmful interference to nor claim protection from international standardized systems operating in the aeronautical radionavigation service (Footnote 5.197A (WRC-12) refers). This provision authorizes to operate, in accordance with ICAO SARPS, GBAS/VDB systems the frequency band 108 – 117.975 MHz.

COMMENTARY (VDL Mode 4): SARPs have also been developed for VDL Mode 4 which supports surveillance (e.g. ADS-B) and point-to-point communication applications. This system can also operate in the band 112–117.975 MHz. Provisions have been made for such use in Annex 10 and the Radio Regulations (Footnote 5.197A (WRC-12) and Resolution 413 (Rev. WRC-12) refer). The development of frequency assignment planning criteria for VDL Mode 4 to secure compatibility with the localizer, VOR and GBAS when operating in the frequency band 112 – 117.975 has been completed.

Allocations to other services

Footnote 5.197 was added by the ITU WARC-87 for mobile services. The footnote introduced the mobile service in the band 108–111.975 MHz in a number of countries. Based on present expectations for the use of the band, it is improbable that this footnote can be considered for implementation for many years in the country mentioned in the footnote. The footnote is not meaningful in practical terms and carries the risk that more country names will be added at future conferences. Hence, it should be deleted in its entirety. Furthermore, it should be noted that no guidance exists on how Footnote 5.197 (WRC-12) would be applied, or what essential prior agreements are necessary within aviation for mobile service operations to commence on any single frequency or within particular sub-bands. This inexactness compounds the problem, as it leaves room for undesirable interpretations that could be used to allow entry of the mobile service in the band. The names of many countries initially included in this footnote have been deleted, leaving the concerns on compatibility and protection of ILS/VOR limited to the country that currently remains mentioned in the footnote.

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WRC-12

At WRC-12 it was confirmed that all compatibility studies between AM(R)S systems and analogue broadcasting operating below 108 MHz had been completed. On the basis of this confirmation Resolution 413 was amended to recognize access to the frequency band 108-117.975 MHz by AM(R)S systems under conditions laid out in Resolution 413 (Rev. WRC-12). In summary, these conditions stipulate:

- AM(R)S systems shall not cause harmful interference to the aeronautical radionavigation service
- AM(R)S systems shall meet the FM broadcasting immunity requirements as per ICAO Annex 10 SARPS
- Only GBAS may operate in the band 108 – 112 MHz
- Any AM(R)S system operating in the band 108 – 117.975 MHz shall meet ICAO SARPs

Resolution 413 continues to call for studies to be undertaken to assess any compatibility issues with aeronautical radionavigation and communication systems operating in the band 108 – 117.975 MHz which are relevant to the introduction of digital broadcasting below 108 MHz.

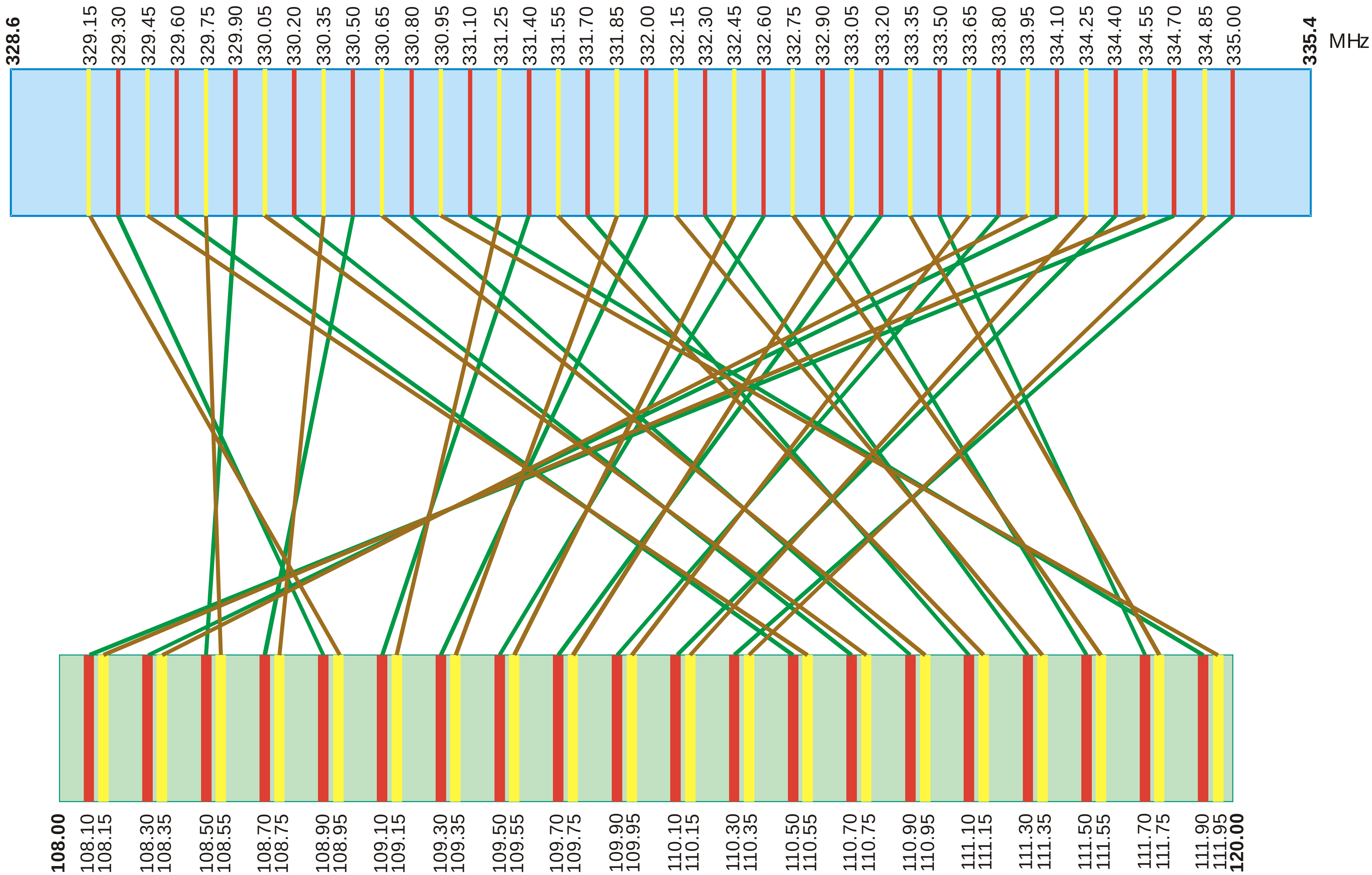

Figure 7-9. Channel pairing between ILS localizer and ILS glide path

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Band: 117.975–137 MHz
Service: AM(R)S (air-ground and air-air communications (VHF voice and data))
Allocation:

MHz 117.975–137		
Allocation to Services		
Region 1	Region 2	Region 3
117.975–137	AERONAUTICAL MOBILE (R) 5.111 5.200 5.201	

Footnotes:

5.111 The carrier frequencies 2 182 kHz, 3 023 kHz, 5 680 kHz, 8 364 kHz and the frequencies 121.5 MHz, 156.525 MHz, 156.8 MHz and 243 MHz may also be used, in accordance with the procedures in force for terrestrial radiocommunication services, for search and rescue operations concerning manned space vehicles. The conditions for the use of the frequencies are prescribed in Article **31**.

The same applies to the frequencies 10 003 kHz, 14 993 kHz and 19 993 kHz, but in each of these cases emissions must be confined in a band of ±3 kHz about the frequency. (WRC-07)

5.200 In the band 117.975–136 MHz, the frequency 121.5 MHz is the aeronautical emergency frequency and, where required, the frequency 123.1 MHz is the aeronautical frequency auxiliary to 121.5 MHz. Mobile stations of the maritime mobile service may communicate on these frequencies under the conditions laid down in Article **31** for distress and safety purposes with stations of the aeronautical mobile service. (WRC-07)

5.201 *Additional allocation*: in Angola, Armenia, Azerbaijan, Belarus, Bulgaria, Estonia, the Russian Federation, Georgia, Hungary, Iran (Islamic Republic of), Iraq, Japan, Kazakhstan, Latvia, Moldova, Mongolia, Mozambique, Uzbekistan, Papua New Guinea, Poland, Kyrgyzstan, Romania, Tajikistan, Turkmenistan and Ukraine, the band 132–136 MHz is also allocated to the aeronautical mobile (OR) service on a primary basis. In assigning frequencies to stations of the aeronautical mobile (OR) service, the administration shall take account of the frequencies assigned to stations in the aeronautical mobile (R) service. (WRC-12)

5.202 *Additional allocation:* in Saudi Arabia, Armenia, Azerbaijan, Belarus, Bulgaria, the United Arab Emirates, the Russian Federation, Georgia, Iran (Islamic Republic of), Jordan, Latvia, Oman, Uzbekistan, Poland, the Syrian Arab Republic, Kyrgyzstan, Romania, Tajikistan, Turkmenistan and Ukraine, the band 136–137 MHz is also allocated to the aeronautical mobile (OR) service on a primary basis. In assigning frequencies to stations of the aeronautical mobile (OR) service, the administration shall take account of the frequencies assigned to stations in the aeronautical mobile (R) service. (WRC-12)

ICAO POLICY:

- No change to the allocations to the aeronautical mobile (route) service in this band.
- No changes to Footnote 5.200.
- No changes to the provisions relating to the use of the emergency channels 121.5 and 123.1 MHz.
- Promote measures for the deletion of Footnotes 5.201 and 5.202.

The band 117.975 – 137 MHz is extensively used for VHF air/ground voice communications and VHF air/ground and air/air data. On a global basis this band is expected to satisfy the aeronautical communication requirements, due to full implementation of 25 kHz and/or 8.33 kHz channel spacing where required. In Europe however, saturation of this band with 8.33 kHz channel spacing being used, is foreseen around 2020-2025. No plan has been developed yet to accommodate spectrum requirements beyond 2020 in Europe.

AVIATION USE: The band 117.975–137 MHz is the main communications band for line-of-sight air-ground voice and data communications and is used at all airports, for en-route, approach and landing phases of flight and for a variety of short-range tasks for general aviation and recreational flying activities (e.g. gliders and balloons). The use of this band is exclusively for air/ground communications relating to the safety and regularity of flight (ATC and AOC)

The band 118–132 MHz was first allocated to aviation in 1947. The extension of the band to 136 MHz was made in 1959 and the extension to 137 MHz in 1979.

To satisfy increased demand and to decrease frequency congestion in high-density traffic areas, the channel width has been reduced on four occasions (from 200 kHz to 100 kHz in the 1950s, to 50 kHz in the 1960s, to 25 kHz in 1972 (Seventh Air Navigation Conference) and finally to 8.33 kHz in 1995 (Special COM/OPS/95)). Frequency assignments and equipment standards may be chosen by regional agreement to suit local demand patterns. Currently, 25 kHz channel spacing is used in all Regions; in parts of the EUR Region also 8.33 kHz channel spacing has been implemented.

Single channel simplex is the mode of operation. Double sideband amplitude modulation voice is the major modulation method. Although FANS recommendations envisaged a transition to data in the future in this band for routine communications, still the main use is for air/ground voice. In cases where in the future data communications will become predominant, voice capability will remain to be required for non-routine communication.
ICAO has allotted the band to national and international services (see Annex 10, Volume V, Chapter 4, Table 4-1).

The AM(R)S is defined in 1.33 and in 43.1 of the Radio Regulations (see Attachment A of this Handbook) as "reserved for communications related to safety and regularity of flight between any aircraft and those aeronautical stations and aeronautical earth stations primarily concerned with flight along national or international civil air routes". Public correspondence, as defined in RR 1.116, is prohibited under RR 43.4 in the bands allocated exclusively to the aeronautical mobile service.

Frequencies for AOC use are covered by the Recommendation in Annex 10, Volume V, Chapter 4, 4.1.8.1.3, which prescribes that frequencies be selected from the band 128.825–132.025 MHz for this purpose, subject to regional agreement in areas where a scarcity exists. Control of AOC communications content rests with the national licensing authority in accordance with Annex 10, Volume II, Chapter 5, 5.1.8.6 and 5.1.8.6.1 together with the note to 5.1.8.6.1. AOC communications are defined in Annex 10, Volume III, Part I, Chapter I as "communications required for the exercise of authority over the initiation, continuation, diversion or termination of flight for safety, regularity and efficiency reasons". AOC is part of the AM(R)S. Specific requirements for flight operations, including AOC, are contained in Annex 6.

The frequency 121.5 MHz is the aeronautical emergency frequency (Annex 10, Volume V, Chapter 4, 4.1.3.1) and is designated in the Radio Regulations (Chapter II) for general distress and safety and emergency locator transmitter (ELT) purposes. The frequency 121.5 MHz is no longer monitored by the International Satellite System for Search and Rescue (COSPAS/SARSAT). Annex 10 requires that ELT's which are carried in compliance with the relevant provisions of Annex 6 operate on both 121.5 MHz and 406 MHz.

The frequency 123.1 MHz is designated as the frequency auxiliary to 121.5 MHz (Annex 10, Volume V, Chapter 4, 4.1.4 refers). This frequency is to be used as an auxiliary search and rescue frequency. The Radio Regulations also designate 123.1 MHz for general search and rescue purposes.

Frequency 123.450 MHz is the frequency designated for air-air communications between aircraft engaged in flights over remote and oceanic areas and while out of range of VHF ground stations.

To give low-level coverage over a large area, offset carrier operation is employed in some areas (see Annex 10, Volume III, Attachment to Part II, 1.2). Such systems, using up to five carriers in one channel, are possible with channel spacing of at least 25 kHz. Offset carrier systems can also be used with 8.33 kHz channel spacing, but are limited to two-frequency offset carrier systems.

VHF receivers in the frequency band 117.975 – 137 MHz are susceptible to interference from FM broadcast signals in the band 87–108 MHz. Annex 10, Volume III, Part II, specifies performance requirements to provide protection from this possibility (see Section 7-III of this Handbook). ITU-R.SM.1009 provides technical planning guidance. Guidance on applying these is in Volume II of this Handbook.

COMMENTARY:

Channel spacing

The Special COM/OPS/95 discussed the shortage of assignable VHF channels necessary to support the growth in air traffic in the years ahead. This scarcity situation occurred in 1992 in the core area of Europe and is expected to expand into other areas or Regions with the increase in air traffic.

Note.— The core area in Europe includes Austria, Belgium, Denmark, France, Germany, Ireland, Luxembourg, Netherlands, Switzerland and the United Kingdom.

The Special COM/OPS/95 agreed to a near-term improvement by using a VHF voice system based on 8.33 kHz channel spacing while recognizing that not all ICAO regions would need to apply this new Standard. Recommendation 6/1 from this divisional meeting, endorsed by the Air Navigation Commission, called for SARPs for 8.33 kHz channel spacing DSB-AM to be incorporated in Annex 10 (Appendix B to the report on Agenda Item 6 refers). These SARPs were adopted by the ICAO Council in 1996. Implementation of 8.33 kHz channel spacing is subject to regional agreement.

Implementation of 8.33 kHz channel spacing in a limited form, i.e. for upper airspace services initially, started around 2000 in Europe under the aegis of ICAO, assisted by the European Organization for the Safety of Air Navigation (EUROCONTROL) in a coordination/planning role. The mandatory carriage of 8.33 kHz radio equipment was introduced for flights above FL195 in the ICAO EUR Region in 2007 Further expansion of the use of 8.33 kHz channel spacing to all airspace is planned in Europe around 2018.

Many other Regions can continue to meet their requirements for VHF channels using 25 kHz spacing for some years without the compelling requirement to convert to 8.33 kHz channel spacing although in some congested areas implementation of 8.33 kHz channel spacing may become necessary.

Use of data in air-ground communications

The CNS/ATM concept placed considerable reliance on the use of air-ground data for pilot/controller exchange of data to supplement the use of voice for certain categories of messages, primarily for routine communications between pilots and ATC. SARPs for VDL Mode 2, VDL Mode 3 and VDL Mode 4 have been incorporated in Annex 10. VDL Mode 2 will become the prime data system for the immediate future. VDL Mode 4 is, initially, foreseen to be regionally implemented. Frequency planning guidance material on VDL Mode 2 and VDL Mode 4 have been developed by the ACP for use in frequency assignment planning.

Band capacity issues

In high-density congested areas such as Europe and North America, the requirement for VHF channels continues to increase. In regular ATC use under normal circumstances, the maximum utilization of a channel dedicated to an ATC sector is around 10 to 20 per cent of the time due to other essential tasks performed by the controller. The use of air-ground data should enable an improvement in utilization of the spectrum, which should be beneficial and delay the time point of spectrum exhaustion. Further expansion of spectrum for short-range, line-of-sight communications as demand increases will meet problems due to the general shortage of frequencies in all parts of the radio frequency spectrum. The strategy and options to deal with this situation require early attention.

Use of the band by other services

The band extensions at 132–136 MHz and 136–137 MHz were agreed to many years ago in ITU but continue to support other services (such as the AM(OR)S) which already existed at that time and now operate under footnote provisions (5.201 and 5.202). Footnotes 5.201 and 5.202 relate to the use, for national purposes, for off-route (OR) services, which was widespread prior to the agreement in 1959 to release 132–136 MHz for exclusive use by the aeronautical mobile (Route) service. In areas where the (OR) service operates on these frequencies, coordination procedures agreed to in the past have been satisfactory. With increasing and intensive use of the frequencies in the band for AM(R)S purposes, it is likely that this (OR) use may become a problem, in which case it will become essential to press for a cessation of this use.

Frequencies: 121.5 MHz, 123.1 MHz and 243 MHz (mobile)
Service: AM(R)S

Emergency frequency in mobile service (243 MHz)

The frequency 243 MHz (twice that of the aeronautical emergency frequency 121.5 MHz) is designated by the Radio Regulations (see Annex 10, Volume V, Chapter 2 — Distress frequencies and Radio Regulation 5.256 (WRC-07)) for use in distress situations. Survival craft stations using VHF are normally fitted with both 121.5 MHz and 243 MHz.

Footnotes: 5.256.

ICAO POLICY:

No change to the provisions in Chapter VII relating to the use of 121.5 MHz, 123.1 MHz and 243 MHz.

AVIATION USE: Emergency frequencies for use in aircraft emergencies and in ELT (121.5 MHz) and for search-of-scene communication (123.1 MHz).

COMMENTARY: Standards relating to the mandatory carriage of ELTs operating simultaneously on 121.5 MHz and 406 MHz are contained in Annex 6. ELT equipment carried to satisfy the requirements of Annex 6 shall operate in accordance with the provisions of Annex 10, Volume III on the frequencies 121.5 MHz and 406.1 MHz.

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Band: 328.6–335.4 MHz
Service: Aeronautical radionavigation (ILS glide path)
Allocation:

MHz 328.6–335.4		
Allocation to Services		
Region 1	Region 2	Region 3
328.6–335.4	AERONAUTICAL RADIONAVIGATION 5.258 5.259	

Footnotes:

5.258 The use of the band 328.6–335.4 MHz by the aeronautical radionavigation service is limited to Instrument Landing Systems (glide path).

5.259 *Additional allocation:* in Egypt and the Syrian Arab Republic, the band 328.6–335.4 MHz is also allocated to the mobile service on a secondary basis, subject to agreement obtained under No. **9.21**. In order to ensure that harmful interference is not caused to stations of the aeronautical radionavigation service, stations of the mobile service shall not be introduced in the band until it is no longer required for the aeronautical radionavigation service by any administration which may be identified in the application of the procedure invoked under No. **9.21**. (Rev. WRC-12)

ICAO POLICY:

- No change to current allocation to the aeronautical radionavigation service.
- No change to Footnote 5.258.
- Deletion of Footnote 5.259.

On a global basis, the frequency band 332.8 – 335.4 MHz is used for the ILS Glide Path, in conjunction with the ILS Localizer (see 5.2.4). This frequency band is expected to meet the aeronautical requirements for ILS Glide Path for the long term. In areas where GBAS is implemented to replace ILS systems, the use of this band for Glide Path systems may be reduced.

AVIATION USE: The ultra-high frequency (UHF) glide path transmitter, operating on one of the 40 ILS channels within the frequency band from 328.6 MHz to 335.4 MHz, radiates its signals in the direction of the ILS localizer front course. The term “glide path” means that portion of the glide slope that intersects the localizer. The signal provides descent information for navigation down to the lowest authorized decision height specified in the approved ILS approach procedure. The glide path projection angle is normally adjusted to 3 degrees above the horizontal plane so that it passes through the middle marker at about 60 m (200 ft) and the outer marker at about 426 m (1 400 ft.) above the runway elevation. The glide slope is normally usable to a distance of 10 NM. However, at some locations, use of the glide slope has been authorized beyond this range. Footnote 5.258 limits the use of this band to ILS glide path. Frequencies are used at a spacing of 150 kHz (Annex 10, Volume I, Chapter 3, 3.1.6.1) and are paired with those of the ILS localizer (see Figure 7-8 in the section on 108–117.975 MHz).

COMMENTARY: ICAO policy for the future need and use of this allocation is described in detail in the general policy for the use of ILS (see commentary on ILS localizer at 108–117.975 MHz).

Use of the band by other services

Footnote 5.259 was inserted by the ITU WARC-87. This footnote uses the same text (except for the list of countries) as Footnote 5.197 for the ILS localizer and VOR band at 108–117.975 MHz. At WRC-2000, most of the countries listed removed their names from this footnote. The remaining country names must now also be deleted to protect ILS glide path services in these areas and to avoid the possibility of new names being added at a future conference.

Band: 406–406.1 MHz
Service: Mobile-satellite (Earth-to-space) (search and rescue)
Allocation:

MHz 406–406.1		
Allocation to Services		
Region 1	Region 2	Region 3
406–406.1	MOBILE-SATELLITE (Earth-to-space) 5.266 5.267	

Footnotes:

5.266 The use of the band 406–406.1 MHz by the mobile-satellite service is limited to low power satellite emergency position-indicating radiobeacons (see also Article **31**). (WRC-07)

5.267 Any emission capable of causing harmful interference to the authorized uses of the band 406–406.1 MHz is prohibited.

ICAO POLICY:

- No change to the allocation to the band 406–406.1 MHz and Footnotes Nos. 5.266 and 5.267.
- Secure protection of emergency locator transmitters (ELTs) which are used in aviation in this frequency band.

AVIATION USE: The use of ELTs offers the possibility of dramatically shortening the time required to alert rescue forces to the distress and to assist in final "homing" by the rescue team. In the ITU, such beacons are named emergency position-indicating radio beacons (EPIRBs). ELTs operating in this frequency band have the capacity to transmit a programmed digital message which contains information related to the ELT and/or the aircraft on which it is carried. The COSPAS/SARSAT service, part of the global maritime distress and safety system (GMDSS) which receives the distress transmissions and relays back to Earth, is a joint enterprise operated on a multinational basis for the benefit of all users. SARPs on the use of ELTs operating in the frequency band 406–406.1 MHz are contained in

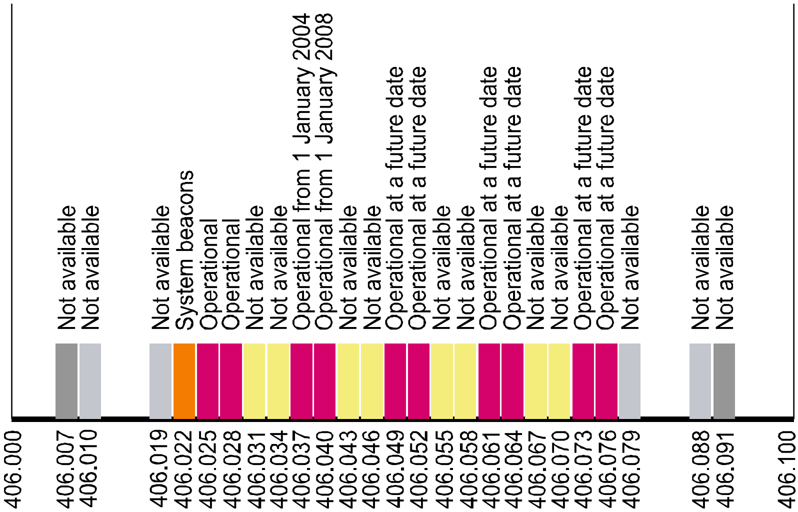
Annex 10, Volume III, Part II, Chapter 5 and Volume V, Chapter 2. Carriage requirements for ELT are contained in Annex 6.

COMMENTARY: ICAO participates with the International Maritime Organization (IMO) and other international bodies in discussions on the global aspects of search and rescue which encompass the use and deployment of this frequency.

Recent cases of serious interference from non-emergency sources have caused concern regarding the effectiveness of COSPAS/SARSAT services (see also ITU Resolution 205 (Rev. WRC-12)).

COSPAS/SARSAT developed specifications for 406 MHz distress beacons (COSPAS/SARSAT Doc. C/S T.001 refers) and a frequency management plan for the band 406-406.1 MHz (Figure 7-10) (COSPAS/SARSAT Doc. C/S T.012 refers).

ITU-R Recommendation M.633-3, which is incorporated by reference into the Radio Regulations (Article 34 (WRC-07) refers), contains the transmission characteristics of a satellite EPIRB system operating through a satellite system in the 406 MHz band.



SAR processors will be able to receive signals in the band 406.01–406.09 MHz. With a Doppler shift of +/– 9 kHz and 1 kHz margin for spreading of beacon carrier frequencies, the channel plan should not include frequencies below 406.02 MHz and above 406.08 Mhz.

Channels are made available on the basis of one pair of adjacent channels with a separation between the pair of 12 kHz in order to provide optimum capacity in both systems using geostationary satellites and low earth-orbiting satellites.

Figure 7-10. COSPAS/SARSAT frequency management plan (2003)

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Band: 960–1 215 MHz
Service: Aeronautical radionavigation/radionavigation satellite and Aeronautical Mobile (Route) Service (DME/SSR/ACAS/GNSS/1090ES/UAT)
Allocation:

MHz 960–1 215		
Allocation to Services		
Region 1	Region 2	Region 3
960–1 164	AERONAUTICAL RADIONAVIGATION 5.328 AERONAUTICAL MOBLE 5.327A	
1 164–1 215	AERONAUTICAL RADIONAVIGATION 5.328 RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.328B 5.328A	

Footnotes:

5.327A The use of the band 960–1 164 MHz by the aeronautical mobile (R) service is limited to systems that operate in accordance with recognized international aeronautical standards. Such use shall be in accordance with Resolution **417(Rev. WRC-12)**. (Rev. WRC-12)

5.328 The use of the band 960–1 215 MHz by the aeronautical radio-navigation service is reserved on a worldwide basis for the operation and development of airborne electronic aids to air navigation and any directly associated ground-based facilities.

5.328A Stations in the radionavigation-satellite service in the band 1 164–1 215 MHz shall operate in accordance with the provision of Resolution **609 (Rev. WRC-07)** and shall not claim protection from stations in the aeronautical radionavigation service in the band 960–1 215 MHz. No. **5.43A** does not apply. The provisions of No. **21.18** shall apply. (WRC-07)

5.328B The use of the bands 1 164–1 300 MHz, 1 559–1 610 MHz and 5 010–5 030 MHz by systems and networks in the radionavigation-satellite service for which complete coordination or notification information, as appropriate, is received by the Radiocommunication Bureau after 1 January 2005 is subject to the provisions of Nos. **9.12, 9.12A** and **9.13**. Resolution **610 (WRC-03)** shall also apply; however, in the case of radionavigation-satellite service (space-to-space) networks and systems, Resolution **610 (WRC-03)** shall only apply to transmitting space stations. In accordance with No**. 5.329A,** for systems and networks in the radionavigation-satellite service (space-to-space) in the bands 1 215–1 300 MHz and 1 559–1 610 MHz, the provisions of Nos**. 9.7, 9.12A** and **9.13** shall only apply with respect to other systems and networks in the radionavigation-satellite service (space-to-space). (WRC-07)

See also:

*Art. 21/18: Administration operating or planning to operate radio-navigation-satellite service systems or networks in the 1 164-1 215 MHz frequency band, for which complete coordination or notification information was received by the Bureau after 2 June 2000, shall, in accordance with resolves 2 of Resolution **609 (Rev. WRC-12)**, take all necessary steps to ensure that actual aggregate interference into aeronautical radionavigation service systems caused by such RNSS systems or networks operating co-frequency in these frequency bands does not exceed the equivalent power flux-density level shown in resolves 1 of Resolution **609 (Rev. WRC-12)**.* (Rev.WRC-12)

ICAO POLICY:

- No change to the current allocation to the aeronautical radionavigation service or to Footnote 5.328 in the band 960–1 215 MHz.
- No change to Footnote 5.328A.
- No change to the aeronautical mobile (route) service (AM(R)S) allocation or to Footnote 5.327A in the band 960–1 164 MHz with the exception of possible changes to remove the restrictions on the use of the AM(R)S due to non-ICAO standardized systems from ITU-R Resolution 417.

On a global basis, the band 960 – 1215 MHz is used for DME systems; this use is expected to increase and continue to well beyond 2030. In RNAV procedures, DME-DME navigation is planned to be one of the major navigation methods as an element of PBN. The band 960 – 1215 MHz is expected to satisfy on a global basis the future requirements for DME, taking into account the protection given to aeronautical radionavigation (DME) in the ITU Radio Regulations. In some areas, the frequency band is heavily congested with DME assignments. Rationalization in this band of frequency assignments to DME stations, including a review of the technical characteristics of DME may be necessary

Two sub-bands of about +/- 10 MHz around the frequencies 1030 MHz and 1090 MHz are reserved for SSR. SSR provides, in addition to secondary surveillance radar, major functionality for ACAS and ADS-B. SSR is expected to continue to be required for surveillance; the frequency bands used for SSR satisfy on a global basis the aeronautical requirements to well beyond 2030.

The band 1164 – 1215 MHz is also used for GPS/Galileo/Beidu/Glonass signals. In accordance with the Radio Regulations, the use of this band by GNSS systems needs to protect DME from interference and accept interference from DME. This frequency band is expected to meet the associated GNSS requirements on a global basis to well beyond 2030.

The band 960 – 1164 MHz is planned to be used for future air/ground (and air/air) data communications (e.g. LDACS) although achieving compatibility with DME/SSR may be problematic. Rationalization of DME may assist in providing the necessary spectrum for the data link system.

The frequency 978 MHz is used for the Universal Access Transceiver (UAT), which provides for ADS-B and up-linking of data messages

AVIATION USE: The band 960–1 215 MHz is a prime radionavigation band which is used intensively, and extensively, to support a number of aviation systems, for both civil and military purposes. The civil systems are:

Distance measuring equipment (DME): DME is the ICAO standard system for the determination of the distance between an aircraft and a ground-based DME beacon within radio line of sight, using pulse techniques and time measurement. DME/N is the standard system used for en-route and terminal navigation. It can be co-located with VOR enabling the aircraft's position to be determined through a measurement of its bearing and the distance relative to the VOR/DME. Alternatively, the aircraft's position can be determined through measurement of the distances from two or three DMEs and the flight management system equipment in the aircraft. DME/P is a precision version of DME with enhanced precision measurement capability which is used in conjunction with MLS to provide accurate distance to touchdown. TACAN is the military equivalent of DME which also has a bearing capability and uses the same channel plan as DME.

The channel plan (Annex 10, Volume I, Chapter 3, Table A) employs discrimination in both pulse length and pulse spacing, generating four possible modes (X, Y, W, and Z) as a means of creating additional channels.

Secondary surveillance radar (SSR): SSR is the ICAO standard system for secondary surveillance radar. It is used either as a stand-alone system or co-located and synchronized with primary radar. The ground equipment is an interrogator and the aircraft equipment is a transponder responding to signals from the interrogator. SSR employs Mode A for transmitting identification and Mode C for transmitting pressure-altitude information. Mode S employs selective addressing of the aircraft and has a limited data link capability. SSR Mode S is a continuing requirement, in particular in high-density airspace.

All SSR installations operate on 1 030 MHz for the ground-to-air interrogation signal, and 1 090 MHz for the air-to-ground reply. Extensive use of pulse repetition frequency (PRF) discrimination and plot plan processing techniques assists in reducing the number of invalidated responses being processed by the ground receiving system.

Airborne collision avoidance system (ACAS): ACAS is the ICAO standard system for detection and avoidance of airborne conflict situations. ACAS aircraft equipment interrogates Mode A/C and Mode S transponders on aircraft in its vicinity and listens to the transponder replies. By processing these replies, the ACAS equipment determines which aircraft represent potential collision threats and provides appropriate display indication or advisories to the flight crew to avoid collisions. ACAS operates as a supplementary system to SSR using the same frequency pair of 1 030 MHz and 1 090 MHz. 1 030 MHz is used for the air-air interrogation and 1 090 MHz for the air-air reply. The three modes, I, II and III, provide increased capability at each level of functional implementation. Provision is made for air-ground communication with ground stations using the Mode S data link. A diagram of the use of the frequencies 1 030 MHz and 1 090 MHz by air and ground elements of SSR and ACAS is at Figures 7-11 and 7-12.

1 090 MHz extended squitter (1090ES): 1 090 MHz extended squitter transmissions from Mode S transponders or other non-transponder devices are used to broadcast information relating to position of aircraft, aerodrome surface vehicles, fixed obstacles and/or other related information. The broadcast can be received by airborne or ground-based receivers and can contain automatic dependent surveillance-broadcast (ADS-B) and/or traffic information service-broadcast (TIS-B) messages.

Universal access transceiver (UAT): ICAO has adopted SARPs and guidance material for UAT. This system is intended to support ADS-B data transmission as well as ground uplink services such as TIS-B and flight information service-broadcast (FIS-B). UAT employs time division multiple access (TDMA) technique on a single 1 MHz channel at 978 MHz and is dedicated for transmission of airborne ADS-B reports and for broadcast of ground-based aeronautical information.

L-Band Datalink Aeronautical Communication System (LDACS):
LDACS is planned to provide for future air/ground data link capacity that cannot be met in the VHF band with either VDL Mode 2 or VDL Mode 4. In particular LDAVCS is intended to provide data link capacity to support trajectory planning in air traffic management. Work on the feasibility of implementing LDACS in the frequency band 960 – 1215 MHz is currently (2012) on-going and initial result show that at best the introduction of LDACS is challenging. In particular the need to secure compatibility with the aeronautical radionavigation service (DME and SSR/ACAS) places significant constraint on LDACS. Currently LDACS is being planned to operate in the bands 985.5 – 1007.5 MHz (uplink) and 1048.5 – 1071.5 MHz (downlink). Rationalization of the DME band that may create an exclusive contiguous sub-band for LACS may be necessary.

COMMENTARY: The present internationally agreed channel plans for DME occupy the full band 960–1 215 MHz. The DME channel plan is displayed at Table A of Annex 10, Volume I, Chapter 3. The arrangement of air-to-ground interrogations and ground-to-air replies showing the standard 63 MHz separation and the interleaving of X and Y channels is shown at Figure 7-11. Both X and Y channels are currently deployed together with 50 kHz VOR/ILS channel spacing in the higher density areas where the implementation of DME (and TACAN) is extensive. W and Z channels are intended for use with MLS, employing an interrogation pulse pair with a different pulse length on the X and Y channels, respectively. In low-density areas, only DME X channels (paired with 100 kHz ILS/DME channel spacing) are used.

Some world areas are prone to frequency scarcity. Frequency pairing of DME with VOR or ILS, triple pairing of DME with ILS and MLS (a necessary operational technique for air safety or for the transition to MLS where this system is brought into use), and co-channel TACAN use are factors often creating difficulties in frequency planning which are not easily overcome.

VOR/DME could be replaced by GNSS or supplemented by the use of area navigation based on DME/DME. The latter system, where it becomes established, is likely to extend beyond the year 2030.

The use of DME/P is intended to provide essential support to higher Category ILS and MLS/RNAV operations. Present expectations are that no Category III operations other than with ILS or MLS are foreseen in the period up to the year 2015.

SSR and SSR Mode S are the main techniques for surveillance in high traffic density areas (FANS II/4 refers). SSR Mode S is a tool for air traffic management mainly in high traffic density continental airspaces.

Carriage of ACAS systems may be mandatory in some airspace by national regulation or by regional agreement.

The overall situation in this band is one of a continuing exploitation of current systems. It can be realistically expected that some important uses of the band, such as ILS/DME, VOR/DME, DME/DME, and SSR Mode S, will continue as the main ATS tools in high-density airspace will extend to well beyond the long future.

Use of the band for GNSS

The frequencies in the band 1 164–1 215 MHz have been identified as suitable to support components for the future development of GNSS, in addition to GNSS components operating on other frequencies. Currently, a main component of GNSS is operating in the band 1 559–1 610 MHz. Proposed schemes include an additional frequency for GPS (L5) with higher signal levels and a more robust interference rejection characteristic at 1 176.45 MHz, and a European initiative (Galileo) for an independent radionavigation-satellite system operating under civil auspices. Both systems, if implemented, are considered for recognition in the GNSS Panel as elements of the ICAO GNSS. The timescale for first use in both cases is the period 2015 to 2020. Also GLONASS (Russian-based) and Beidou (China) intends to use this band for a component of the GLONASS system.

WRC-2000 adopted Footnote 5.328A which includes an allocation to the radionavigation-satellite service (RNSS, the ITU terminology for GNSS systems) in the band 1 164–1 215 MHz. WRC-03 developed detailed regulatory provisions for the protection of the aeronautical radionavigation service in this band. Protection of the DME channels 77X to 126X, the use of which can be affected by this allocation, is to be assured by imposing an equivalent power flux-density limit of –121.5 dB(W/m^2) in any 1 MHz for the space-to-Earth signals produced by all satellites of all RNSS systems operating in this band, and by a regulatory provision requiring that RNSS shall not claim protection from the stations of the ARNS.

Use of the band by other services

In some countries the band is also used by national communications systems (e.g. Joint Tactical Information Distribution System (JTIDS)/Multifunctional Information Distribution System (MIDS)). Such systems have no internationally recognized status in the band and therefore are only permitted to operate on a strict basis of non-interference to the radionavigation systems using the band in accordance with the ITU allocation (Article 4 of the Radio Regulations refers).

TACAN is a military development providing both the azimuth and distance components by equipment operating in the band 960–1 215 MHz. Where a TACAN transponder is co-located with a VOR, the distance measuring component of the TACAN substitutes for and fulfills any civil requirement for DME. The VOR is then referred to as “VORTAC”. As with DME, tuning to the VOR will automatically interlock with the associated TACAN distance measuring element. When used by civil aircraft, the guidance derived from a VOR/DME and a VORTAC is identical.

Certain airborne TACAN systems function as a standard TACAN interrogator system (measuring the slant-range distance and relative bearing to a selected ground station or an airborne TACAN beacon, and computing velocity and time-to-go to that station) and providing an air-air bearing transmit capability (beacon mode) used to provide rendez-vous capability between aircraft.

Non-ICAO standard aeronautical radionavigation systems
The frequency band 960 – 1215 MHz is also used for certain non-ICAO standard aeronautical radionavigation systems and mainly used in east-European countries. The technical characteristics on protection criteria for these systems are in Recommendation ITU-R M.2013. Use of the band 960 – 1164 MHz by the aeronautical mobile (R) service (e.g. LDACS) needs to secure protection of these systems.

WRC-12

At WRC-12 it was agreed that all of the studies called for by ITU-R Resolution 417 between AM(R)S systems operating in the frequency band 960-1164 MHz and non-ICAO ARNS systems. On the basis of the results of these studies it was agreed that the AM(R)S allocation made at the last WRC can be used subject to the conditions contained in the revised version of ITU-R Resolution 417.

ITU-R Resolution 417 requires that any communication system, with the exception of UAT, introduced into the frequency band 960-1164 MHz must be co-ordinated when intended to operate within 934 km of a number of States (mainly in east Europe) using non-ICAO standard systems in this band. The Resolution also places a maximum e.i.r.p limit on the emissions from any AM(R)S system that is based on the frequency offset from 1164MHz and a fixed out of band limit above 1164 MHz for the protection of the radionavigation satellite service.

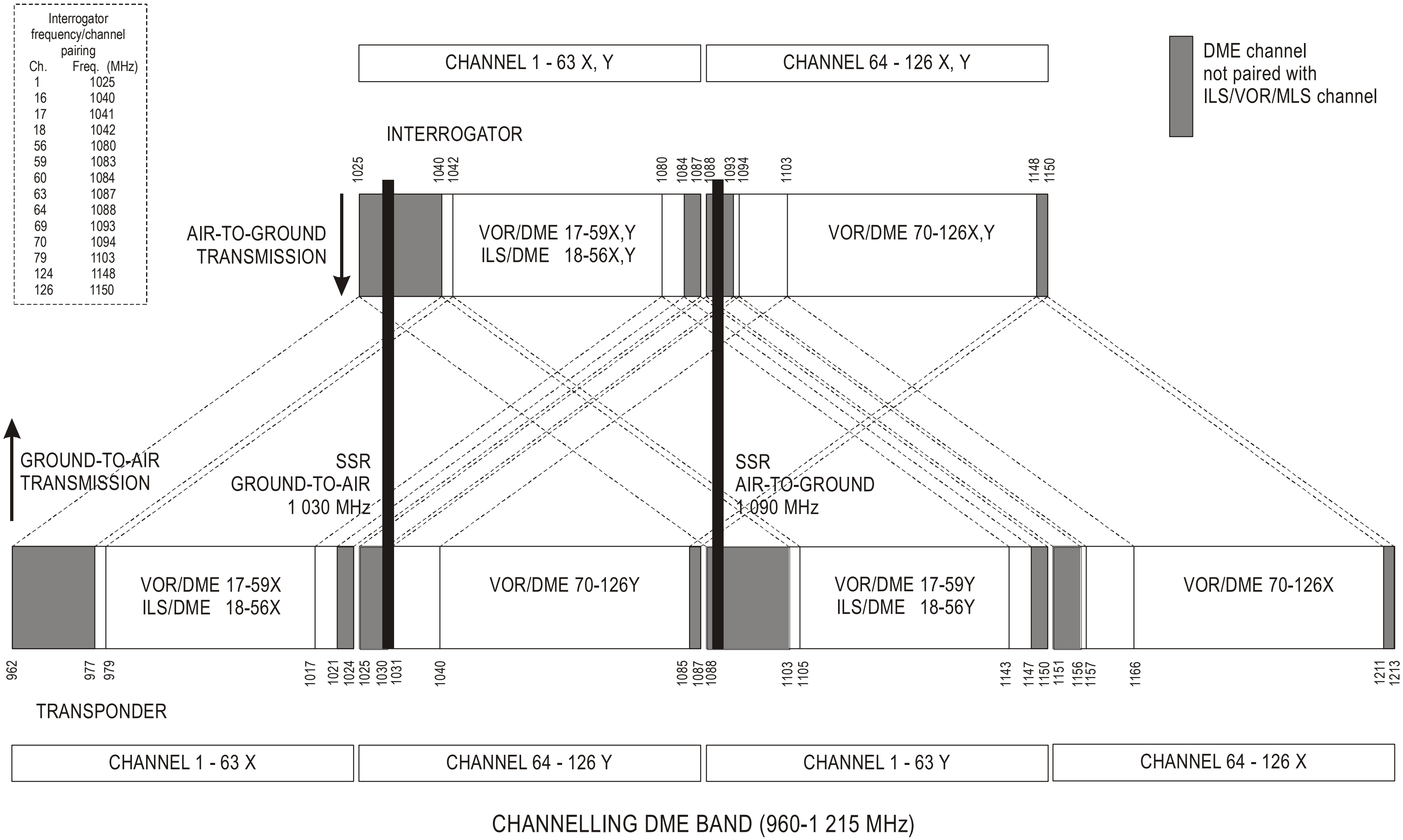

Figure 7-11. Channelling DME bank (960–1215 MHz)

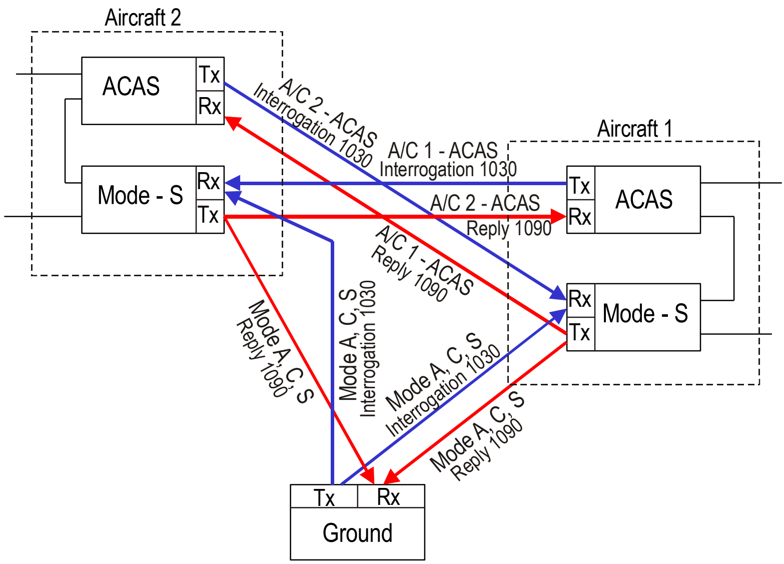

Figure 7-12. Use of frequencies 1 030 MHz and 1 090 MHz by SSR and ACAS air and ground elements

Band: 1 215–1 400 MHz
Service: Radionavigation/aeronautical radionavigation/radiolocation/radionavigation-satellite (RNSS/primary surveillance radar)
Allocation:

<table>
<tr><th colspan="3">MHz
1 215–1 400</th></tr>
<tr><th colspan="3">Allocation to Services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td>1 215–1 240</td><td colspan="2">EARTH EXPLORATION-SATELLITE (active)
RADIOLOCATION
RADIONAVIGATION-SATELLITE
(space-to-Earth) (space-to-space)
5.328B 5.329 5.329A
SPACE RESEARCH (active)
5.330 5.331 5.332</td></tr>
<tr><td>1 240–1 300</td><td colspan="2">EARTH EXPLORATION-SATELLITE (active)
RADIOLOCATION
RADIONAVIGATION-SATELLITE
(space-to-Earth) (space-to-space)
5.328B 5.329 5.329A
SPACE RESEARCH (active)
Amateur
5.282 5.330 5.331 5.332 5.335 5.335A</td></tr>
<tr><td>1 300–1 350</td><td colspan="2">AERONAUTICAL RADIONAVIGATION 5.337
RADIOLOCATION
RADIONAVIGATION-SATELLITE
(Earth-to-space)
5.149 5.337A</td></tr>
<tr><td>1 350–1 400
FIXED
MOBILE
RADIOLOCATION
5.149 5.338 5.339
5.338A</td><td colspan="2">1 350–1 400
RADIOLOCATION 5.338A

5.149 5.334 5.339</td></tr>
</table>

Footnotes:

5.149 In making assignments to stations of other services to which the bands: ... 1 330–1 400 MHz, ... are allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. **4.5** and **4.6** and Article **29**). (WRC-07)

5.282 In the bands 435–438 MHz, 1 260–1 270 MHz, 2 400–2 450 MHz, 3 400–3 410 MHz (in Regions 2 and 3 only) and 5 650–5 670 MHz, the amateur-satellite service may operate subject to not causing harmful interference to other services operating in accordance with the Table (see No. **5.43**). Administrations authorizing such use shall ensure that any harmful interference caused by emissions from a station in the amateur-satellite service is immediately eliminated in accordance with the provisions of No. **25.11**. The use of the bands 1 260–1 270 MHz and 5 650–5 670 MHz by the amateur-satellite service is limited to the Earth-to-space direction.

5.328B The use of the bands 1 164–1 300 MHz, 1 559–1 610 MHz and 5 010–5 030 MHz by systems and networks in the radionavigation-satellite service for which complete coordination or notification information, as appropriate, is received by the Radiocommunication Bureau after 1 January 2005 is subject to the application of the provisions of Nos. **9.12**, **9.12A** and **9.13**. Resolution **610 (WRC-03)** shall also apply; however, in the case of radionavigation-satellite service (space-to-space) networks and systems, Resolution **610 (WRC-03)** shall only apply to transmitting space stations. In accordance with No. **5.329A,** for systems and networks in the radionavigation-satellite service (space-to-space) in the bands 1 215–1 300 MHz and 1 559–1 610 MHz, the provisions of Nos. **9.7, 9.12A** and **9.13** shall only apply with respect to other systems and networks in the radionavigation-satellite service (space-to-space). (WRC-07)

5.329 Use of the radionavigation-satellite service in the band 1 215–1 300 MHz shall be subject to the condition that no harmful interference is caused to, and no protection claimed from, the radionavigation service authorized under No. **5.331**. Furthermore, the use of the radionavigation-satellite service in the band 1 215–1 300 MHz shall be subject to the condition that no harmful interference is caused to the radiolocation service. No. **5.43** shall not apply in respect of the radiolocation service. Resolution **608 (WRC-03)** shall apply. (WRC-03)

5.329A Use of systems in the radionavigation-satellite service (space-to-space) operating in the bands 1 215–1 300 MHz and 1 559–1 610 MHz is not intended to provide safety service applications, and shall not impose any additional constraints on radionavigation satellite service (space to Earth) or on other systems or services operating in accordance with the Table of Frequency Allocations. (WRC-07)

5.330 *Additional allocation:* in Angola, Saudi Arabia, Bahrain, Bangladesh, Cameroon, China, Djibouti, the United Arab Emirates, Eritrea, Ethiopia, Guyana, India, Indonesia, Iran (Islamic Republic of), Iraq, Israel, , Japan, Jordan, Kuwait, Nepal, Oman, Pakistan, the Philippines, Qatar, the Syrian Arab Republic, Somalia, Sudan, South Sudan, Chad, Togo and Yemen, the band 1 215–1 300 MHz is also allocated to the fixed and mobile services on a primary basis. (WRC-12)

5.331 *Additional allocation*: in Algeria, Germany, Saudi Arabia, Australia, Austria, Bahrain, Belarus, Belgium, Benin, Bosnia and Herzegovina, Brazil, Burkina Faso, Burundi, Cameroon, China, Korea (Rep. of), Croatia, Denmark, Egypt, the United Arab Emirates, Estonia, the Russian Federation, Finland, France, Ghana, Greece, Guinea, Equatorial Guinea, Hungary, India, Indonesia, Iran (Islamic Republic of), Iraq, Ireland, Israel, Jordan, Kenya, Kuwait, The Former Yugoslav Republic of Macedonia, Lesotho, Latvia, Lebanon, Liechtenstein, Lithuania, Luxembourg, Madagascar, Mali, Mauritania, Montenegro, Nigeria, Norway, Oman, Pakistan, the Netherlands, Poland, Portugal, Qatar, the Syrian Arab Republic, Dem People's Republic of Korea, Slovakia, the United Kingdom, Serbia, Slovenia, Somalia, Sudan, South Sudan, Sri Lanka, South Africa, Sweden, Switzerland, Thailand, Togo, Turkey, Venezuela and Viet Nam the band 1 215–1 300 MHz is also allocated to the radionavigation service on a primary basis. In Canada and the United States the band 1 240–1 300 MHz is also allocated to the radionavigation service, and use of the radionavigation service shall be limited to the aeronautical radionavigation service. (WRC-12)

5.332 In the band 1 215–1 260 MHz, active spaceborne sensors in the Earth exploration-satellite and space research services shall not cause harmful interference to, claim protection from, or otherwise impose constraints on operation or development of the radiolocation service, the radionavigation-satellite service and other services allocated on a primary basis.

5.334 *Additional allocation:* in Canada and the United States, the band 1 350–1 370 MHz is also allocated to the aeronautical radionavigation service on a primary basis. (WRC-03)

5.335 In Canada and the United States in the band 1 240–1 300 MHz, active spaceborne sensors in the earth exploration-satellite and space research services shall not cause interference to, claim protection from, or otherwise impose constraints on operation or development of the aeronautical radionavigation service.

5.335A In the band 1 260–1 300 MHz, active spaceborne sensors in the Earth exploration-satellite and space research services shall not cause harmful interference to, claim protection from, or otherwise impose constraints on operation or development of the radiolocation service and other services allocated by footnotes on a primary basis.

5.337 The use of the bands 1 300–1 350 MHz, 2 700–2 900 MHz and 9 000–9 200 MHz by the aeronautical radionavigation service is restricted to ground-based radars and to associated airborne transponders which transmit only on frequencies in these bands and only when actuated by radars operating in the same band.

5.337A The use of the band 1 300–1 350 MHz by earth stations in the radionavigation-satellite service and by stations in the radiolocation service shall not cause harmful interference to, nor constrain the operation and development, of the aeronautical-radionavigation service.

5.338 In Kyrgyzstan, Slovakia and Turkmenistan, existing installations of the radionavigation service may continue to operate in the band 1 350–1 400 MHz. (WRC-12)

5.338A In the bands 1 350–1 400 MHz, 1 427–1 429 MHz, 1 429–1 452 MHz, 22.55–23.55 GHz, 30–31 GHz, 31–31.3 GHz, 49.7–50.2 GHz, 50.4–50.9 GHz and 51.4–52.6 GHz, Resolution **750 (Rev. WRC-12)** applies. (WRC-12)

5.339 The bands 1 370–1 400 MHz, 2 640–2 655 MHz, 4 950–4 990 MHz and 15.20–15.35 GHz are also allocated to the space research (passive) and Earth exploration-satellite (passive) services on a secondary basis.

ICAO POLICY:

- No change to the status of the allocation to the radionavigation service in Footnotes 5.331 and 5.334.
- No change to Footnote 5.332.
- No change to the provisions of Footnotes 5.329 and 5.337A regarding the protection of radar stations from the radionavigation-satellite service
- Support further ITU-R studies relating to Resolution **608**.

On a global basis the band 1300 – 1350 MHz (and in many countries also the band 1215 – 1300 MHz) is extensively used for primary surveillance radar, mainly providing long range independent non-cooperative airspace surveillance. This use is expected to continue to be required for the long term.

The use of this band for GNSS signals (GPS L2, GLONASS L2, Galileo E6 and Beidou B6) is not for civil aircraft applications.

A new development in radar technology is the multi static primary surveillance radar (MSPSR). MSPSR may provide more spectrum efficient use of this band and better coverage at lower altitudes. However, the implementation of MSPSR is dependent on the cost and improved spectrum efficiency that can be obtained.

AVIATION USE: These bands are used extensively for 23 cm (L-band) primary surveillance radar (PSR), for both en-route and terminal surveillance tasks. Modern systems employing digitized plot extraction often operate on multiple frequencies and use pulse repetition frequency (PRF) discrimination where up to four or even six frequencies may be used by a single radar spaced over a band of 100 MHz. For these requirements, the band from around 1 215 to 1 370 MHz (as for example in Footnote 5.334) must be available. The band is also used extensively by other users for the long-range detection of aircraft targets. Co-located SSR and primary surveillance radar are often employed with combined plot extraction, electronic processing and display. Electronically generated labels displaying flight number and other data, i.e. altitude reported from SSR Mode C, are often added to provide a complete radar data picture.

Twenty-three cm is the preferred wavelength for long-range radar where a sufficiently large antenna can be installed to provide narrow beams in azimuth and phased arrays for beam switching for multi-purpose mode operation.

COMMENTARY: Under FANS recommendations, the use of primary radar is expected, in the long term, to diminish in both en-route and terminal areas (Agenda Item 7 of the *Report of the Tenth Air Navigation Conference (1991)* (Doc 9583) refers). The recommended replacement system is SSR Mode S or some form of ADS using air-ground data link. Future possible use of ADS or ADS-B may affect the requirements for primary or secondary radar. Primary radar with its high-level investment is, however, expected to continue to be utilized in civil aviation for many years into the future. One of the important features of primary radar is the independent role it plays in surveillance of airspace allowing for the detection of non-cooperating aircraft.

The Communications/Meteorology/Operations (COM/MET/OPS) Divisional Meeting (1990) (Attachment 4 to Appendix B to the report on Agenda Item 1 refers) reported the wide use of this band (and also of the band 2 700–2 900 MHz) for en-route and terminal surveillance. Table 1 in Attachment 4 provides estimates of the use amounting to 583 radars worldwide. Paragraph 4 proposes the ICAO position of no change to the allocation at 1 300–1 350 MHz and adjoining bands.

The conclusion of these considerations was that these bands should be retained and protected for the foreseeable future for the operation of radar systems.

Use of the band by the radionavigation-satellite service

The band 1 215–1 300 MHz is also used for GLONASS (initially 1 246 MHz + 24 × 437.5 kHz). These frequencies are expected to be shifted in the near future (1 243.5 MHz + 14 × 437.5 kHz). The frequency 1 227.6 MHz is used for the precise positioning service (PPS, L2) of GPS, extending the accuracy of GPS. A new signal, GPS L2C will soon become available for civil use. Techniques have been developed for the use of ground stations to correct for ionospheric delays (see also commentary on GNSS usage of the band 1 559–1 610 MHz).

WRC-2000 introduced an allocation to the RNSS in the frequency bands 1 260–1 300 MHz for space-to-Earth and space-to-space direction, and 1 300–1 350 MHz for the Earth-to-space direction to meet the requirements of a proposed European civil operated satellite radionavigation system (Galileo). The service is not expected to be fully operational before about 2018. The use of the band 1 260–1 300 MHz by Galileo is not intended to support safety service applications. The components in these bands are not being considered as a part of the ICAO GNSS system.

WRC-03 reviewed the allocation and decided that in the frequency band 1 215–1 300 MHz the radionavigation-satellite service shall be subject to the condition that no harmful interference is caused to, and no protection claimed from, the radionavigation service authorized under No. 5.331 (WRC-12). Furthermore, the use of the radionavigation-satellite service in the frequency band 1 215-1 300 MHz shall be subject to the condition that no harmful interference is caused to the radiolocation service. Resolution 608 resolves that no constraints in addition to those in place prior to WRC-2000 shall be placed on RNSS (space-to-Earth) frequency assignments in the frequency band 1 215 –1 260 MHz brought into use until 2 June 2000.

Studies in ITU-R SG 8 are underway to further define protection criteria for primary surveillance radars.

COMMENTARY: WRC-2000 adopted an allocation to the radio-navigation-satellite service in the space-to-space direction in this frequency band. GPS and GLONASS already operate in this frequency band in the space-to-Earth direction. The allocation improves reception of GNSS signals on board space vehicles. The Galileo and Beidou satellite navigations systems are also planning to use this frequency band.

Bands: Mobile-satellite bands 1 525–1 559 MHz and 1 626.5–1 660.5 MHz
Service: AMS(R)S (satellite communications)

1. Space-to-Earth

<table>
<tr><th colspan="3">MHz
1 525–1 559</th></tr>
<tr><td colspan="3">Allocation to Services</td></tr>
<tr><td>Region 1</td><td>Region 2</td><td>Region 3</td></tr>
<tr><td>1 525–1 530
SPACE OPERATION
(space-to-Earth)
FIXED
MOBILE-SATELLITE
(space-to-Earth)
5.208B 5.351A
Earth exploration-satellite
Mobile except aeronautical mobile 5.349

5.341 5.342 5.350
5.351 5.352A 5.354</td><td>1 525–1 530
SPACE OPERATION
(space-to-Earth)
MOBILE-SATELLITE
(space-to-Earth)
5.208B 5.351A
Earth exploration-satellite
Fixed
Mobile 5.343

5.341 5.351 5.354</td><td>1 525–1 530
SPACE OPERATION
(space-to-Earth)
FIXED
MOBILE-SATELLITE
(space-to-Earth)
5.208B 5.351A
Earth exploration-satellite
Mobile 5.349

5.341 5.351 5.352A
5.354</td></tr>
<tr><td>1 530–1 535
SPACE OPERATION
(space-to-Earth)
MOBILE-SATELLITE
(space-to-Earth)
5.208B 5.351A
5.353A
Earth exploration-satellite
Fixed
Mobile except aeronautical mobile

5.341 5.342 5.351
5.354</td><td colspan="2">1 530–1 535
SPACE OPERATION (space-to-Earth)
MOBILE-SATELLITE (space-to-Earth)
5.208B 5.351A 5.353A
Earth exploration-satellite
Fixed
Mobile 5.343

5.341 5.351 5.354</td></tr>
<tr><td>1 535–1 559</td><td colspan="2">MOBILE-SATELLITE (space-to-Earth)
5.208B 5.351A 5.341 5.351 5.353A
5.354 5.355 5.356 5.357 5.357A 5.359
5.362A</td></tr>
</table>

2. Earth-to-space

MHz 1 626.5–1 660.5		
Allocation to Services		
Region 1	Region 2	Region 3
1 626.5–1 660	MOBILE-SATELLITE (Earth-to-space) 5.351A 5.341 5.351 5.351A 5.353A 5.354 5.355 5.357A 5.359 5.362A 5.374 5.375 5.376	
1 660–1 660.5	MOBILE-SATELLITE (Earth-to-space) 5.351A RADIO ASTRONOMY 5.149 5.341 5.351 5.351A 5.354 5.362A 5.376A	

Footnotes:

5.149 In making assignments to stations of other services to which the bands: ... 1 660–1 670 MHz, ... are allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. **4.5** and **4.6** and Article **29**) (WRC-07).

5.208B In the bands …1 525-1 610 MHz … Resolution **739 (Rev. WRC-07)** applies. (WRC-07)

5.341 In the bands 1 400–1 727 MHz, 101–120 GHz and 197–220 GHz, passive research is being conducted by some countries in a programme for the search for intentional emissions of extraterrestrial origin.

5.342 *Additional allocation:* in Armenia, Azerbaijan, Belarus, the Russian Federation, Uzbekistan, Kyrgyzstan and Ukraine, the band 1 429–1 535 MHz, and in Bulgaria the band 1 525-1 535 MHz, are also allocated to the aeronautical mobile service on a primary basis exclusively for the purposes of aeronautical telemetry within the national territory. As of 1 April 2007, the use of the band 1 452–1 492 MHz is subject to agreement between the administrations concerned. (WRC-12)

5.343 In Region 2, the use of the band 1 435–1 535 MHz by the aeronautical mobile service for telemetry has priority over other uses by the mobile service.

5.349 *Different category of service:* in Saudi Arabia, Azerbaijan, Bahrain, Cameroon, Egypt, France, Iran (Islamic Republic of), Iraq, Israel, Kazakhstan, Kuwait, The Former Yugoslav Republic of Macedonia, Lebanon, Morocco, Qatar, Syrian Arab Republic, Kyrgyzstan, Turkmenistan and Yemen, the allocation of the band 1 525–1 530 MHz to the mobile, except aeronautical mobile, service is on a primary basis (see No. **5.33**). (WRC-07)

5.350 *Additional allocation:* in Azerbaijan, Kyrgyzstan and Turkmenistan, the band 1 525–1 530 MHz is also allocated to the aeronautical mobile service on a primary basis.

5.351 The bands 1 525–1 544 MHz, 1 545–1 559 MHz, 1 626.5–1 645.5 MHz, 1 646.5–1660.5 MHz shall not be used for feeder links of any service. In exceptional circumstances, however, an earth station at a specified fixed point in any of the mobile-satellite services may be authorized by an administration to communicate via space stations using these bands.

5.351A For the use of the bands 1 518–1 544 MHz, 1 545–1 559 MHz, 1 610–1 645.5 MHz, 1 646.5–1 660.5 MHz, 1 668–1 675 MHz, 1 980–2 010 MHz, 2 170–2 200 MHz, 2 483.5–2 500 MHz, 2 500–2 520 MHz and 2 670–2 690 MHz by the mobile-satellite service, see Resolutions **212 (Rev. WRC-07)** and **225 (Rev. WRC-12)**. (WRC-12)

5.352A In the band 1 525–1 530 MHz, stations in the mobile-satellite service, except stations in the maritime mobile-satellite service, shall not cause harmful interference to, or claim protection from, stations of the fixed service in France and French overseas territories in Region 3, Algeria, Saudi Arabia, Egypt, Guinea, India, Israel, Italy, Jordan, Kuwait, Mali, Morocco, Mauritania, Nigeria, Oman, Pakistan, the Philippines, Qatar, Syrian Arab Republic, Tanzania, Viet Nam and Yemen notified prior to 1 April 1998. (WRC-12)

5.353A In applying the procedures of Section II of Article **9** to the mobile-satellite service in the bands 1 530–1 544 MHz and 1 626.5–1 645.5 MHz, priority shall be given to accommodating the spectrum requirements for distress, urgency and safety communications of the Global Maritime Distress and Safety System (GMDSS). Maritime mobile-satellite distress, urgency and safety communications shall have priority access and immediate availability over all other mobile satellite communications operating within a network. Mobile-satellite systems shall not cause unacceptable interference to, or claim protection from, distress, urgency and safety communications of the GMDSS. Account shall be taken of the priority of safety-related communications in the other mobile-satellite services. (The provisions of Resolution **222 (Rev. WRC-12)** shall apply.) (WRC-12)

5.354 The use of the bands 1 525–1 559 MHz and 1 626.5–1 660.5 MHz by the mobile-satellite services is subject to coordination under No. **9.11A**.

5.355 *Additional allocation*: in Bahrain, Bangladesh, Congo (Rep of the), Djibouti, Egypt, Eritrea, Iraq, Israel, Kuwait, Qatar, Syrian Arab Republic, Somalia, Sudan, South Sudan, Chad, Togo and Yemen, the bands 1 540–1 559 MHz, 1 610–1 645.5 MHz and 1 646.5–1 660 MHz are also allocated to the fixed service on a secondary basis. (WRC-12)

5.356 The use of the band 1 544–1 545 MHz by the mobile-satellite service (space-to-Earth) is limited to distress and safety communications (see Article **31**).

5.357 Transmissions in the band 1 545–1 555 MHz from terrestrial aeronautical stations directly to aircraft stations, or between aircraft stations, in the aeronautical mobile (R) service are also authorized when such transmissions are used to extend or supplement the satellite-to-aircraft links.

5.357A In applying the procedures of Section II of Article **9** to the mobile-satellite service in the bands 1 545–1 555 MHz and 1 646.5–1 656.5 MHz, priority shall be given to accommodating the spectrum requirements of the aeronautical mobile-satellite (R) service providing transmission of messages with priority 1 to 6 in Article **44**. Aeronautical mobile-satellite (R) service communications with priority 1 to 6 in Article **44** shall have priority access and immediate availability, by pre-emption if necessary, over all other mobile-satellite communications operating within a network. Mobile-satellite systems shall not cause unacceptable interference to, or claim protection from, aeronautical mobile-satellite (R) service communications with priority 1 to 6 in Article **44**. Account shall be taken of the priority of safety-related communications in the other mobile-satellite services. (The provisions of Resolution **222 (Rev. WRC-12)** shall apply.)

5.359 *Additional allocation*: in Germany, Saudi Arabia, Armenia, Austria, Azerbaijan, Belarus, Benin, Cameroon, the Russian Federation, France, Georgia, Greece, Guinea, Guinea-Bissau, Jordan, Kazakhstan, Kuwait, Lithuania, Mauritania, Uganda, Uzbekistan, Pakistan, Poland, the Syrian Arab Republic, Kyrgyzstan, the Dem. People's Rep. of Korea, Romania, Tajikistan, Tanzania, Tunisia, Turkmenistan and Ukraine, the bands 1 550–1 559 MHz, 1 610–1 645.5 MHz and 1 646.5–1 660 MHz are also allocated to the fixed service on a primary basis. Administrations are urged to make all practicable efforts to avoid the implementation of new fixed-service stations in these bands. (WRC-12)

5.362A In the United States, in the bands 1 555–1 559 MHz and 1 656.5–1660.5 MHz, the aeronautical mobile-satellite (R) service shall have priority access and immediate availability, by pre-emption if necessary, over all other mobile-satellite communications operating within a network. Mobile-satellite systems shall not cause unacceptable interference to, or claim protection from, aeronautical mobile-satellite (R) service communications with priority 1 to 6 in Article **44**. Account shall be taken of the priority of safety-related communications in the other mobile-satellite services.

5.374 Mobile earth stations in the mobile-satellite service operating in the bands 1 631.5–1 634.5 MHz and 1 656.5–1 660 MHz shall not cause harmful interference to stations in the fixed service operating in the countries listed in No. **5.359**.

5.375 The use of the band 1 645.5–1 646.5 MHz by the mobile-satellite service (Earth-to-space) and for inter-satellite links is limited to distress and safety communications (see Article **31**).

5.376 Transmissions in the band 1 646.5–1 656.5 MHz from aircraft stations in the aeronautical mobile (R) service directly to terrestrial aeronautical stations, or between aircraft stations, are also authorized when such transmissions are used to extend or supplement the aircraft-to-satellite links.

5.376A Mobile earth stations operating in the band 1 660–1 660.5 MHz shall not cause harmful interference to stations in the radio astronomy service.

ICAO POLICY:

- Support the establishment of adequate technical and regulatory procedures to:
  - a) guarantee access to spectrum in these bands for aeronautical communications as required; and
  - b) ensure that aeronautical communications in categories 1 to 6 of Article 44 are given priority and immediate access at all times.
- If acceptable procedures cannot be established, recover the exclusive allocation of the bands 1 545–1 555 MHz and 1 646.5–1 656.5 MHz to the AMS(R)S.
- If required, modify Footnotes 5.357A and 5.362A to strengthen AMS(R)S access to the bands.
- No change to Footnotes 5.357 and 5.376.
- Support the deletion of Footnotes 5.355 and 5.359.
- Provide support to the procedure to implement Footnote 5.357A and Resolution 222 (Rev. WRC-12)
- Support studies with respect to Resolution 422 (WRC-12).

In the bands 1545 – 1555 MHz and 1646.5 – 1656.5 MHz (and in the United States also the bands 1555 – 1559 MHz and 1656.5 – 1660.5 MHz as per footnote 5.362A), the provisions in ITU Radio Regulations stipulate that priority shall be given during the frequency coordination process to the spectrum requirements for the aeronautical mobile satellite (R) service. Over a long period of time (prior to WRC-12), these provisions did not provide for the required access for aeronautical mobile satellite (R) communications. In order to secure that the aeronautical requirements for in particular long distance communications using satellite technology are met the relevant radio regulatory provisions in Resolution 222 were amended at WRC-12 as an attempt improve and secure in all cases access by aviation to those bands.

AVIATION USE: These frequencies are used for air-ground communications and, in the FANS scenarios, expected to replace HF voice over oceanic/remote areas. In continental airspace, satellite communications may be used as a supplement to VHF. The system supports voice and data for ATC or ADS purposes. SARPs were adopted by ICAO in 1995.

Also included in the allocation table shown above are the mobile-satellite bands 1 544–1 545 MHz and 1 645.5–1 646.5 MHz which are to be used for any mobile service for distress and safety communications only.

AMS(R)S services will be provided by service providers for both the space segment and the ground segment. The connection to ATC centres would normally be made by landline from the ground earth station.

COMMENTARY: The use of satellites for communications (and navigation) was recommended as official ICAO policy by the Tenth Air Navigation Conference (Montreal, 5 to 20 September 1991), as part of the future CNS/ATM systems recommended by FANS. The Tenth Air Navigation Conference discussions comprehensively covered all aspects of the subject. The ICAO Council endorsed the FANS recommendations at the twentieth meeting of its 134th Session on 29-31 October 1991. The prime use would be in oceanic and continental low-density airspace. The system supports voice and data, the latter being a support element for ADS.

At the above-mentioned conference, the role of ICAO in satellite communications with aircraft was explored (Agenda Item 8 of the *Report of the Tenth Air Navigation Conference (1991)* (Doc 9583) refers), and was seen to be basically that of a facilitator and coordinator. The complexities of the institutional and legal arrangements and interfaces between the concerned parties, such as air traffic service provider, space system provider and ground system provider, were addressed in Agenda Item 4 of the same conference. Appendix A to Agenda Item 4 sets out guidelines and recommendations for study on these aspects.

Generic allocations/access to frequencies

Until 1997, ITU allocations to the AMS(R)S were exclusive and worldwide in accordance with the definition at RR 1.36 and the rules at Chapter VIII for aeronautical mobile services. The exclusive condition ensured that ICAO SARPs could be applied, and the system operators would provide a service with the required integrity and reliability. Frequencies for mobile-satellite use were under intensive demand for other mobile applications, which led ITU to focus attention on the relatively unused AMS(R)S allocation.

WRC-97 discussed at great length the introduction of a generic allocation to the mobile-satellite service which replaced the exclusive allocations to the aeronautical, land and maritime mobile-satellite services, noting the dissenting views of the international civil aviation and maritime communities (see Section 7-III, paragraph 7-III.3.1.4 of this handbook). Frequencies in a generic allocation may be used for providing service to any class of mobile user (land, sea or air) and may carry any type of communication (safety, public correspondence, voice or data). Against the stated policies of ICAO and IMO, the introduction of generic allocations was approved, together with a new Footnote 5.357A which was intended to provide a guarantee of future frequency access for aeronautical safety services. With this new generic allocation to the mobile-satellite service, aircraft have to share the 10 MHz in the bands 1 545–1 555 MHz and 1 646.5–1 656.5 MHz with non-aeronautical systems, services and service providers (and an additional 4 MHz in the bands 1555 – 1559 MHz and 1656.5 – 1660.5 MHz in the United States).

Footnote 5.357A and 5.362A, inserted at WRC-97, provide the mechanism intended by radio regulatory authorities to compensate for the loss of the exclusive 10 MHz of spectrum to the AMS(R)S and assure access in the future. It relied on cooperation between administrations and satellite system operators and by itself had no apparent regulatory force. In a situation where there are no spare frequencies for aeronautical use in the bands quoted in the footnote, with some used for other (non-aeronautical) mobile-satellite systems, expansion of aeronautical use is only possible by a release of frequencies from a non-aeronautical user. In effect, there was no guarantee that such release could be made possible. Two important features of the footnote are that they address only the 10 MHz (14 MHz in the United States) of spectrum allocated to the AMS(R)S prior to WARC-92 (as quoted in the footnote) and that the priorities are Categories 1 to 6 of Article 44 of the Radio Regulations. These are identical to Annex 10, Volume II, Chapter 5, 5.1.8 (see Section 7-III, paragraph 7-III.3.8 of this handbook). This excludes Public Correspondence, a category which covers passenger and airline administrative communications.

The aviation concern on this point led to Resolution 222 (WRC-2000). Resolves 3 of the Resolution states that administrations shall ensure that MSS operators yield capacity to accommodate AMS(R)S requirements, either through the coordination process described below or through prioritization and real-time pre-emptive access, where feasible. To give this Resolution a positive regulatory force, a linked reference has been placed in Footnote 5.357A, which under present ITU rules gives it the same status as a Radio Regulation. This regulatory formula, while not fully meeting the ICAO policy calling for a recovery of the exclusive allocation to the AMS(R)S, is still a considerable improvement on the original.

The current practice of the application of 5.357A is that all satellite service providers planning to operate in the bands 1 525–1 559 MHz and 1 626.6–1 660.5 MHz register the use of the whole band with the ITU. With this registration, the obligations of the Radio Regulations to internationally coordinate the frequency assignments are satisfied. However, the actual allotment of portions of this spectrum to satellite system operators is taking place under the auspices of a Memorandum of Understanding (MOU) between the concerned satellite system operators and relevant administrations. Under the MOU, satellite system operators are provided with spectrum on a yearly basis, using actual and predicted traffic characteristics, and satisfying their needs as long as these can be accommodated in the available spectrum. The results of these yearly consultations are not available in the public domain. ICAO is not invited to become a party to this MOU nor is it informed about the results. The frequency coordination and assignment process has been factually taken outside the traditional ITU frequency planning and coordination process. The secrecy around the results of the activities under the MOU does not give ICAO or the aviation community the possibility to assess if the aeronautical spectrum requirements will be met in the longer term. Furthermore, the process under the MOU does not provide for any alternative measures if it is no longer supported by administrations or satellite system operators. This creates serious concern about the practical ability to make frequency spectrum available for aeronautical communications, when required, which under the MOU has already been assigned to a particular non-aeronautical satellite system operator.

Spectrum requirements for satellite communications

The amount of spectrum required for civil aviation has been a subject of study since 1971 when the first allocation of 15 MHz in both directions for safety communications only was made. Later (in 1987), with the realization that safety communications alone could not justify a satellite system with dedicated frequencies, and to meet airline needs, the scope was increased to include public correspondence. The WARC Mob-87 further reduced this exclusive allocation. Finally the WRC-97 concluded on the present 10 MHz (no longer exclusive) quoted in Footnote 5.357A. The generic allocation permits public correspondence, subject to the priority terms for Categories 1 to 6 of Article 44 as quoted in the footnote.

EDITORIAL COMMENT: The whole section above needs further revision in particular to remove material that is no longer relevant and to reflect the "promises" from the Radio Regulators that aeronautical spectrum will be provided as and when necessary.

The present ICAO policy statement recognizes that the anticipated growth pattern for satellite communications may be slower than predicted and, as a consequence, accepts a lower capacity requirement with guarantees on priority access and absence of harmful interference. This is in line with present ITU policy, which no longer accepts unused spectrum or ineffective spectrum use.

Studies on AMS(R)S using generic allocations

At WRC-2000 this subject was considered again and Resolution 222 on the "use of the bands 1 525–1 559 MHz and 1 626.5–1 660.5 MHz by the mobile-satellite service" was adopted, which, *inter alia,* stipulates:

"…

resolves

1 that, in frequency coordination of MSSs in the bands 1 525–1 559 MHz and 1 626.5–1 660.5 MHz, administrations shall ensure that the spectrum needed for distress, urgency and safety communications of GMDSS, as elaborated in Articles 32 and 33, in the bands where No. 5.353A applies, and for AMS(R)S communications within priority categories 1 to 6 of Article 44 in the bands where No. 5.357A applies is accommodated;

2 that administrations shall ensure the use of the latest technical advances, which may include prioritization and real-time pre-emptive access between MSS systems, when necessary and where feasible, in order to achieve the most flexible and practical use of the generic allocations;

3 that administrations shall ensure that MSS operators carrying non-safety-related traffic yield capacity, as and when necessary, to accommodate the spectrum requirements for distress, urgency and safety communication of GMDSS communications, as elaborated in Articles 32 and 33, and for AMS(R)S communications within priority categories 1 to 6 of Article 44; this could be achieved in advance through the coordination process in resolves 1, and, when

necessary and where feasible, through prioritization and real-time pre-emptive access,

invites ITU-R

to complete studies to determine the feasibility and practicality of prioritization and real-time pre-emptive access between different networks of mobile-satellite systems as referred to in resolves 2 above, while taking into account the latest technical advances in order to maximize spectral efficiency,

invites

ICAO, the International Maritime Organization (IMO), the International Air Transport Association (IATA), administrations and other organizations concerned to participate in the studies identified in *invites the ITU-R* above**."**

However, as most of these sub-bands are already used for non-safety communications, current spectrum requirements of AMS(R)S have not been satisfied in practice for some satellite operators. Therefore, it seems difficult to expect future long-term stable spectrum availability requirements for AMS(R)S in these bands can be met under current provisions of the Radio Regulations.

WRC-03 agreed to consider this subject at WRC-07 under Agenda Item 7.2 by Resolution 803 providing a provisional Agenda Item for WRC-10 (now rescheduled to 2012). WRC-07 agreed to put this as an agenda item for WRC-12:

"1.7 to consider results of ITU-R studies in accordance with Resolution 222 (Rev. WRC-07) to ensure spectrum availability and access to spectrum necessary to meet requirements for the aeronautical mobile-satellite (R) service, and to take appropriate action on this subject, while retaining unchanged the generic allocation to the mobile-satellite service in the bands 1 525–1 559 MHz and 1 626.5–1 660.5 MHz;"

ITU-R studies on AMS(R)S — Intersystem real-time pre-emption

To respond to the request by WRC-2000 with regard to Resolution 222, the ITU-R has completed studies begun in 2000 to determine the feasibility and practicality of prioritization and real-time pre-emptive access (intersystem real-time pre-emption).

The concept of real-time pre-emption was proposed at WRC-97 as an expedient mechanism to open the sub-bands 1 545–1 555 and 1 646.5–1 656.5 MHz to generic MSS.

ITU-R considered various elements, such as characteristics of the aeronautical safety communications and aeronautical traffic, and applicability of real-time pre-emption and its practicality and effectiveness. The study also “identified a number of significant technical, operational and economic issues that would have to be overcome to make ‘prioritization and intersystem real-time pre-emption’ a reality.” The results of this study are available from the ITU as Report M.2073 (Feasibility and practicality of prioritization and real-time pre emptive access between different networks of mobile-satellite service in the bands 1 525–1 559 MHz and 1 626.5–1 660.5 MHz).

The study noted that although some mobile-satellite networks currently provide *intra*-system pre-emptive access functions, there are no actual MSS systems providing “prioritization and *inter*system real-time pre-emption” functions, and despite several years of study there are no methods yet developed.

The study further summarized that “prioritization and intersystem real-time pre-emption” would not necessarily increase the efficiency of spectrum use compared to the current situation, but it would certainly complicate substantially the coordination process and network structure. Furthermore, it may not satisfy the operational and commercial requirements of AMS(R)S communications.

It was concluded that “prioritization and intersystem real-time pre-emption is not practical and, without significant advance in technology, is unlikely to be feasible for technical, operational and economic reasons.”

Noting that the conclusions in ITU Report M.2073 identify that intersystem real-time pre-emption will not be effective to ensure spectrum availability and protection for the AMS(R)S communications, the WRC-12 is urged to provide appropriate regulatory provisions to ensure long-term and stable spectrum availability for AMS(R)S.

WRC-12

At WRC-12 the issue of recognised access for AMS(R)S systems to the frequency bands 1 525–1 559 MHz and 1 626.5–1 660.5 MHz was debated. As a result of that debate it was agreed that the process for ensuring the enforcement of the priority access given by footnote no 5.357A should be strengthened in a manner that also increased transparency within the process.

ITU-R Resolution 222 was modified to:

- place an obligation on administrations to ensure that their MSS operators who are not carrying AMS(R)S traffic yield capacity when a requirement for AMS(R)S traffic cannot be met;

- invite ICAO where appropriate to comment on the AMS(R)S traffic requirements;
- add an annex that details the procedure for the implementation of footnote no 5.357A;
- ensure that an agreed methodology be used for the translation of traffic requirements into spectrum requirements;
- Require notifying administrations inform the ITU bureau of the results with respect to AMS(R)S requirements of any coordination meeting;
- Formalize dispute resolution meetings.

The WRC, noting that there was not an agreed methodology for the translation of traffic requirements into spectrum requirements also called for, through ITU-R Resolution 422, the development of such a methodology.

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Band: 1 559–1 626.5 MHz
Service: Aeronautical radionavigation/Radionavigation satellite/Mobile satellite (GNSS)
Allocation:

MHz **1 559–1 613.8**		
Allocation to Services		
Region 1	Region 2	Region 3
1 559–1 610	AERONAUTICAL RADIONAVIGATION RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.208B 5.328B 5.329A 5.341 5.362B 5.362C	
1 610–1 610.6 MOBILE-SATELLITE (Earth-to-space) 5.351A AERONAUTICAL RADIONAVIGATION 5.341 5.355 5.359 5.364 5.366 5.367 5.368 5.369 5.371 5.372	**1 610–1 610.6** MOBILE-SATELLITE (Earth-to-space) 5.351A AERONAUTICAL RADIONAVIGATION RADIODETERMINATION- SATELLITE (Earth-to-space) 5.341 5.364 5.366 5.367 5.368 5.370 5.372	**1 610–1 610.6** MOBILE-SATELLITE (Earth-to-space) 5.351A AERONAUTICAL RADIONAVIGATION Radiodetermination- satellite (Earth-to-space) 5.341 5.355 5.359 5.364 5.366 5.367 5.368 5.369 5.372
1 610.6–1 613.8 MOBILE-SATELLITE (Earth-to-space) 5.351A RADIO ASTRONOMY AERONAUTICAL RADIONAVIGATION 5.149 5.341 5.355 5.359 5.364 5.366 5.367 5.368 5.369 5.371 5.372	**1 610.6–1 613.8** MOBILE-SATELLITE (Earth-to-space) 5.351A RADIO ASTRONOMY AERONAUTICAL RADIONAVIGATION RADIODETERMINATION- SATELLITE (Earth-to-space) 5.149 5.341 5.364 5.366 5.367 5.368 5.370 5.372	**1 610.6–1 613.8** MOBILE-SATELLITE (Earth-to-space) 5.351A RADIO ASTRONOMY AERONAUTICAL RADIONAVIGATION Radiodetermination- satellite (Earth-to-space) 5.149 5.341 5.355 5.359 5.364 5.366 5.367 5.368 5.369 5.372

MHz 1 613.8–1 626.5		
Allocation to Services		
Region 1	Region 2	Region 3
1 613.8–1 626.5 MOBILE-SATELLITE (Earth-to-space) 5.351A AERONAUTICAL RADIONAVIGATION Mobile-satellite (space-to-Earth) 5.208B 5.341 5.355 5.359 5.364 5.365 5.366 5.367 5.368 5.369 5.371 5.372	**1 613.8–1 626.5** MOBILE-SATELLITE (Earth-to-space) 5.351A AERONAUTICAL RADIONAVIGATION RADIODETERMINATION-SATELLITE (Earth-to-space) Mobile-satellite (space-to-Earth) 5.208B 5.341 5.364 5.365 5.366 5.367 5.368 5.370 5.372	**1 613.8–1 626.5** MOBILE-SATELLITE (Earth-to-space) 5.351A AERONAUTICAL RADIONAVIGATION Mobile-satellite (space-to-Earth) 5.208B Radiodetermination-satellite (Earth-to-space) 5.341 5.355 5.359 5.364 5.365 5.366 5.367 5.368 5.369 5.372

Footnotes:

5.149 In making assignments to stations of other services to which the bands: ... 1 610.6–1 613.8 MHz, ... are allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. **4.5** and **4.6** and Article **29**). (WRC-07)

5.208B In the bands … 1 525–1 610 MHz … Resolution **739 (Rev. WRC-07)** applies. (WRC-07)

5.328B The use of the bands 1 164–1 300 MHz, 1 559–1 610 MHz and 5 010-5 030 MHz by systems and networks in the radionavigation-satellite service for which complete coordination or notification information, as appropriate, is received by the Radiocommunication Bureau after 1 January 2005 is subject to the provisions of Nos. **9.12, 9.12A** and **9.13**. Resolution **610 (WRC-03)** shall also apply; however, in the case of radionavigation-satellite service (space-to-space) networks and systems, Resolution **610 (WRC-03**) shall only apply to transmitting space stations. In accordance with No. **5.329A**, for systems and networks in the radionavigation-satellite service (space-to-space) in the bands 1 215–1 300 MHz and 1 559–1 610 MHz, the provisions of Nos. **9.7, 9.12A** and **9.13** shall only apply with respect to other systems and networks in the radionavigation-satellite service (space-to-space). (WRC-07)

5.329A Use of systems in the radionavigation-satellite service (space-to-space) operating in the bands 1 215–1 300 MHz and 1 559–1 610 MHz is not intended to provide safety service applications, and shall not impose any additional constraints on radionavigation-satellite service (space-to-Earth) systems or on other services operating in accordance with the Table of Frequency Allocations. (WRC-07)

5.341 In the bands 1 400–1 727 MHz, 101–120 GHz and 197–220 GHz, passive research is being conducted by some countries in a programme for the search for intentional emissions of extraterrestrial origin.

5.351A For the use of the bands 1 518–1 544 MHz, 1 545–1 559 MHz, 1 610–1 645.5 MHz, 1 646.5–1 660.5 MHz, 1 668–1 675 MHz, 1 980–2 010 MHz, 2 170–2 200 MHz, 2 483.5–2 500 MHz, 2 500–2 520 MHz and 2 670–2 690 MHz by the mobile-satellite service, see Resolutions **212 (Rev.WRC-07)** and **225 (Rev WRC-07)**. (WRC-07)

5.355 *Additional allocation*: in Bahrain, Bangladesh, Congo (Rep of the), Djibouti, Egypt, Eritrea, Iraq, Israel, Kuwait, Qatar, Syrian Arab Republic, Somalia, Sudan, South Sudan, Chad, Togo and Yemen, the bands 1 540–1 559 MHz, 1 610–1 645.5 MHz and 1 646.5–1 660 MHz are also allocated to the fixed service on a secondary basis. (WRC-12)

5.359 *Additional allocation:* in Germany, Saudi Arabia, Armenia, Austria, Azerbaijan, Belarus, Benin, Cameroon, the Russian Federation, France, Georgia, Greece, Guinea, Guinea-Bissau, Jordan, Kazakhstan, Kuwait, Lithuania, Mauritania, Uganda, Uzbekistan, Pakistan, Poland, the Syrian Arab Republic, Kyrgyzstan, the Dem. People's Rep. of Korea, Romania, Tajikistan, Tanzania, Tunisia, Turkmenistan and Ukraine, the bands 1 550–1 559 MHz, 1 610–1 645.5 MHz and 1 646.5–1 660 MHz are also allocated to the fixed service on a primary basis. Administrations are urged to make all practicable efforts to avoid the implementation of new fixed-service stations in these bands. (WRC-12)

5.362B *Additional allocation:* The band 1 559–1 610 MHz is also allocated to the fixed service on a primary basis until 1 January 2010 in Algeria, Saudi Arabia, Cameroon, Jordan, Mali, Mauritania, Syrian Arab Republic and Tunisia. After this date, the fixed service may continue to operate on a secondary basis until 1 January 2015, at which time this allocation shall no longer be valid. The band 1 559–1 610 MHz is also allocated to the fixed service on a secondary basis in Algeria, Armenia, Azerbaijan, Belarus, Benin, Russian Federation, Gabon, Georgia, Guinea, Guinea-Bissau, Kazakhstan, Lithuania, Nigeria, Uzbekistan, Pakistan, Poland, Kyrgyzstan, Dem. People's

Rep. of Korea, Romania, Senegal, Tajikistan, Tanzania, Turkmenistan and Ukraine until 1 January 2015, at which time this allocation shall no longer be valid. Administrations are urged to take all practicable steps to protect the radionavigation-satellite service and the aeronautical radionavigation service and not authorize new frequency assignments to fixed-service systems in this band. (WRC-12)

5.362C *Additional allocation:* in Congo (Rep. of the), Eritrea, Iraq, Israel, Jordan, Qatar, the Syrian Arab Republic, Somalia, Sudan, South Sudan, Chad, Togo and Yemen, the band 1 559–1 610 MHz is also allocated to the fixed service on a secondary basis until 1 January 2015, at which time the allocation shall no longer be valid. Administrations are urged to take all practicable steps to protect the radionavigation-satellite service and not authorize new frequency assignments to fixed-service systems in this band. (WRC-12)

5.364 The use of the band 1 610–1 626.5 MHz by the mobile-satellite service (Earth-to-space) and by the radiodetermination-satellite service (Earth-to-space) is subject to coordination under No. **9.11A**. A mobile earth station operating in either of the services in this band shall not produce a peak e.i.r.p. density in excess of –15 dB(W/4 kHz) in the part of the band used by systems operating in accordance with the provisions of No. **5.366** (to which No. **4.10** applies), unless otherwise agreed by the affected administrations. In the part of the band where such systems are not operating, the mean e.i.r.p. density of a mobile earth station shall not exceed –3 dB(W/4 kHz). Stations of the mobile-satellite service shall not claim protection from stations in the aeronautical radionavigation service, stations operating in accordance with the provisions of No. **5.366** and stations in the fixed service operating in accordance with the provisions of No. **5.359**. Administrations responsible for the coordination of mobile-satellite networks shall make all practicable efforts to ensure protection of stations operating in accordance with the provisions of No. **5.366**.

5.365 The use of the band 1 613.8–1 626.5 MHz by the mobile-satellite service (space-to-Earth) is subject to coordination under No. **9.11A**.

5.366 The band 1 610–1 626.5 MHz is reserved on a worldwide basis for the use and development of airborne electronic aids to air navigation and any directly associated ground-based or satellite-borne facilities. Such satellite use is subject to agreement obtained under No. **9.21**.

5.367 *Additional allocation:* The frequency band 1 610–1 626.5 MHz is also allocated to the aeronautical mobile-satellite (R) service on a primary basis, subject to agreement obtained under No. **9.21**. (WRC-12)

5.368 With respect to the radiodetermination-satellite and mobile-satellite services the provisions of No. **4.10** do not apply in the band 1 610–1 626.5MHz, with the exception of the aeronautical radionavigation- satellite service.

5.369 *Different category of service:* in Angola, Australia, China, Eritrea, Ethiopia, India, Iran (Islamic Republic of), Israel, Lebanon, Liberia, Madagascar, Mali, Pakistan, Papua New Guinea, Syrian Arab Republic, the Dem. Rep. of the Congo, Sudan, South Sudan, Togo and Zambia, the allocation of the band 1 610–1 626.5 MHz to the radiodetermination-satellite service (Earth-to-space) is on a primary basis (see No. **5.33**) subject to agreement obtained under No. **9.21** from countries not listed in this provision. (WRC-12)

5.370 *Different category of service*: in Venezuela, the allocation to the radiodetermination-satellite service in the band 1 610–1 626.5 MHz (Earth-to-space) is on a secondary basis.

5.371 *Additional allocation:* in Region 1, the bands 1 610–1 626.5 MHz (Earth-to-space) is also allocated to the radiodetermination-satellite service on a secondary basis, subject to agreement obtained under No. **9.21**. (WRC-12)

5.372 Harmful interference shall not be caused to stations of the radio astronomy service using the band 1 610.6–1 613.8 MHz by stations of the radiodetermination-satellite and mobile-satellite services. (No. **29.13** applies.)

ICAO POLICY:

- No change to the allocation to the radionavigation-satellite service in the band 1 559–1 610 MHz.
- 1 559–1 610 MHz: No change to the use of this band for future GNSS elements, including GLONASS and GPS which must be protected.
- No new allocations to be made in the band 1 559–1 610 MHz.
- No change to Footnotes 5.364, 5.365, 5.366, 5.367 and 5.368.
- Delete Footnotes 5.362B and 5.362C from these bands on the grounds that the allocation to the fixed service is not compatible with the safe operation of ICAO GNSS services.
- Delete Footnote 5.371.

The band 1559 – 1610 MHz is used by GNSS satellite systems as well as by GNSS

satellite augmentation systems and is intensively used for aeronautical radionavigation applications. GNSS already plays a vital role in RNAV operations, ADS-B surveillance and the GLS/GBAS landing system. This band is used by GPS, GLONASS, Beidou and is planned to be used by Galileo.
The band 1559 – 1610 MHz is however subject to intentional interference (GPS jammers) and un-intentional interference (potentially caused by an inadequate regulatory framework and improper implementation of pseudolites and GNSS repeaters). In addition, the proposed use of terrestrial cellular mobile systems in the (adjacent) band 1545 – 1559 MHz is expected to cause harmful interference to GNSS receivers (see also 5.2.9). Protection of GNSS signals is of paramount importance given the variety of GNSS applications for aeronautical navigation and surveillance.

Although this band is also shared with the fixed service, this use is expected to be terminated by 1 January 2015. Until such time the fixed service already operates as a secondary service (it cannot cause harmful interference to the radionavigation satellite service).

The frequency band 1610 – 1626.5 MHz is used by Iridium which is a standardized aeronautical mobile satellite (R) system

AVIATION USE: The bands between 1 559 and 1 626.5 MHz are allocated to the aeronautical radionavigation service and the frequency band 1559 – 1610 MHz is allocated to the radionavigation-satellite. At WRC-92, the allocation to the mobile-satellite service (Earth-to-space) in the band 1610 – 1626.5 MHz was introduced and currently provides the service link (to the mobile stations) for the Global star and the IRIDIUM mobile satellite systems.. The prime civil aviation interest is in the band 1 559–1 610 MHz which supports the main frequency components of the GPS, GLONASS, Beidou and Galileo radionavigation satellite systems. In addition, in the frequency band 1610 – 1626.5 MHz IRIDIUM is providing aeronautical mobile (R) satellite communications in compliance with the relevant ICAO SARPS. The allocations of the band 1610 – 1626.5 MHz to the aeronautical radionavigation services and the radiodetermination satellite services are not supporting any civil aeronautical requirement. The satellites for Globalstar and IRIDIUM operate in a non-geostationary orbit.

1 559–1 610 MHz: The radionavigation-satellite (space-to-Earth) allocation of 51 MHz is the main allocation available for GNSS. Other bands identified to support this main component and provide a more robust system with the possibility of compensation for ionospheric delay are at 1 164–1 215 MHz and planned for use by all radionavigation satellite systems. In accord with the CNS/ATM concept, GNSS is foreseen to provide the basis for most civil aviation radionavigation requirements in the future. Present use of the band includes the standard positioning service of the

GPS system as well as GLONASS. With the planning and implementation of Galileo and Beidou, signals will be added in the band 1559 – 1610 MHz in a manner compatible with all users..

1 610–1 626.5 MHz: The IRIDIUM non-geostationary Satellite system provides AMS(R)S service in this band in accordance with Footnote 5.367. The IRIDIUM system provides for AM(R)S communications in accordance with the relevant SARPs as contained in Annex 10, Volume III, Chapter 4. Information on the IRIDIUM system and its compliance with ICAO SARPs is contained in the ICAO *Manual on the Aeronautical Mobile Satellite (Route) Service* (Doc. 9925)

COMMENTARY:

Band 1 610–1 626.5 MHz
The allocations in this frequency band to the aeronautical radionavigation service and the radiodetermination service are not supporting requirements for international civil aviation. The allocation to the mobile satellite service supports the Globalstar and the IRIDIUM mobile satellite communication systems. The allocation to the mobile satellite service is primary in the Earth-to-space direction and secondary in the space-to-Earth direction. However, footnote 5.367 has allocated the frequency band 1610 – 1626.5 MHz to the aeronautical mobile satellite (R) service on a primary basis in both the Earth-to-space and space-to-Earth direction. IRIDIUM uses this allocation to provide the service link for the aeronautical mobile (R) communications it provides.

Under Footnote 5.364, the peak e.i.r.p. is limited to –15dB (W/4kHz) unless otherwise agreed between concerned administrations and in certain parts of the band to –3dB (W/4kHz). There have been no sharing studies carried out for the services operating in this band and, effectively, the MSS has now assumed control of the frequencies.

GlobalStar and IRIDIUM NGSO MSS systems are intended provide a (near) global service of voice and data for commercial purposes to all classes of mobile users, including personal handset users. The Earth-to-space direction for a mobile-satellite service is the path between the mobile transmitting terminals, many of which will be hand-held devices, and the satellite. The potential for interference to aeronautical GPS and GLONASS receivers by hand-held devices operating in the Earth-to-space direction is hence high, particularly for mobile terminals operating on the lower frequencies in the band and especially in the vicinity of airports. This has led to the development of ITU-R Recommendation M.1343 which provides for maximum limits of unwanted emissions from these terminals into the GNSS band (see commentary for that band below).

Footnote 5.367 provides for an additional allocations to the AMS(R)S services in the band 1610 – 1626.5 MHz subject to RR No. 9.21, which requires coordination with other administrations before a registration in the MIFR can be made. The allocation to the AMS(R)S is on a primary basis in both directions of transmission. IRIDIUM, which operates in this band, has been validated to conform to the ICAO AMS(R)S SARPs.

The fixed service is allowed to operate in the band 1610 – 1626.5 MHz under Footnotes 5.355 and 5.359. This use conflicts with all the satellite services in the band and is undesirable.

The use of the band 1 610.6–1 613.8 MHz for aeronautical purposes is constrained by sharing with the radio astronomy allocation, which has primary status. Footnote 5.149 (WRC-07) limits airborne use of this portion of the band. In practical terms, the band is of limited use for aviation services, in particular for aviation systems and services of international standard status.

Footnote 5.366 reserving the band 1 610–1 626.5 MHz for aeronautical purposes needs to be maintained.

The primary allocation to the radiodetermination service in Region 2, and in Region 1 under Footnote 5.371 and, on a secondary basis in Region 3, was made to accommodate a position-fixing service for general use, which was originally proposed for use by aviation. This service is only implemented to a limited extent and has never been recognized internationally as an approved service for aviation purposes. Footnote 5.364 requires coordination of this service with the MSS under the terms of Resolution 46. This system is not being used by international civil aviation

Band 1 559–1 610 MHz
This band is the main allocation base for RNSS available for general use. (There are other RNSS systems which operate in other bands only for special purposes or for national defense purposes.) These systems (GPS, GLONASS, Beidou and Galileo) share the band in a complex sharing arrangement which is agreed by the respective service providers. Typically, RNSS requires some 12 to 15 MHz or so of spectrum depending on the system's chipping rate and the accuracy requirement. Signal levels at the Earth's surface tend to be low, demanding an interference-free environment. To combat the effects of ionospheric delay and to provide a system with increased immunity to interference, another GNSS component, for civil use, in the frequency band 1164 – 1215 MHz has been accommodated. (see commentary for the DME band at 960–1 215 MHz).

WRC-2000 added a (space-to-space) service to the (space-to-Earth) allocation to

RNSS on a "no constraint to existing services" basis (see Footnote 5.329A). This use is for the many operators of space services of all kinds who utilize the GPS system as a source of accurate timing or for position fixing of the satellites. This regularizes a practice which has existed for many years but gives the service no rights over the main class of GNSS user and other allocations.

Global navigation satellite system (GNSS)

GNSS was identified by the FANS Committee as a replacement for many of the existing terrestrial systems and is a main component of the CNS/ATM concept. The specifications for the ICAO GNSS presently recognize the GPS and GLONASS systems. The required characteristics for GNSS are incorporated in SARPs. This forms the basis for satellite navigation as envisaged in the CNS/ATM concept and provides service for both en-route and airport approach and landing. SARPs and guidance material for GNSS are included in Annex 10, Volume I, Chapters 2 and 3 and Attachment D.

Proposals for second generation RNSS have appeared, with timescales of implementation from 2009 onwards. Of note are the additions of a new GPS frequency (L5) in the DME band, and a European civil operated system (Galileo) planning to use this band and the 1 164–1 215 MHz and 1 260–1 300 MHz bands. The Russian Federation is also planning to use this band for GLONASS. Also Beidou (China) and Galileo (Europe) are considering such improvements.WRC-2000 regularized these proposals with suitable allocations, together with Resolutions calling for study of protection requirements for existing services such as DME and SSR. A study by the ICAO NSP is under way to determine the extent to which these new systems can qualify for incorporation in the formula for GNSS. Further (third generation) improvements for all radionavigation satellite systems are on-going.

Protection of GNSS signals from harmful interference

The protection of GNSS signals from harmful interference is of major concern to aviation. GNSS signal levels at the aircraft receiver are of very low level (in the order of –160 dBW) and, despite receiver signal processing having high interference rejection properties, the system is vulnerable to other in-band signals and to spurious signals from non-aviation systems operating in adjacent bands. Additionally, the GNSS antenna placement on the aircraft and how its signal interfaces with other on-board radio systems require extreme care and careful design to ensure that the system can deliver the required performance on a continuous basis. The characteristics and protection of GNSS are addressed in a number of ITU-R Recommendations (see below) and specific studies have been made of the compatibility of GNSS with other systems to determine whether sharing is safe. In respect of the total radio environment in which GPS must operate, the aggregate sum of all interferences is of major importance. For this reason, aviation has pressed for the inclusion of a safety margin factor in all assessments for individual interfering systems. ICAO policy supports a factor of 6 to 10 dB for this feature. General details of some of the interference scenarios already identified are given below:

Sharing with fixed services

The band 1 559–1 610 MHz is also shared with the fixed service under Footnotes 5.362B and 5.362C in a large number of countries (fifty-two). ICAO's concerns on this use have been expressed at a number of ITU conferences. This use by the fixed service, which is confined to parts of Europe and the Middle East, is well established and of long standing. Studies presented to ITU WP8D have indicated the need for a separation between the fixed service location and the GNSS reception point of line of sight. This effectively makes GNSS unusable over a major part of Europe and the Middle East. The ICAO position for a removal of the fixed service from the GNSS band resulted in the acceptance by most administrations at WRC-2000 that these fixed services should be ceased. Footnotes 5.362B and 5.362C were agreed to at this conference to place a final date of 2015 for the removal of all of these services. At WRC-07, the secondary status of the fixed service in a large number of countries was confirmed. In a small number of countries, however, the reversion date to secondary status is 2010. As of 2010, the fixed service operates in this band on a secondary status on a global basis and as from 2015 the allocation to the fixed service is no longer valid. However, actual removal of the fixed service needs to be confirmed. The secondary allocation to the fixed services still presents a threat; therefore, cessation of operation is important.

Hand-held devices in the band 1 610–1 626.5 MHz and mobile terminals in the band 1 626.5–1 660.5 MHz

Problems with high levels of spurious emissions from hand-held mobile-satellite devices operating in the band 1 610–1 626.5 MHz have appeared and are the subject of European Telecommunication Standards Institute (ETSI) European Standards and ITU-R Recommendations. This work resulted in the approval of ITU-R Recommendation M.1343 and the adoption of Standards by ETSI, both of which recognize the ICAO requirements on the level of protection to be given to GNSS. Further work on the protection of the band 1 559–1 610 MHz from the spurious emissions from mobile earth stations operating in the band 1 626.5–1 660.5 MHz has been completed and resulted in ITU-R Recommendation M.1480.

Proposal for an allocation to MSS in band 1 559–1 567 MHz

A proposal to WRC-97 to allocate the frequency band between 1 559 MHz and

1 567 MHz to the mobile-satellite service in the space-to-Earth direction, strongly opposed by aviation interests, was eventually not adopted by that conference. The proposal was referred through Resolution 220 (WRC-97) to the ITU-R for further study. The results of this study indicating that sharing is not feasible were included in the CPM Report to WRC-2000. WRC-2000 accepted these results, and Resolutions 226 and 227 of that conference, which address the question of additional spectrum for mobile-satellite services in the bands between 1 and 3 GHz, specifically exclude the band 1 559–1 610 MHz from the study.

Potential interference from ultra-wide-band (UWB) devices

Recent technological advances have resulted in the development of devices used in radar and communications applications. These emitters known as ultra-wide-band (UWB) devices utilize very narrow pulses, typically less than 1 nanosecond, and radiate over very wide bandwidths, typically several gigahertz. Devices used in radar applications have many commercial and government uses, such as radar imaging through walls.

Developers of UWB devices anticipate extensive marketability due to the varied use and capabilities of these low power transmitter devices. Manufacturers of these devices are currently seeking approval to operate UWB systems on an unlicensed basis. Considering UWB device output power is low enough to operate unlicensed, their very wide bandwidth emissions would be present within restricted bands. Many of the restricted bands subject to UWB emissions include aeronautical bands reserved for safety-of-life services and, in particular, the 1 559–1 610 MHz band used by GNSS. The aggregate emission levels of UWB devices could interfere with many aeronautical systems; however, at this early stage of beginning to understand the potential degradation of aviation safety services, it is believed that GNSS receivers may be more vulnerable to interference from UWB devices. It must be realized, however, that many other aeronautical services are potentially at risk of interference from UWB devices.

In regard to growing concern with development of UWB devices which could operate as unlicensed applications causing harmful interference to aeronautical safety-of-life services, ICAO submitted a preliminary draft new question to the ITU-R Study Group 8 at its meeting in October 2000. Parallel to the concerns raised by ICAO, State regulatory and telecommunications authorities have undertaken active study and analysis of UWB emission characteristics and the potential effects on a variety of aeronautical services. Reports on the results of these ongoing activities by State authorities are currently available. Four ITU-R Recommendations (ITU-R SM.1754, 1755, 1756 and 1757) and one ITU-R report on the impact of UWB technology on radiocommunication services have been developed. The comprehensive results may also be taken into consideration by ITU-R Study Group 5 to further advance necessary action to ensure protection of safety-of-life services.

Considering especially the mobility of aircraft and the large “viewing” area to which aircraft are exposed, together with the variability and uncertainty of a significant number of factors (such as UWB emitter density, signal characteristics and activity factors) necessary for the interference analysis of devices using UWB technology with systems operating within safety services, UWB devices should in general not be operated in frequency bands allocated to safety services. In those cases where such use cannot be avoided, administrations should take all steps necessary to ensure that UWB devices do not cause harmful interference to the reception by stations operating under a safety service allocation. The level of harmful interference to safety systems needs to be determined on a case-by-case basis in the form of a safety analysis. This analysis would assess the use being made of the safety system and demonstrate that the required levels of integrity, reliability and availability are still maintained under all operational conditions. Factors such as the impact on safety service link budget margins and measures to preclude interference from UWB devices that malfunction need to be considered.

It is recommended that State aviation representatives continue to actively participate in the ITU-R Study Group activities and provide knowledge of the potential impact to aeronautical services through liaison with their respective ITU administrations.

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Band: 2 700–3 300 MHz
Service: Aeronautical radionavigation/Radionavigation/Radiolocation (primary surveillance radar)
Allocation:

MHz 2 700–3 300		
Allocation to Services		
Region 1	Region 2	Region 3
2 700–2 900	AERONAUTICAL RADIONAVIGATION 5.337 Radiolocation 5.423 5.424	
2 900–3 100	RADIOLOCATION 5.424A RADIONAVIGATION 5.426 5.425 5.427	
3 100–3 300	RADIOLOCATION Earth exploration-satellite (active) Space research (active) 5.149 5.428	

Footnotes:

5.149 In making assignments to stations of other services to which the bands: ... 3 260–3 267 MHz ... are allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. **4.5** and **4.6** and Article **29**) (WRC-07).

5.337 The use of the bands 1 300–1 350 MHz, 2 700–2 900 MHz and 9 000–9 200 MHz by the aeronautical radionavigation service is restricted to ground-based radars and to associated airborne transponders which transmit only on frequencies in these bands and only when actuated by radars operating in the same band.

5.423 In the band 2 700–2 900 MHz, ground-based radars used for meteorological purposes are authorized to operate on a basis of equality with stations of the aeronautical radionavigation service.

5.424 *Additional allocation*: in Canada, the band 2 850–2 900 MHz is also allocated to the maritime radionavigation service, on a primary basis, for use by shore-based radars.

5.424A In the band 2 900-3 100 MHz, stations in the radiolocation service shall not cause harmful interference to, nor claim protection from, radar systems in the radionavigation service. (WRC-03)

5.425 In the band 2 900–3 100 MHz, the use of the shipborne interrogator-transponder (SIT) system shall be confined to the sub-band 2 930–2 950 MHz.

5.426 The use of the band 2 900–3 100 MHz by the aeronautical radionavigation service is limited to ground-based radars.

5.427 In the bands 2 900–3 100 MHz and 9 300–9 500 MHz, the response from radar transponders shall not be capable of being confused with the response from radar beacons (racons) and shall not cause interference to ship or aeronautical radars in the radionavigation service, having regard, however, to No. **4.9**.

5.428 *Additional allocation*: in Azerbaijan, Mongolia, Kyrgyzstan and Turkmenistan, the band 3 100–3 300 MHz is also allocated to the radionavigation service on a primary basis. (WRC-12)

ICAO POLICY:

- No change to the frequency allocations to the aeronautical radionavigation service in these bands.
- No change to Footnotes 5.423, 5.424A, 5.426 and 5.427.
- Oppose any in-band or near-band allocation that would endanger the operation of radar services including those potentially being considered for International Mobile Telecommunications/ mobile broadband under ITU-R Resolution 233.
- Given the pressure on the use of this frequency band from non-aeronautical sources and in support of the ICAO Overall Policy Statement:
  a) insist that any sharing studies carried out encompass the total technical and operational aspects of radar use, including possible impact on the safety case; and
  b) oppose any proposal that places undue or unreasonable economic penalty on radar systems presently in use.

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The band 2700 – 2900 MHz, and to a lesser extent the band 2900 – 3300 MHz is heavily used for primary surveillance radar mainly providing medium range (to about 60 NM) independent non-cooperative surveillance. These radars typically provide surveillance in terminal and approach areas around major airports.

The band 2700 – 2900 MHz is also used for meteorological radar. This use is expected, on a global basis, to extend to well beyond 2030.

Radar stations are subject to interference from out-of-band and fundamental emissions from cellular mobile systems (e.g. WIMAX) operating in the adjacent band below 2700 MHz. This interference can be mitigated in principle by improving RF selectivity in the radar stations and by reducing the mobile system the mobile system emissions that fall into the radar pass-band.

Another area of interference is by the use of the band 2700 – 2900 MHz for digital cordless cameras to support Electronic News Gathering (ENG). In Europe such use is permitted by some Administrations on the basis of CEPT/ECC Recommendation (02)09 and ECC Report 6. Digital cordless camera operation on a frequency within about +/- 10 MHz of the nominal frequency of the radar station can cause harmful interference to that primary surveillance radar up to distances of about 250 NM. Such use may become globally harmonized. ECC Report 6 is based on an out-of-date version of ITU-R Recommendation ITU-R M1464 and should be revised to take into account proper protection of radar stations.

The frequency band 2700 – 2900 MHz may also be considered as one of the candidate bands under WRC-15 Agenda Item 1.1 (IMT – terrestrial mobile broadband). The use of this band by aviation may also become subject to "Spectrum Pricing". (See also Chapter 8).

AVIATION USE: These bands are extensively used for primary surveillance radar (10 cm) for medium-range, en-route surveillance, and for terminal area and approach monitoring. The bands are also used by other radionavigation services (particularly maritime) and radiolocation as well as radars for national purposes on a shared basis. Airborne use is prohibited under the Footnotes 5.337 and 5.426. Civil aviation radars tend to be concentrated in the band 2 700–2 900 MHz, although the use of the band 2 900–3 400 MHz is increasing. The major users in the band 2 900–3 400 MHz are radionavigation radars for maritime purposes and radio- location radars for national defence purposes.

Some countries are reviewing the long-term requirement for primary surveillance radar. Until about the mid-seventies primary radar was the prime surveillance technology for air traffic management to support air traffic control. During the seventies and the eighties ATC (SSR) transponders became increasingly important in supporting both air traffic control and the airborne collision avoidance system (ACAS). In the nineties, some countries adopted the philosophy to use only SSR (no PSR) for en-route flights but to retain PSR in terminal areas to detect potential violations of controlled airspace and to detect aircraft with faulty SSR transponders. However, in the future, some have suggested using SSR and ADS-B only in busy terminal areas. The cost of providing PSR may be high but can be considered the extra premium that needs to be paid in order to secure the required level of surveillance in the interest of safety and security. However, the consequences of undetected violation of controlled airspace could be catastrophic.

Ten-centimetre radar technologies and practices date from the 1940s and modern versions employ the latest radar techniques for plot extraction and display on formatted synthetic displays. Frequency diversity and pulse compression techniques are used to extract weak echoes from interference and to improve range resolution. Multiple frequency operation, commonly using two to four frequencies separated by 60–100 MHz, is necessary and requires careful frequency planning and separation of stations. More stable solid state transmitter frequency control is leading to a more effective use of spectrum than older magnetron systems, although the latter systems still have many years of useful life.

COMMENTARY: The *Report of the Communications/Meteorology/Operations Divisional Meeting (1990)* (Doc 9566) indicated considerable use of the band 2 700–2 900 MHz for surveillance purposes worldwide (Attachment 4 to Appendix B to the report on Agenda Item 1 refers). Table 1 indicated over 1 200 radars reported in response to an ICAO survey. Some use by meteorological radar was also reported.

The ICAO position at paragraph 4 (page 1B-35) of the report was that no change was made to the allocation at 2 700–2 900 MHz or adjacent bands. This position recognized the considerable investment made in equipment, the suitability of the frequency band for the surveillance role and the long useful life of the equipment. Replacement systems will be required to prove their operational benefit over a long period of time.

While it is possible that SSR, GNSS and ADS will take over some of the functions of en-route surveillance, it is premature to derive a timescale for a reduction in the number of radars or the use of these bands. Airport use is likely to remain for many years and well beyond 2012.

S-band marine (shipborne) radar is concentrated at 3 050 ±30 MHz.

Proposals for other allocations in the band 2 700–2 900 MHz

To locate spectrum for the new global terrestrial/satellite multi-purpose communications service radio regulators and mobile systems providers have focused on these radar bands to determine possible sharing with, or release of, spectrum allocated for use by aeronautical radar systems. At the outset, sharing does not seem possible since there appears to be a high probability of intolerable interference to both services. For example, strobing on radar displays and high-power pulse interference to mobile receivers are considered as highly probable, and unacceptable, risks. An additional problem is that the terrestrial broadband spectrum requirements appear to be for overflow purposes in high demand urban areas, which is the same location requirement as that for airport radar.

The precise use of the band 2 700–2 900 MHz has been initially reviewed by ITU-R WP8B in 1999. Early research indicates that air traffic radars tend to be concentrated in the 2 700–2 900 MHz band, but this is not yet considered a conclusive result. Any suggestion of compressing the band into a smaller spectrum segment must be carefully examined to determine whether there is sufficient capacity and what are the economics of such spectrum refarming.

Any decision on changes to the allocations in these bands, whether by reduction or by sharing, can only be taken after a full examination of current and future use. Present indications are that these radars will continue well into the long future and their numbers may increase as airport congestion becomes an even greater problem than it is now. Most use of 10 cm radars is at airports, and these are installed following a national decision to provide an independent surveillance support to the air traffic services at the airport. Increase in airport movements and congestion on runways at many major airports, necessitates the provision of more effective monitoring of the airspace. Primary radar has the benefit that it does not require the carriage of equipment in the aircraft and it ensures comprehensive monitoring of all aircraft in the airspace.

Intensive studies are continuing in Europe to establish the possibility of an allocation to non-aeronautical users in this band. These studies include co-frequency and off-frequency sharing, and the efficient use of the band by radars. All sharing with mobile users is viewed with extreme concern due to the difficulty of tracing sources of interference, as well as the roaming and largely uncontrolled character of mobile use. Transfer to the bands above 2 900 MHz, also used for radar for mainly national defence purposes, is also an option proposed by the broadband mobile community. Transfer to these bands will lead to economic penalties which many aviation authorities cannot accept and will make planning in the new bands very difficult taking into account their present use.

The firm ICAO policy is to insist on a full and comprehensive study programme, including not only the technical parameters for a compatible and safe operation of radar, but also the operational and financial implications of sharing frequencies with a use — such as that by mobile users — which is not amenable to effective control.

ITU-R studies

An intensive study has been carried out by ITU-R WP8B to document the characteristics and protection requirements of radars operating in these bands. It is difficult to carry out a comprehensive review of this kind because of the confidential nature of those systems used for national defence. Furthermore, ITU-R work has concentrated on PPI-type display radars, often used in maritime operations, and less work has been carried out on the modern plot extracted type systems now in extensive use in civil aviation.

Results indicate that co-frequency sharing is not practicable or feasible, requiring too large a geographic separation between radar stations and other users. Refinement and extrapolation to define the separation required at offset frequencies is expected to continue. Agreements on propagation models and protection ratios also require study and documentation.

WRC-12

AT WRC-12 one of the agenda items agreed for the agenda of WRC-15 seeks to identify additional spectrum that can be allocated to International Mobile Telecommunications/mobile broadband. The frequency band 2 700-2 900 MHz is specifically mentioned as a band of interest.

As indicated above a number of studies have been conducted in the past on this issue. Additionally there have been a number of recent studies undertaken on adjacent band issues between LTE/WiMAX operating below 2 690 MHz and Radars operating above 2 700 MHz. All of these studies indicate that co-frequency operation would not be feasible between the Mobile Service and radar stations in the frequency band 2700 – 2900 MHz.

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Band: 4 200–4 400 MHz
Service: Aeronautical radionavigation (radio altimeter)
Allocation:

MHz 4 200–4 400		
Allocation to Services		
Region 1	Region 2	Region 3
4 200–4 400	AERONAUTICAL RADIONAVIGATION 5.438 5.439 5.440	

Footnotes:

5.438 Use of the band 4 200–4 400 MHz by the aeronautical radionavigation service is reserved exclusively for radio altimeters installed on board aircraft and for the associated transponders on the ground. However, passive sensing in the Earth exploration-satellite and space research services may be authorized in this band on a secondary basis (no protection is provided by the radio altimeters).

5.439 *Additional allocation*: in Iran (Islamic Republic of), the band 4 200–4 400 MHz is also allocated to the fixed service on a secondary basis. (WRC-12)

5.440 The standard frequency and time signal-satellite service may be authorized to use the frequency 4 202 MHz for space-to-Earth transmissions and the frequency 6 427 MHz for Earth-to-space transmissions. Such transmissions shall be confined within the limits of ±2 MHz of these frequencies, subject to agreement obtained under No. **9.21**.

ICAO POLICY:

- No change to the allocation to the radionavigation service in the light of the continuing requirement for radio altimeters to operate in this band and of the results of ITU-R studies indicating that 200 MHz is required to meet the stringent operational requirements for accuracy and integrity for radio altimeters.
- No change to 5.438 which could constrain the operation of radio altimeters.
- Oppose any in-band or near-band allocation that would endanger the operation of the aeronautical radionavigation service including those allocations that may potentially be considered for International Mobile Telecommunications/mobile broadband under ITU-R Resolution 233.
- Delete 5.439.

The whole of the band 4200 – 4400 MHz is globally used for radio altimeters on board aircraft. Radio altimeters provide an essential safety-of-life function for all phases of flight, including the final stages of landing where the aircraft has to be maneuvered into the flare position or attitude. [Use of this band for radio altimeters is expected to continue.]

The frequency band 4200 – 4400 MHz may also be considered as a potential candidate band for the “Spectrum Release” activities. In addition, the use of this band by aviation may also become subject to “Spectrum Pricing”. (See Chapter 8 Section “ICAO Spectrum Strategy”).

AVIATION USE: The band is used exclusively for airborne radio altimeters (also called radar altimeters) (see Footnote 5.438), which have a vital task during all phases of flight, including being a prime component in automated landing for flare guidance, and as the sensor component in ground proximity warning systems. The basic function of radio altimeters is to measure the aircraft’s absolute height above ground level. Considerable studies have been undertaken to identify the need for a 200 MHz wide-band for this system (see CCIR Report BL8, Düsseldorf 1990). These studies show that the full band is required to meet the accuracy and integrity requirements of radio altimeters. As noted, these radio altimeters are operational during all phases of flight.

COMMENTARY:

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WRC-12

AT WRC-12 one of the agenda items agreed for the agenda of WRC-15 seeks to identify additional spectrum that can be allocated to International Mobile Telecommunications/mobile broadband. The frequency bands 3 400-4 200 and 4 500-4 800 MHz are specifically mentioned as a band of interest. These frequency bands are either side of the frequency band 4 200-4 400 MHz that is used for radio altimeters, a vital component of all landing aids and ground proximity warning systems.

Any allocation to International Mobile Telecommunications/mobile broadband in the frequency bands 3 400-4 200 and 4 500-4 800 MHz should be opposed until it can be demonstrated to aviation's satisfaction that they will not cause interference to radio altimeters.

Band: 5 000–5 250 MHz
Service: Aeronautical radionavigation (MLS), Aeronautical Mobile (R) (airport communications, terrestrial UAS) and Aeronautical Mobile Satellite (R) (UAS)
Allocation:

MHz 5 000–5 250		
Allocation to Services		
Region 1	Region 2	Region 3
5 000-5 010	AERONAUTICAL MOBILE-SATELLITE (R) 5.443AA AERONAUTICAL RADIONAVIGATION RADIONAVIGATION-SATELLITE (Earth-to-space)	
5 010-5 030	AERONAUTICAL MOBILE-SATELLITE (R) 5.443AA AERONAUTICAL RADIONAVIGATION RADIONAVIGATION-SATELLITE (space-to-Earth) (space-to-space) 5.328B 5.443B	
5 030–5 091	AERONAUTICAL MOBILE (R) 5.443C AERONAUTICAL MOBILE-SATELLITE (R) 5.443D AERONAUTICAL RADIONAVIGATION 5.444	
5 091–5 150	AERONAUTICAL MOBILE 5.444B AERONAUTICAL MOBILE-SATELLITE (R) 5.443AA AERONAUTICAL RADIONAVIGATION 5.444 5.444A	
5 150–5 250	AERONAUTICAL RADIONAVIGATION FIXED-SATELLITE (Earth-to-space) 5.447A MOBILE except aeronautical mobile 5.446A 5.446B 5.446 5.446C 5.447 5.447B 5.447C	

Footnotes:

5.328B The use of the bands 1 164–1 300 MHz, 1 559–1 610 MHz and 5 010–5 030 MHz by systems and networks in the radionavigation-satellite service for which complete coordination or notification information, as appropriate, is received by the Radiocommunication Bureau after 1 January 2005 is subject to the provisions of Nos. **9.12, 9.12A** and **9.13**. Resolution **610 (WRC-03)** shall also apply; however, in the case of radionavigation-satellite service (space-to-space) networks and systems, Resolution **610 (WRC-03**) shall only apply to transmitting space stations. In accordance with No. **5.329A**, for systems and networks in the radionavigation-satellite service (space-to-space) in the bands 1 215–1 300 MHz and 1 559–1 610 MHz, the provisions of Nos. **9.7, 9.12A** and **9.13** shall only apply with respect to other systems and networks in the radionavigation-satellite service (space-to-space). (WRC-07)

5.443B In order not to cause harmful interference to the microwave landing system operating above 5 030 MHz, the aggregate power flux-density produced at the Earth's surface in the band 5 030–5 150 MHz by all the space stations within any radionavigation-satellite service system (space-to-Earth) operating in the band 5 010–5 030 MHz shall not exceed –124.5 dB (W/m^2) in a 150 kHz band. In order not to cause harmful interference to the radio astronomy service in the band 4 990–5 000 MHz, radionavigation-satellite service systems operating in the band 5 010–5 030 MHz shall comply with the limits in the band 4 990–5 000 MHz defined in Resolution **741 (Rev. WRC-12)**. (WRC-12)

5.444 The band 5 030–5 150 MHz is to be used for the operation of the international standard system (microwave landing system) for precision approach and landing. In the frequency band 5 030–5 091 MHz, the requirements of this system shall have priority over other uses of this band. For the use of the frequency band 5 091–5 150, No. **5.444A** and Resolution **114 (Rev. WRC-12)** apply. (WRC-12)

5.444A *Additional allocation*: the band 5 091–5 150 MHz is also allocated to the fixed-satellite service (Earth-to-space) on a primary basis. This allocation is limited to feeder links of non-geostationary satellite systems in the mobile-satellite service and is subject to coordination under No. **9.11A.**

In the band 5 091–5 150 MHz, the following conditions also apply:

— prior to 1 January 2018, the use of the band 5 091–5 150 MHz by feeder links of non-geostationary-satellite systems in the mobile-satellite service shall be made in accordance with Resolution **114 (Rev. WRC-12)**;

— after 1 January 2016, no new assignments shall be made to earth stations providing feeder links of non-geostationary mobile-satellite systems;

— after 1 January 2018, the fixed-satellite service will become secondary to the aeronautical radionavigation service. (WRC-07)

5.444B The use of the band 5 091–5 150 MHz by the aeronautical mobile service is limited to:

— systems operating in the aeronautical mobile (R) service and in accordance with international aeronautical standards, limited to surface applications at airports. Such use shall be in accordance with Resolution **748 (Rev. WRC-12)**;

— aeronautical telemetry transmissions from aircraft stations (see No. **1.83**) in accordance with Resolution **418 (Rev. WRC-12)**. (WRC-12)

5.446 *Additional allocation*: in the countries listed in Nos. **5.369**, the band 5 150–5 216 MHz is also allocated to the radiodetermination- satellite service (space-to-Earth) on a primary basis, subject to agreement obtained under No. **9.21**. In Region 2, the band is also allocated to the radiodetermination-satellite service (space-to-Earth) on a primary basis. In Regions 1 and 3, except those countries listed in Nos. **5.369** and Bangladesh, the band is also allocated to the radiodetermination-satellite service (space-to-Earth) on a secondary basis. The use by the radiodetermination-satellite service is limited to feeder links in conjunction with the radiodetermination-satellite service operating in the bands 1 610–1 626.5 MHz and/or 2 483.5–2 500 MHz. The total power flux-density at the Earth's surface shall in no case exceed –159 dB(W/m^2) in any 4 kHz band for all angles of arrival. (WRC-12)

5.446A The use of the bands 5 150–5 350 MHz and 5 470–5 725 MHz by the stations in the mobile, except aeronautical mobile, service shall be in accordance with Resolution **229 (Rev.WRC-12)**. (WRC-12)

5.446B In the band 5 150–5 250 MHz, stations in the mobile service shall not claim protection from earth Stations in the fixed-satellite service. No. **5.43A** does not apply to the mobile service with respect to fixed-satellite service earth stations. (WRC-03)

5.446C Additional allocation: in Region 1 (except in Algeria, Saudi Arabia, Bahrain, Egypt, United Arab Emirates, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Syrian Arab Republic, Sudan South Sudan and Tunisia) and in Brazil, the band 5 150–5 250 MHz is also allocated to the aeronautical mobile service on a primary basis, limited to aeronautical telemetry transmissions from aircraft stations (see No. **1.83**), in accordance with Resolution **418 (WRC 07)**. These stations shall not claim protection from other stations operating in accordance with Article 5. No. **5.43A** does not apply. (WRC 12)

5.447 *Additional allocation*: in Côte d'Ivoire, Egypt, Israel, Lebanon, the Syrian Arab Republic and Tunisia, the band 5 150–5 250 MHz is also allocated to the mobile service, on a primary basis, subject to agreement obtained under No. **9.21**. In this case, the provisions of Resolution **229 (Rev. WRC-12)** do not apply. (WRC-12)

5.447A The allocation to the fixed-satellite service (Earth-to-space) is limited to feeder links of non-geostationary-satellite systems in the mobile-satellite service and is subject to coordination under No. **9.11A.**

5.447B *Additional allocation*: the band 5 150–5 216 MHz is also allocated to the fixed-satellite service (space-to-Earth) on a primary basis. This allocation is limited to feeder links of non-geostationary-satellite systems in the mobile-satellite service and is subject to provisions of No. **9.11A**. The power flux-density at the Earth's surface produced by space stations of the fixed-satellite service operating in the space-to-Earth direction in the band 5 150–5 216 MHz shall in no case exceed –164 dB(W/m^2) in any 4 kHz band for all angles of arrival.

5.447C Administrations responsible for fixed-satellite service networks in the band 5 150–5 250 MHz operated under Nos. **5.447A** and **5.447B** shall coordinate on an equal basis in accordance with No. **9.11A** with administrations responsible for non-geostationary-satellite networks operated under No. **5.446** and brought into use prior to 17 November 1995. Satellite networks operated under No. **5.446** brought into use after 17 November 1995 shall not claim protection from, and shall not cause harmful interference to, stations of the fixed-satellite service operated under Nos. **5.447A** and **5.447B**.

5.443AA In the frequency bands 5 000-5 030 MHz and 5 091-5 150 MHz, the aeronautical mobile-satellite (R) service is subject to agreement obtained under No. **9.21**. The use of these bands by the aeronautical mobile-satellite (R) service is limited to internationally standardized aeronautical systems.

5.443C The use of the frequency band 5 030-5 091 MHz by the aeronautical mobile (R) service is limited to internationally standardized aeronautical systems. Unwanted emissions from the aeronautical mobile (R) service in the frequency band 5 030-5 091 MHz shall be limited to protect RNSS system downlinks in the adjacent 5 010-5 030 MHz band. Until such time that an appropriate value is established in a relevant ITU-R Recommendation, the e.i.r.p. density limit of −75 dBW/MHz in the frequency band 5 010-5 030 MHz for any AM(R)S station unwanted emission should be used.

5.443D In the frequency band 5 030-5 091 MHz, the aeronautical mobile-satellite (R) service is subject to coordination under No. **9.11A**. The use of this frequency band by the aeronautical mobile-satellite (R) service is limited to internationally standardized aeronautical systems.

ICAO POLICY:

- No change to footnotes 5.444 and 5.444A.
- If necessary, support changes to Footnotes 5.367 and 5.444B in order to facilitate the implementation of aeronautical mobile (route) service (AM(R)S) and aeronautical mobile-satellite (route) service (AMS(R)S) systems.
- Apply the methodology contained in ITU-R Recommendation S.1342 on the coordination of microwave landing system (MLS) with fixed-satellite service (FSS) earth stations in the band 5 091–5 150 MHz.
- Support studies under ITU-R Resolution 114 in order that they can be completed by WRC-15.
- Ensure that in addressing the future use of the frequency band 5 091-5 150 MHz by the FSS current and intended future use by aeronautical systems are not adversely impacted.

Priority is given to the Microwave Landing System in the band 5030 – 5091 MHz.. Other applications for using this band (e.g. in the aeronautical mobile (R) service and aeronautical mobile satellite (R) service to support unmanned aircraft) are emerging.

The aeronautical mobile (R) service in the band 5091 – 5150 MHz is reserved for airport surface communication systems (AeroMACS) which are currently being developed. A tuning range of 5000 – 50150 MHz for AeroMACS is being considered to support either Regional or sub-Regional requirements

The band 5000 – 5030 MHz is also planned for use by the radionavigation satellite service.

AVIATION USE: The band 5 000–5 250 MHz was allocated to the ARNS in 1947 in anticipation of a future microwave landing system as a replacement for ILS, and for other radionavigation uses for which the band would be particularly suited. At that time it was estimated that 250 MHz of spectrum was required to support a microwave landing system, and some of the later candidate systems occupied the full 250 MHz. Footnote 5.367 was added to allow use of the band for AMS(R)S as an option which could be taken up at a later date. Following the decision by ICAO, in 1978, to adopt the time reference scanning beam MLS as the future international standard system, Footnote 5.444 was added by WARC-79 giving precedence to this system over all other uses. The scanning beam system required 60 MHz for the initial channel plan, with the possibility of needing a further 60 MHz later. As of WRC-07, the MLS system only has precedence in the portion 5 030–5 091 MHz, while 5 091–5 150 MHz has also been allocated to the aeronautical mobile service, limited to AM(R)S surface applications at airports and aeronautical telemetry. See Footnote 5.444B (WRC-07).

Annex 10, Volume I, Chapter 3, 3.11.4.1.1 was amended to include the channeling requirement for MLS of 200 channels based on capacity studies made by the AWOP. The channeling plan for 200 channels, spaced 300 kHz apart between 5 030 and 5 090.7 MHz, including the pairing with DME, is at Table A in Annex 10, Volume I, Chapter 3.

One ICAO region (EUR) has prepared a regional frequency assignment and implementation plan for MLS based on possible use at airports in the region in the years ahead. In this work, it was noted that the band 5 030–5 091 MHz could only support a portion of the foreseeable regional requirements if MLS were to become the standard for all non-visual needs. The Regional Air Navigation Plans for the other ICAO regions currently lack provisions for implementation of MLS.

The longer-term requirement for aids to precision approach to support all weather operations was discussed at the Special COM/OPS/95 meeting under Agenda Item 3. Recommendation 3/4 identifies some of the options for precision approach, and Attachment C to Agenda Item 3 provides a statement of the possible MLS implementation sequence. Under Agenda Item 5 (Appendix A), a strategy for the introduction of non-visual aids was developed and incorporated in Annex 10. Appendix B to Agenda Item 5 outlines the ICAO regional considerations for MLS, which include a progression to MLS for CAT II and III requirements if GNSS is not available at the time of the ILS replacement.

It should be noted that the total ARNS use of this band will also include systems for national requirements, civil or military, as well as those for international civil aviation purposes.

The non-aeronautical uses (for mobile services and for fixed-satellite services) of the band 5 091–5 250 MHz, allowed by Footnotes 5.444A, 5.446, 5.446A, 5.446B, 5.447, 5.447A, 5.447B and 5.447C should also be noted.

COMMENTARY: This important radionavigation frequency band has, in recent years, been the subject of close attention by other ITU radio services seeking worldwide exclusive spectrum. The very long delay in implementing the new ICAO standard system (MLS), and the prospect of GNSS offering equivalent capability, have accelerated this attention and have led to new allocations to non-aeronautical radionavigation uses for the frequencies in the band 5 150–5 250 MHz and the band 5 091–5 150 MHz. These were adopted by ITU conferences in 1987, 1992, 1995 2003 and 2007. The changes to the 5 091–5 150 MHz band by the addition of the fixed-satellite service (FSS) for the provision of feeder links for NGSO satellites in the mobile-satellite service will eventually lead to a complete reappraisal by the ITU of the future aviation requirement for these bands.

The present situation is that the FSS allocation is a primary one in the band 5 150–5 216 MHz for the space-to-Earth direction (with a power flux-density limitation of –164 dBW/m^2/4 kHz) (see Footnote 5.447B). For the Earth-to-space direction (subject to Footnote 5.447A) the FSS is primary in the band 5 091–5 150 MHz for Earth-to-space links (with a foreseen reversion to secondary in 2018).

At WRC-07, the precedence to MLS was removed in MLS extension band (5 091–5 150 MHz) and the sunset date for assignments for the FSS in this band was extended from 2012 to 2016 (a date after which no new assignments should be made to the FSS). A review of the allocation to the FSS in this band is now scheduled for WRC-2015, in particular with regard to the “sunset date”. The date-limitations to the FSS were introduced in 1995 to protect the use of the band 5 091–5 150 MHz for MLS. However, as a result of removing the precedence to the MLS in this band, the limitations to the FSS may be removed at a future conference (i.e. the allocation to the FSS may become permanent). This extension provides for stable sharing conditions with the MLS and AM(R)S in the band.

FSS earth station implementation has commenced in some areas and includes the use of the band 5 091–5 150 MHz. Such implementation is being coordinated with aviation authorities (using the procedures of No. 9.11A), and is being made in accordance with the terms of Resolution No. 114. Resolves 2 of that Resolution requires administrations to ensure that these stations shall not cause harmful interference to the ARNS. Coordination with the aeronautical radionavigation service using the technical provision of ITU-R Recommendation S.1342 is therefore required. In effect, FSS earth stations which have been coordinated, agreed and implemented will compete for spectrum with any later MLS frequency assignment plan that makes use of the band 5 091–5 150 MHz. This may create a first-come, first-served situation whereby the first service implemented acquires control of the band. Since there is unlikely to be any MLS use of the 5 091–5 150 MHz band in the early years of MLS implementation ahead, this can lead to a loss, partial or whole, of the band for aviation use until the year 2010 and possibly after that date as well.

An allocation to the AM(R)S in the band 5 091–5 150 MHz (MLS extension band), limited to airport surface operations was agreed at WRC-07 and updated at WRC-12. This is a shared allocation with the aeronautical radionavigation service (MLS), fixed satellite service (FSS) and aeronautical mobile telemetry (AMT) AMT is a new allocation made during WRC-07 (see Footnote 5.444B (WRC-07) and Resolutions 418). The precedence that was given to MLS in this band over other uses has been removed. For the use of the band by the AM(R)S and AMT, provisions to protect the FSS (feeder link), which operates in the same band, were introduced.

The frequency band between 5 150 and 5 250 MHz is shared on a joint primary basis between the ARNS and the FSS. The latter use is specifically for feeder links for NGSO mobile satellites (see Footnote 5.447A) in the Earth-to-space direction. Footnote 5.447B also allocates the band 5 150–5 216 MHz to the FSS in the space-to-Earth direction subject to a power flux-density limitation and to agreement under No. 9.11A. In addition, under Footnote 5.447 the band 5 150–5 250 MHz is in use in six countries for the mobile service with primary status. More countries may be added to this list in the future as the use of the systems operating in this band proliferates. In practical terms, this spectrum between 5 150–5 250 MHz can no longer support any international standard ARNS system.

The radiodetermination-satellite service (space-to-Earth) is allocated in the band 5 150–5 216 MHz in Region 2 on a primary basis, and on a secondary basis in Regions 1 and 3 with a power flux-density limitation of –159 dB(W/m^2)/4 kHz, except in some countries (see Footnote 5.446). This radiodetermination system also uses the frequency bands 1 610–1 626.5 MHz and/or 2 483.5–2 500 MHz (see Footnote 5.446). No identification of a need for international aviation support has yet appeared for this system.

The band 5 000–5 150 MHz is also allocated to the aeronautical mobile-satellite service on a primary basis under the provisions of 5.443AA and 5.443D. Particular consideration is being given to using the 5030 – 5091 portion of this band for AMS(R)S control links in support of UAS,

Addition of the radionavigation-satellite service (RNSS) in the band 5 000–5 030 MHz

The search for spectrum for new RNSS (space-to-Earth of 20 MHz and Earth-to-space of 10 MHz) has focused attention on this band. This band was particularly considered to be required for the Galileo system. There are benefits in the use of these higher frequencies, such as a lower ionospheric delay (often reduced by a factor of 6 or more compared to the 1 GHz or 1.5 GHz band), smaller antenna size and higher tracking accuracies without augmentation. The main disadvantage is that of the need for higher power in the satellites due to radio frequency (RF) propagation losses. While both frequency bands 5000 – 5010 MHz and 5010 – 5030 MHz are identified in RNSS system plans to provide for feeder link capacity, no RNSS system has published firm plans to implement a service link in the band 5010

– 5030 MHz.

ITU-R WP8D analyzed the use of various segments of the band 5 000–5 030 MHz (see Attachment 18 of the Report of the 6th Meeting of WP8D) and noted, in particular, the requirement to protect the radio astronomy allocation in the band below 5 000 MHz which would entail a guard band of around 10 MHz to be provided from 5 000–5 010 MHz.

However, WRC-2000 approved the new Footnote 5.443A for the RNSS in the band 5 000–5 010 MHz in the Earth-to-space direction, and Footnote 5.443B for the RNSS in the band 5 010–5 030 MHz in the space-to-Earth direction. The latter footnote imposes power flux-density limitations on the space transmissions of the RNSS to protect MLS in the band 5 030–5 150 MHz and the radio astronomy in the band below 5 000 MHz. The addition of this RNSS allocation was not opposed by civil aviation. However, in the interest of protecting MLS, Resolution 603 (WRC-2000) was agreed, which calls for study of the necessary technical, operational and regulatory measures necessary for the protection of MLS from the spurious emissions of the RNSS. For protection of MLS from unwanted emissions from RNSS earth stations in the 5 000–5 010 MHz band, the preferred technical measure is likely to establish a minimum separation distance between these and MLS facilities, in the same way as applies to the operation of the FSS in the 5 091–5 150 MHz under ITU-R Rec. S.1342.

Outlook for the future

The failure to use the MLS frequency band effectively has focused the attention of other services on aeronautical spectrum not in use and has led to the present situation where the 250 MHz originally available for aeronautical services has been considerably reduced, and the remaining part of the original band is now also under challenge for aviation to show the need for its retention. Present ITU policies support this procedure as a means of satisfying the demands stated by expanding services, particularly those for mobile services. The aviation community can expect this process to continue with a consequential loss of expansion possibilities and a limitation on the future spectrum available to aviation radio services. It is important that positive actions be taken to prepare firm statements of intent in order to secure availability of spectrum for the future as aviation continues to expand.

Current spectrum requirements for European States require retaining the band 5 031–5 150 MHz for MLS use.

ITU-R Studies

ITU-R Recommendation S.1342 provides the basis to establish geographic separation distances for the siting of FSS earth stations to protect MLS assignments in the band 5 030–5 090 MHz from interference from FSS earth stations in the band 5 091–5 150 MHz. Further changes to this Recommendation are not supported. (See section on protection requirements below.)

Resolution 114 (WRC-12) invites the ITU-R to study the technical and operational issues relating to sharing of the band 5 091–5 150 MHz between new systems of the aeronautical radionavigation service and the FSS providing feeder links to non-geostationary satellites.

WRC-12

The potential use of the frequency range 5 000-5 150 MHz to support unmanned aircraft command and non-payload communications as well as airport surface communications was debated at WRC-12. Additionally the need for an agenda item at WRC-15 to address the use of the frequency band 5091-5150 MHz by the fixed satellite service was also considered and agreed.

With respect to UAS the conference agreed to the addition of a new AM(R)S allocation in the frequency band 5 030-5 091 MHz to support, terrestrial, unmanned aircraft command and non-payload communications. The conference also converted a footnote allocation to the AMS(R)S into a table allocation in the frequency range 5 000-5 150 MHz with co-ordination requirements in the frequency band 5 030-5 091 MHz being relaxed.

WRC-12 removed from the frequency band 5 091-5 150 MHz the provisions for using this band for aeronautical security transmissions. The proposal to allocate the frequency band 5 000-5 010 MHz for to the AM(R)S for airport surface communication was rejected although it was demonstrated that AM(R)S and RNSS feeder links can share this frequency band. I n order to ensure interoperability, ICAO is considering the opportunities to extend the tuning range for AeroMacs in the ICAO SARPs and include the frequency band 5000 – 5030 MHz for use by AeroMACS taking into account the Radio Regulatory provisions for the use of this band.

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Band: 5 350–5 470 MHz
Service: Aeronautical radionavigation (airborne weather and ground mapping radar)
Allocation:

MHz 5 350–5 470		
Allocation to Services		
Region 1	Region 2	Region 3
5 350–5 460	EARTH EXPLORATION-SATELLITE (active) 5.448B SPACE RESEARCH (active) 5.448C AERONAUTICAL RADIONAVIGATION 5.449 RADIOLOCATION 5.448D	
5 460–5 470	RADIONAVIGATION 5.449 EARTH EXPLORATION-SATELLITE (active) SPACE RESEARCH (active) RADIOLOCATION 5.448D 5.448B	

Footnotes:

5.448B The Earth exploration-satellite (active) service operating in the band 5 350–5 570 MHz and space research service (active) operating in the band 5 460–5 470 MHz shall not cause harmful interference to the aeronautical radionavigation service in the band 5 350-5 460 MHz, the radionavigation service in the band 5 460–5 470 MHz and the maritime radionavigation service in the band 5 470–5 570 MHz. (WRC-03)

5.448C The space research service (active) operating in the band 5 350–5 460 MHz shall not cause harmful interference to nor claim protection from other services to which this band is allocated.

5.448D In the frequency band 5 350–5 470 MHz, stations in the radiolocation service shall not cause harmful interference to, nor claim protection from, radar systems in the aeronautical radionavigation service operating in accordance with No. **5.449**. (WRC-03)

5.449 The use of the band 5 350–5 470 MHz by the aeronautical radionavigation service is limited to airborne radars and associated airborne beacons.

ICAO POLICY:

- No change to footnotes 5.448B, 5.448C and 5.448D.
- These bands are used extensively, particularly for airborne weather radar, and are needed for the foreseeable future. No changes should be made which would restrict this aeronautical use.

The band 5350 – 5470 MHz is globally used for airborne weather radar. The airborne weather radar is a safety critical instrument assisting pilots in deviating from potential hazardous weather conditions and detecting wind shear and microbursts. This use is expected to continue for the long term.

AVIATION USE: A prime use of the band 5 350–5 470 MHz is for airborne weather and ground mapping radar, which is in conformity with Footnote 5.449.

COMMENTARY: The use of the band 5 350–5 470 MHz for airborne weather radar (a mandatory carriage item in many countries) is well established and has existed for many years. Such equipment supports the safe passage of an aircraft in the vicinity of turbulent weather conditions. It provides timely warnings of rapidly changing weather conditions as an aid to in-flight route planning. In addition, such equipment allows maintaining contact with geographic features, such as shorelines, as a supplement to navigational orientation. Annex 6, Part I, Chapter 6, 6.11 recommends that aircraft operating in areas with potentially hazardous weather conditions be equipped with airborne weather radar. The ICAO policy (Appendix C to the *Report of the Communications/Operations (COM/OPS) Divisional Meeting (1985)* (Doc 9464) refers) is to retain the allocation without changes. While airborne weather radar also use the band 9 300–9 500 MHz, there remains a substantial preference also for the lower frequency band since this band is very suitable for detecting clear air turbulence. One of the uses of airborne weather radar is to avoid penetration of aircraft into hazardous weather.

The band 5 350–5 470 MHz is used on larger aircraft which permit the installation of larger antennas. In this band, RF waves penetrate dense moisture better than in the higher frequency bands. Many aircraft are equipped with this system.

The *Report of the Communications/Meteorology/Operations (COM/MET/OPS) Divisional Meeting (1990)* (Doc 9566) (Appendix A to the report on Agenda Item 1 (page 1A-4) refers) reports the emergence of radar for wind shear detection for the band 5 600–5 650 MHz which would be an admissible use under Footnote 5.452.

There is every reason to support the continued retention of the band 5 350–5 470 MHz, and adjacent bands, without change.

WRC-97 added the Earth exploration service on a primary basis. At WRC-03, the Earth exploration-satellite service was also added, and the radiolocation service was upgraded to a primary service. These services can operate in this band under the express condition that they will not cause harmful interference to the (aeronautical) radionavigation service nor claim protection.

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Band: 8 750–8 850 MHz
Service: Aeronautical radionavigation/Radiolocation (airborne Doppler radar)
Allocation:

MHz 8 750–8 850		
Allocation to Services		
Region 1	Region 2	Region 3
8 750–8 850	RADIOLOCATION AERONAUTICAL RADIONAVIGATION 5.470 5.471	

Footnotes:

5.470 The use of the band 8 750–8 850 MHz by the aeronautical radionavigation service is limited to airborne Doppler navigation aids on a centre frequency of 8 800 MHz.

5.471 *Additional allocation:* in Algeria, Germany, Bahrain, Belgium, China, Egypt, the United Arab Emirates, France, Greece, Indonesia, Iran (Islamic Republic of), Libya, the Netherlands, Qatar, Sudan and South Sudan, the bands 8 825–8 850 MHz and 9 000–9 200 MHz are also allocated to the maritime radionavigation service, on a primary basis, for use by shore-based radars only. (WRC-12)

ICAO POLICY:

- No change since the requirement is a continuing one.
- No change to Footnote 5.470.

The band 8750 – 8850 MHz is extensively used for airborne Doppler radar and ground mapping radar. These systems are used to determine ground speed, drift and distance travelled as well as ground mapping. The use of these radar systems is expected to continue for the long term. The band 8750 – 8850 MHz is shared with the radiolocation service and the maritime radionavigation service.

AVIATION USE: Footnote 5.470.

Airborne Doppler navigation systems are widely used for specialized applications such as continuous determination of ground speed and drift angle information of an aircraft with respect to the ground. The information is derived by measuring the Doppler shift of signals transmitted from the aircraft in several narrow beams pointed towards the surface, backscattered by the surface and received by the Doppler radar receiver.

COMMENTARY: The ICAO policy is a continuing one of no change to the allocation, as expressed in the *Report of the Communications/Operations (COM/OPS) Divisional Meeting (1985)* (Doc 9464), page 8C-11. Hence, the current allocation to the aeronautical radionavigation service in this band must be retained.

Band: 9 000–9 500 MHz
Service: Aeronautical radionavigation/Radionavigation (precision approach radar, airborne weather and ground mapping radar)
Allocation:

MHz 9 000–9 500		
Allocation to Services		
Region 1	Region 2	Region 3
9 000–9 200	AERONAUTICAL RADIONAVIGATION 5.337 RADIOLOCATION 5.471 5.473A	
9 200–9 300	RADIOLOCATION MARITIME RADIONAVIGATION 5.472 5.473 5.474	
9 300–9 500	RADIONAVIGATION EARTH EXPLORATION-SATELLITE (active) SPACE RESEARCH (active) RADIOLOCATION 5.427 5.474 5.475 5.475A 5.475B 5.476A	

Footnotes:

5.337 The use of the bands 1 300–1 350 MHz, 2 700–2 900 MHz and 9 000–9 200 MHz by the aeronautical radionavigation service is restricted to ground-based radars and to associated airborne transponders which transmit only on frequencies in these bands and only when actuated by radars operating in the same band.

5.427 In the bands 2 900–3 100 MHz and 9 300–9 500 MHz, the response from radar transponders shall not be capable of being confused with the response from radar beacons (racons) and shall not cause interference to ship or aeronautical radars in the radionavigation service, having regard, however, to No. **4.9**.

5.471 *Additional allocation:* in Algeria, Germany, Bahrain, Belgium, China, Egypt, the United Arab Emirates, France, Greece, Indonesia, Iran (Islamic Republic of), Libya, the Netherlands, Qatar, Sudan and South Sudan, the bands 8 825–8 850 MHz and 9 000–9 200 MHz are also allocated to the maritime radionavigation service, on a primary basis, for use by shore-based radars only. (WRC-12)

5.472 In the bands 8 850–9 000 MHz and 9 200–9 225 MHz, the maritime radionavigation service is limited to shore-based radars.

5.473 *Additional allocation:* in Armenia, Austria, Azerbaijan, Belarus, Cuba, the Russian Federation, Georgia, Hungary, Mongolia, Uzbekistan, Poland, Kyrgyzstan, Romania, Tajikistan, Turkmenistan and Ukraine, the bands 8 850–9 000 MHz and 9 200–9 300 MHz are also allocated to the radionavigation service on a primary basis. (WRC-07)

5.473A In the band 9 000–9 200 MHz, stations operating in the radiolocation service shall not cause harmful interference to, nor claim protection from, systems identified in No. **5.337** operating in the aeronautical radionavigation service, or radar systems in the maritime radionavigation service operating in this band on a primary basis in the countries listed in No. **5.471**. (WRC-07)

5.474 In the band 9 200–9 500 MHz, search and rescue transponders (SART) may be used, having due regard to the appropriate ITU-R Recommendation (see also Article **31**).

5.475 The use of the band 9 300–9 500 MHz by the aeronautical radionavigation service is limited to airborne weather radars and ground-based radars. In addition, ground-based radar beacons in the aeronautical radionavigation service are permitted in the band 9 300–9 320 MHz on condition that harmful interference is not caused to the maritime radionavigation service. (WRC-07)

5.475A The use of the band 9 300–9 500 MHz by the Earth exploration-satellite service (active) and the space research service (active) is limited to systems requiring necessary bandwidth greater than 300 MHz that cannot be fully accommodated within the 9 500–9 800 MHz band. (WRC 07)

5.475B In the band 9 300–9 500 MHz, stations operating in the radiolocation service shall not cause harmful interference to, nor claim protection from, radars operating in the radionavigation service in conformity with the Radio Regulations. Ground-based radars used for meteorological purposes have priority over other radiolocation uses. (WRC-07)

5.476A In the band 9 300–9 800 MHz, stations in the Earth exploration-satellite service (active) and space research service (active) shall not cause harmful interference to, nor claim protection from, stations of the radionavigation and radiolocation services. (WRC 07)

ICAO POLICY:

- Oppose any changes to the allocations that could adversely affect their use by aviation.
- No change to Footnotes 5.337, 5.427, 5.473A, 5.474, 5.475, 5.475A, 5.475B and 5.476A.
- Support studies under ITU-R Resolution 651 in order that they can be completed by WRC-15
- Ensure that proposals to extend the earth exploration satellite service into the frequency band 9 000-9 200 MHz do not adversely impact the use of the frequency band by airport surface movement radar.

The band 9000 – 9200 MHz is used for ground based primary surveillance radar systems including Precision Approach Radar (PAR) and airport surveillance detection equipment (ASDE). The main purpose of these systems is to provide surveillance to support precision approach to aircraft and to detect traffic at airports. This use is expected to continue to well beyond 2030. The use of the band is shared with the maritime radionavigation service and the radiolocation service.

The band 9300 – 9500 MHz is globally used for airborne weather radar and ground based radar. This use is expected to continue to well beyond 2030. The airborne weather radar is a safety critical instrument assisting pilots to avoid potential hazardous weather conditions and detecting wind shear and microbursts. The use of this band by the ground based primary surveillance radar is similar to the use of the band 9000 – 9200 MHz. This band is shared with the Earth exploration satellite service and the space research service.

AVIATION USE: These 3 cm radar bands are used extensively by aeronautical, maritime (land-based and shipborne) and national defense radar systems. They cater for essentially shorter range surveillance and precision functions up to a 50 km range. In aviation, they find considerable application in precision monitoring and approach functions and in airborne weather radar (AWR) systems where their shorter wavelength is very suitable for the detection of storm clouds. In this latter role, the frequency band 9 345–9 375 MHz has been coordinated with other users within ITU-R as the agreed aeronautical airborne frequencies for this purpose. This band provides for a narrower beam than AWR operating at 5.3 GHz and, therefore, provides a better resolution and less ground clutter. Although the 5 GHz band is generally preferred, 70 per cent of aircraft use weather radar operating in this band. One of the uses of AWR is to give warning of hazardous weather. In many countries the carriage of AWR is a mandatory requirement. AWR supports the safe passage of an aircraft in the vicinity of turbulent weather conditions. It provides timely warnings of rapidly changing weather conditions as an aid to in-flight route planning. In addition, such equipment could support maintaining contact with geographic features such as shorelines as a supplement to navigational orientation. This band is also used for surface detection radar. Some national uses employ transportable and mobile systems for national defense purposes.

The sharing of the bands with maritime coast and shipborne radar requires care and the application of modern technology to alleviate interaction effects. Footnote 5.475 draws attention to this sharing but does not alter the principle that both services have equal access rights. It should be noted that AWR is categorized for aeronautical navigation, i.e. storm warning and avoidance in accordance with the definition in RR 1.10, while meteorological radar for observation and recordings is in the category radiolocation (see last sentence in Footnote 5.475).

COMMENTARY: The ICAO policy for these radar bands is based upon the requirement that these radars are likely to remain in service for many years into the future. Sharing with maritime radar is very manageable and practical because of the different geographical usage, and coordination between the two services is good. Sharing with other services in the areas of important operational use is not feasible. At WRC-07, the radiolocation service in the bands 9 000–9 200 MHz and 9 300–9 500 MHz was upgraded to primary status and the 9 300–9 500 MHz band was also allocated to the Earth exploration-satellite service (EESS) on a primary basis. These new allocations were afforded on the basis that they should not cause harmful interference to, nor claim protection from, the radionavigation service operating in the band 9 000–9 500 MHz (5.475B and 5.476A refer).

WRC-12

As a result of WRC-12 an item has been placed on the agenda of WRC-15 to consider a possible extension of 600 MHz to the earth exploration satellite service (active) currently operating in the frequency range 9 300-9 900 MHz. The current allocation was extended at WRC-07 from 300 MHz to 600 MHz and it is now proposed to double the bandwidth allocated. Aviation use of the frequency band 9 000-9 200 MHz needs to be protected.

Band: 13.25–13.4 GHz
Service: Aeronautical radionavigation (airborne Doppler radar)
Allocation:

GHz 13.25–13.4		
Allocation to Services		
Region 1	Region 2	Region 3
13.25–13.4	EARTH EXPLORATION-SATELLITE (active) AERONAUTICAL RADIONAVIGATION 5.497 SPACE RESEARCH (active) 5.498A 5.499	

Footnotes:

5.497 The use of the band 13.25–13.4 GHz by the aeronautical radionavigation service is limited to Doppler navigation aids.

5.498A The Earth exploration-satellite (active) and space research (active) services operating in the band 13.25–13.4 GHz shall not cause harmful interference to, or constrain the use and development of, the aeronautical radionavigation service.

5.499 *Additional allocation*: in Bangladesh and India, the band 13.25–14 GHz is also allocated to the fixed service on a primary basis. In Pakistan, the band 13.15-13.75 MHz is allocated to the fixed service on a primary basis. (WRC-12)

ICAO POLICY:

- No change to the allocations as there is a continuing aeronautical requirement for this band.
- No change to 5.497.
- Oppose any changes to the allocations that could adversely affect their use by aviation as a result of studies undertaken in response to ITU Resolutions 151 and 152

The band 13.25 – 13.4 GHz is extensively used for airborne Doppler radar and ground mapping radar. These systems are used to determine ground speed, drift and distance travelled as well as ground mapping. The use of these radar systems is expected to continue for the long term. The band is shared with the Earth exploration satellite service and the space research service.

AVIATION USE: Footnote 5.497 limits the use to Doppler navigation aids, which will continue to be used. Airborne Doppler navigation systems are widely used for specialized applications such as continuous determination of ground speed and drift angle information of an aircraft with respect to the ground. The information is derived by measuring the Doppler shift of signals transmitted from the aircraft in several narrow beams pointed towards the surface, backscattered by the surface and received by the Doppler radar receiver.

COMMENTARY: The Communications Divisional Meeting (1978) and the *Report of the Communications/Operations (COM/OPS) Divisional Meeting (1985)* (Doc 9464) (Appendix C to the report on Agenda Item 8 refers) both confirmed the need to retain this allocation. This requirement was confirmed in 1997.

WRC-12

As a result of WRC-12 an item has been palace on the agenda of WRC-15 to consider new allocations to the FSS in the frequency range 10-17 GHz in ITU region 1 and 13-17 GHz in ITU regions 2 and 3. Aviation use of the frequency band 13.25-13.4 GHz needs to be protected from harmful interference.

Band: 15.4–15.7 GHz
Service: Aeronautical radionavigation (ASDE/airborne weather radar, other systems)
Allocation:

GHz 15.4–15.7		
Allocation to Services		
Region 1	Region 2	Region 3
15.4–15.43	RADIOLOCATION 5.511E 5.511F AERONAUTICAL RADIONAVIGATION 5.511D	
15.43–15.63	FIXED-SATELLITE (Earth-to-space) 5.511A RADIOLOCATION 5.511E 5.511F AERONAUTICAL RADIONAVIGATION 5.511C	
15.63–15.7	RADIOLOCATION 5.A121 5.B121 AERONAUTICAL RADIONAVIGATION 5.511D	

Footnotes:

5.511A The band 15.43–15.63 GHz is also allocated to the fixed-satellite service (space-to-Earth) on a primary basis. Use of the band 15.43–15.63 GHz by the fixed-satellite service (space-to-Earth and Earth-to-space) is limited to feeder links of non-geostationary systems in the mobile-satellite service, subject to coordination under No. **9.11A.** The use of the frequency band 15.43–15.63 GHz by the fixed-satellite service (space-to-Earth) is limited to feeder links of non-geostationary systems in the mobile-satellite service for which advance publication information has been received by the Bureau prior to 2 June 2000. In the space-to-Earth direction, the minimum earth station elevation angle above and gain towards the local horizontal plane and the minimum coordination distances to protect an earth station from harmful interference shall be in accordance with Recommendation ITU-R S.1341. In order to protect the radio astronomy service in the band 15.35–15.4 GHz, the aggregate power flux-density radiated in the 15.35–15.4 GHz band by all the space stations within any feeder link of a non-geostationary system in the mobile-satellite service (space-to-Earth) operating in the 15.43–15.63 GHz band shall not exceed the level of –156 dB (W/m^2) in a 50 MHz bandwidth, into any radio astronomy observatory site for more than 2% of the time. (WRC-2000)

5.511C Stations operating in the aeronautical radionavigation service shall limit the effective e.i.r.p. in accordance with Recommendation ITU-R S.1340. The minimum coordination distance required to protect the aeronautical radionavigation stations (No. **4.10** applies) from harmful interference from feeder-link earth stations and the maximum e.i.r.p. transmitted towards the local horizontal plane by a feeder-link earth station shall be in accordance with Recommendation ITU-R S.1340. (WRC-97)

5.511D Fixed-satellite service systems for which complete information for advance publication has been received by the Bureau by 21 November 1997 may operate in the bands 15.4–15.43 GHz and 15.63–15.7 GHz in the space-to-Earth direction and 15.63–15.65 GHz in the Earth-to-space direction. In the bands 15.4–15.43 GHz and 15.65–15.7 GHz, emissions from a non-geostationary space station shall not exceed the power flux-density limits at the Earth's surface of –146 dB(W/(m^2 • MHz)) for any angle of arrival. In the band 15.63–15.65 GHz, where an administration plans emissions from a non-geostationary space station that exceed –146 dB(W/ (m^2 • MHz)) for any angle of arrival, it shall coordinate under No. **9.11A** with the affected administrations. Stations in the fixed-satellite service operating in the band 15.63–15.65 GHz in the Earth-to-space direction shall not cause harmful interference to stations in the aeronautical radionavigation service (No. **4.10** applies). (WRC-97)

5.511E In the frequency band 15.4-15.7 GHz, stations operating in the radiolocation service shall not cause harmful interference to, or claim protection from, stations operating in the aeronautical radionavigation service.

5.511F In order to protect the radio astronomy service in the frequency band 15.35-15.4 GHz, radiolocation stations operating in the frequency band 15.4-15.7 GHz shall not exceed the power flux-density level of −156 dB(W/m^2) in a 50 MHz bandwidth in the frequency band 15.35-15.4 GHz, at any radio astronomy observatory site for more than 2 per cent of the time.

ICAO POLICY:

- No change to the allocation to the aeronautical radionavigation service.
- No change to Footnotes 5.511A, 5.511C and 5.511D which would introduce further restrictions to aeronautical use of this band.

The band 15.4 – 15.7 GHz is used for ground based primary surveillance radar systems including Precision Approach Radar (PAR) and airport surveillance detection equipment (ASDE) The main purpose of these systems is to provide surveillance to support precision approach to aircraft and to detect traffic at airports. This use is expected to continue to well beyond 2030. The use of the band is shared with the fixed satellite service (Earth-to-space and space-to-Earth) and the Radio Location Service (RLS. No FSS use has been registered with the ITU within this band.

AVIATION USE: This 20 mm band is used for a variety of civil and military systems using conventional radionavigation and radar techniques. An important civil use of this band is for airport surface detection equipment (ASDE) for operational control of aircraft and vehicle ground movement at airports. This is an expanding requirement, as congestion at airports spreads and ground maneuvering areas begin to saturate. Predictions made in Europe, for example, indicate a growing problem with surface movement, already affecting a number of major hubs, with saturation occurring at all major Western European airports before the year 2010. ASDE radar is one preferred solution, and equipment operating in this frequency band, which offers a good compromise between antenna size and propagation characteristics, is presently in use at several main international airports. Typically, in Region 2, the band 15.6–16.6 GHz is used for ASDE radar.

Another civil use is that of height and obstruction measurement using radar techniques. This use is presently limited for general application to smaller aircraft operating into secondary and temporary landing areas. A forecast expansion in this use for specialized civil (as well as military) use has been predicted.

Both of these civil uses are on-going for the foreseeable future.

The band 15.5–15.7 GHz is also used for airborne weather and ground mapping radar. These systems support the safe passage of an aircraft in the vicinity of turbulent weather conditions. It provides timely warnings of rapidly changing weather conditions as an aid to in-flight route planning. In addition, such equipment could support maintaining contact with geographic features, such as shorelines, as a supplement to navigational orientation.

This band is also available for use by civil or military radionavigation systems implemented for national purposes. The band offers the possibility for compact airborne systems which are light in weight and which have small antenna dimensions. High definition radar and precision landing systems are some examples of applications.

COMMENTARY:

Discussions and agreements at ITU conferences

WRC-95 discussed and agreed upon an allocation in the band 15.4–15.7 GHz for the FSS for feeder links to NGSO mobile satellites. The decision was made without full knowledge of the use made of the band by the ARNS. To identify and resolve any compatibility problem, Resolutions 116 and 117 were adopted calling for further study. These studies were undertaken by ITU-R WP4/1 — dealing mostly with the FSS — which identified a much more extensive use of the band than had originally been envisaged at CPM-95 and WRC-95. A range of applications, covering both airborne and ground systems, for both civil and military aviation purposes was identified. Sharing criteria were developed and are now fully documented in ITU-R Recommendations S.1340 and S.1341 which also recommend a partitioning of the band into three sections, which now appear in the Table of Frequency Allocations. Primarily, this was done to give added protection to the radio astronomy service in the band below 15.4 GHz and because the bottom 300 kHz and the top 700 kHz were too restrictive to be exploited by the FSS. The FSS allocation is for both Earth-to-space and space-to-Earth directions.

WRC-97 reviewed the results of studies, adopted the partitioning of the band, and modified Footnotes 5.511A and 5.511D to provide a framework of control on the FSS to protect other services. Footnote 5.511B, which prohibited airborne use in the 15.45–15.65 GHz section, was deleted in line with the agreed ICAO policies. Footnote 5.511C is a restriction placed on the ARNS to limit the interference to FSS earth stations and to impose a coordination distance on the FSS for the protection of ARNS stations.

WRC-97 also adopted Resolution 123 calling for studies of the protection required for the radio astronomy service. The Resolution was reviewed at WRC-2000, which made further changes to the footnotes to make the control more effective, and was subsequently deleted.

The allocation of the fixed-satellite service to this band has the potential to significantly affect the flexible use by aviation systems. At the WRC-95 the FSS requirement was stated as for a “small number of stations”. Despite the failure of one mobile satellite operator (at least) to proceed with an implementation to use the band, aviation has continued to meet a determined resistance within ITU to limit the allocation to a more realistic level. A country or regional footnote would be an example of an appropriate limitation measure.

The sequence of events which has taken place in the discussions on this band is indicative of the present intense pressure to find spectrum for the new NGSO services. Towards this purpose, the normal ITU processes of "study then allocate" have been reversed. Experience shows that it is considerably more difficult to remove an unjustified allocation once agreed to at a WRC than it is to allocate one in the first place. While a moderate amount of sharing with downlink space services is technically possible in this band, as determined by the ITU-R work, constraining the present use of this band by aviation and future exploitation of the allocation by aeronautical services and systems is not a satisfactory situation.

ARNS protection and planning implications

The ITU-R Recommendations quoted above have identified and calculated the sharing criteria necessary for the protection of all of the present ARNS systems known to use the band. These indicate, among other criteria, the need for coordination distances of between 310 km (landing and airborne radar measurement systems) and 600 km for general purpose airborne radar, referenced to the areas of operation. Coordination with the location of ground earth stations prior to implementation is necessary to assess the potential for interference. These limitations and those of the power flux-density in the space-to-Earth direction create difficulties in terms of the siting of the FSS earth station. Concern is expressed on the practicalities to maintain an exclusion zone around FSS stations for aircraft equipped with these systems.

The results of sharing studies (see Attachment G) to protect the aeronautical radionavigation services, which included ASDE and a radar altimeter, have been found unduly restrictive to the FSS — for example, very large dish sizes at earth stations were necessary, and the distance separations from navigation facilities were large. The use of this band by the FSS appears to be minimal, and a worldwide allocation to the FSS is hence an inefficient deployment of scarce spectrum. Limited use in only a few countries in the future should be accommodated by a footnote. A footnote allocation is reasonable since the ITU-R Recommendation on sharing can be used as an effective criterion for coordination between countries.

In FSS terms, this band is a supplementary band for feeder link operation for possible use as a back-up or spill-over from the main FSS feeder link bands at 19 and 29 GHz. Resolution No. 117, recognizing (b), indicates only a small number of stations, and ITU discussions show a limited interest among FSS operators (possibly only one country in North America and one in Europe). Provided that the ARNS has a flexible use of the band, based on an agreed set of clear and safe technical sharing conditions, there is a manageable sharing situation. As a service to be shared with the ARNS, the FSS is likely to be disciplined in its operations, highly stable in its implementation and technical characteristics, and hence be preferred as a sharing partner if sharing is necessary.

The future outlook for the band

The considerations above are the main elements in defining the aeronautical position on this matter. The band is in intensive use and will remain so. The short wavelength of operation permits the deployment of systems on the ground with a minimum of interference planning. Likewise, airborne use is highly practical and economical. The pressures on the spectrum are such that all worldwide exclusive bands above 1 GHz are very suitable for satellite services, and existing users, such as the ARNS, will continue to be pressured to share or vacate, especially in the situation where there is a perception of less than full use. This is a highly useful band for the exploitation of compact airborne radar and radio altimeter systems for use in civil aviation and needs to be preserved for possible future implementation. The ICAO policy is based on these principles and aims to coordinate efforts to preserve the future use.

WRC-12

At WRC-12 new allocations to the radio location service, on a primary basis, were introduced into the Table of Allocations in the frequency range 15.4-15.7 GHz following successful compatibility studies having been completed with systems operating under the ARNS.

WRC-15 will consider new allocations to the fixed satellite service in the frequency range of 10 - 17 GHz in ITU Region 1 and in the range 13 – 17 GHz in ITU Regions 2 and 3. Aeronautical use in this band (see section 13.25 – 13.4 GHz and 15.4 – 15.7 GHz of this handbook) needs to be protected from harmful interference.

Band: 24.25–24.65 GHz
Service: Radionavigation (ASDE)
Allocation:

GHz 24.25–24.65		
Allocation to Services		
Region 1	Region 2	Region 3
24.25–24.45 FIXED	**24.25–24.45** RADIONAVIGATION	**24.25–24.45** RADIONAVIGATION FIXED MOBILE
24.45–24.65 FIXED INTER-SATELLITE	**24.45–24.65** INTER-SATELLITE RADIONAVIGATION 5.533	**24.45–24.65** FIXED INTER-SATELLITE MOBILE RADIONAVIGATION 5.533

Footnote:

5.533 The inter-satellite service shall not claim protection from harmful interference from airport surface detection equipment stations of the radionavigation service.

ICAO POLICY:

No change to the radionavigation allocations in Region 2 and Region 3.

AVIATION USE: These bands supplement the 15.4–15.7 GHz band for airport surface detection equipment (ASDE). The higher frequency provides greater target resolution although performance in precipitation, such as rain and fog, is inferior. Footnote 5.533 should be noted.

COMMENTARY: In 1997 the need to retain this allocation was reconfirmed. The ASDE requirement assumes greater priority with increasing airport congestion.

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Band: 31.8–33.4 GHz
Service: Radionavigation (ASDE)
Allocation:

GHz 31.8–33.4		
Allocation to Services		
Region 1	Region 2	Region 3
31.8–32	FIXED 5.547A RADIONAVIGATION SPACE RESEARCH (deep space) (space-to-Earth) 5.547 5.547B 5.548	
32–32.3	FIXED 5.547A RADIONAVIGATION SPACE RESEARCH (deep space) (space-to-Earth) 5.547 5.547C 5.548	
32.3–33	FIXED 5.547A INTER-SATELLITE RADIONAVIGATION 5.547 5.547D 5.548	
33–33.4	FIXED 5.547A RADIONAVIGATION 5.547 5.547E	

Footnotes:

5.547 The bands 31.8–33.4 GHz, 37–40 GHz, 40.5–43.5 GHz, 51.4–52.6 GHz, 55.78–59 GHz and 64–66 GHz are available for high-density applications in the fixed service (see Resolution **75 (WRC-2000)**). Administrations should take this into account when considering regulatory provisions in relation to these bands. Because of the potential deployment of high-density applications in the fixed-satellite service in the bands 39.5–40 GHz and 40.5–42 GHz (see No. **5.516B**), administrations should further take into account potential constraints to high-density applications in the fixed service, as appropriate. (WRC-07)

5.547A Administrations should take practical measures to minimize the potential interference between stations in the fixed service and airborne stations in the radionavigation service in the 31.8–33.4 GHz band, taking into account the operational needs of the airborne radar systems. (WRC-2000)

5.547B *Alternative allocation:* in the United States, the band 31.8–32 GHz is allocated to the radionavigation and space research (deep space) (space-to-Earth) services on a primary basis. (WRC-97)

5.547C *Alternative allocation:* in the United States, the band 32–32.3 GHz is allocated to the radionavigation and space research (deep space) (space-to-Earth) services on a primary basis. (WRC-03)

5.547D *Alternative allocation:* in the United States, the band 32.3–33 GHz is allocated to the inter-satellite and radionavigation services on a primary basis. (WRC-97)

5.547E *Alternative allocation:* in the United States, the band 33–33.4 GHz is allocated to the radionavigation service on a primary basis. (WRC-97)

5.548 In designing systems for the inter-satellite service in the band 32.3–33 GHz, for the radionavigation service in the band 32-33 GHz, and for the space research service (deep space) in the band 31.8–32.3 GHz, administrations shall take all necessary measures to prevent harmful interference between these services, bearing in mind the safety aspects of the radionavigation service (see Recommendation **707**). (WRC-03)

ICAO POLICY:

No change to the radionavigation allocations.

The band 31.8 – 33.4 GHz is used by aviation to support ground based airport surface detection equipment (ASDE) radar, mainly to detect traffic at airports. The band is shared with the mobile, the fixed and the space research service.

AVIATION USE: Use of the band for ground movement radar detection equipment is reported.

COMMENTARY: The *Report of the Communications Divisional Meeting (1978)* (Doc 9239) (Appendix C to the report on Agenda Item 3 refers) reported some use of these bands for ASDE and for airborne precision approach mapping radar.

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SECTION 7-III. RADIO REGULATIONS AND OTHER ITU MATERIAL OF IMPORTANCE TO AERONAUTICAL SERVICES

7-III.1 GENERAL

7-III.1.1 The ITU, which is governed by its Constitution and Convention, is an important forum for aeronautical radio services, and ultimately, for the continued operation of aviation. The principal areas where the ITU organization exercises its influences are:

a) the radio frequency bands needed to sustain the radio services; these may only be obtained through agreements made at ITU World Radiocommunication Conferences (WRCs);

b) standardization of systems and equipment with other services, to the degree necessary, which are often only achievable within the technical organs of the ITU;

c) problems of radio interference;

d) important regulations relating to frequencies and procedures for distress and safety communications which also affect the maritime and land mobile services; these can only be agreed and formalized within a common international forum; and

e) provisions dealing with licensing of radio stations and personnel.

7-III.1.2 Through the exercise of its authority and competence over the full telecommunications field, the ITU provides a focus for discussion and agreement. For example:

a) in the use of satellite navigation and communication services which usually is multinational, multi-purpose and commercial in character, the full range of representative interests may only be addressed in a common telecommunications forum such as the ITU; and

b) in aviation, the cohesion necessary between the airworthiness certification of aircraft, the inspection and approval of ground stations, and the radio licensing aspects need a common international focus.

7-III.1.3 The ITU Radio Regulations contain authoritative treaty provisions representing the worldwide agreement on the telecommunications matters within the ITU areas of interest.

7-III.1.4 The ITU deals with all telecommunications matters, both for radio and for line transmission purposes, and is supported by its technical agencies ITU-R and ITU-T for study and research in radio and line transmission, respectively. Their output is normally in the form of Recommendations and for worldwide publication and dissemination. A small proportion of ITU-R documentation is validated to the same treaty status as that in the Radio Regulations by means of a linked reference.

7-III.1.5 This section highlights Regulations of special importance to aviation indicating their context and scope in relation to aeronautical use of the spectrum.

7-III.2 ITU CONSTITUTION AND CONVENTION

7-III.2.1 The ITU is governed by the agreements contained in its Constitution, which defines the objectives, composition and basic structure of the organization. The ITU Convention lays down the personnel procedures, working methods and other matters of a procedural character. The present Constitution and Convention were last amended at the Plenipotentiary Conference in 2010 (Guadalajara, Mexico) (PP-10). Amendments were introduced as a consequence of extending participation of Observers and Sector Members of the ITU-R Sector to WRCs.

7-III.2.2 The need to ensure the safety of life is covered in Article 1 of the Convention which states that one of the purposes of the Union is to "*promote the adoption of measures for ensuring the safety of life through the cooperation of telecommunication* services;". Additionally Article 40 of the Constitution on the priority of telecommunications concerning safety of life states that "*International telecommunication services must give absolute priority to all telecommunications concerning safety of life at sea, on land, in the air or in outer space, as well as to epidemiological telecommunications of exceptional urgency of the World Health Organization*"

7-III.2.3 Of special importance is Article 50 of the Constitution, which deals with relations with other international organizations, and stipulates that "In furtherance of complete international coordination on matters affecting telecommunication, the Union shall cooperate with international organizations having related interests and activities".

7-III.2.4 The participation of ICAO in plenipotentiary conferences is regulated in Article 23 of the Convention, which states:

"...

No. 267 1 The following shall be admitted to plenipotentiary conferences:

…

No. 269 d) observers of the following organizations, agencies and entities to participate in an advisory capacity:

...

No. 269D iv) the specialized agencies of the United Nations and the International Atomic Energy Agency;

…"

7-III.2.5 The participation of ICAO in radiocommunication conferences is regulated in Article 24 of the Convention, which states:

"…

No. 276 1 The following shall be admitted to radiocommunication conferences:

...

No. 278 b) observers of organizations and agencies referred to in Nos. 269A to 269D of this Convention, to participate in an advisory capacity;

…"

7-III-2.6 The participation of ICAO in radiocommunication assemblies is regulated in Article 25 of the Convention, which states:

"…

No. 295 1 The following shall be admitted to the assembly or conference:

…

No. 297 c) observers, to participate in an advisory capacity, from:

…

No. 297bis i) the organizations and agencies referred to in Nos. 269A to 269D of this Convention;

...”

7-III.2.7 The *General Rules of Conferences, Assemblies and Meetings of the Union* state in GR 44 that “... observers that may attend conferences in accordance with the relevant provisions of the Convention, shall not be entitled to submit proposals”.

7-III.2.8 The *General Rules of Conferences, Assemblies and Meetings of the Union* (GR 61) indicate that “It shall be the duty of the chairman to protect the right of each delegation to express its opinion freely and fully on the point at issue”. The Annex to the Constitution defines a delegation as “The totality of the delegates ... sent by the same Member State”. As a result, the right to express an opinion freely and fully is granted by the ITU solely to Member States.

7-III.2.8 The application and a peculiar interpretation of the above provisions at WRC-2000 severely restricted the ability of ICAO to express its view at WRCs. Later during that conference, the restrictions were partly lifted. Action taken by ICAO, supported by the IMO, triggered the ITU to revise the role of observes (including those observers from United Nations specialized Agencies like ICAO) at their Conferences and Meetings.

7-III.2.9 The Plenipotentiary Conference (Marrakech, Morocco, 2002) (PP-02) considered the situation of observers in ITU conferences and meetings. Particular attention was given to the situation of observers from organizations and agencies within the United Nations system, several of which play an important role in relation to the use of the radio frequency spectrum and satellite orbits. It was recognized that the current provisions of the Constitution, Convention and General Rules support the furnishing of advice to conferences from these observers on matters within their competence. It was, however, noted that certain misunderstandings arose at WRC-2000 that resulted in a departure from the established practice of previous conferences concerning their participation. There was agreement at PP-02 that such misunderstandings must be avoided in the future.

7-III.2.10 Therefore, “the Plenipotentiary Conference decided to confirm to upcoming radiocommunication conferences that observers referred to in Nos. 259 (269A) and 262 (269D) of the Convention may submit to these conferences information documents relevant to their mandates to be noted by Member States. These information documents will continue to be distributed to the conference as per past practice and shall be referenced for information on the relevant daily agendas. Further, observers referred to in Nos. 259 (269A) and 262 (269D) may, with the authorization of the Chairman and in accordance with the Rules of Procedures (i.e. RP 16 and 17) (GR 44), provide advice on points relevant to their mandates. The information documents and advice shall not include or be treated as proposals. The right to make proposals, either written or oral, to such conferences is clearly reserved to Member States."

7-III.2.11 This decision was to be taken into consideration, along with proposals concerning observers made to PP-02, in the work of the Group of Experts established through Resolution 109 by PP-02 on the review and consolidation of the provisions of the Convention concerning observers. It was further decided to instruct the Secretary-General of the ITU to bring this decision to the attention of upcoming radiocommunication conferences, notably WRC-03, for the guidance of its proceedings.

7-III.2.12 The Group of Experts, open to ITU Member States only, reviewed relevant provisions of the basic texts of the ITU concerning observers and prepared a report for consideration by the ITU Council, including recommendations regarding Sector Member observers to Council. The Council was instructed to report to the next plenipotentiary conference on the implementation of the recommendations of the Group of Experts. This activity, which took into consideration the decision of PP-02 on the participation of the organizations and agencies within the United Nations system as noted above, would include the role and participation of all observers and Sector Members of the ITU.

7-III.2.13 PP-06 further analyzed the role of observers in the ITU and agreed to various suggested modifications regarding observers to the ITU Convention and the General Rules, and agreed to plenipotentiary conference Resolution 145 on the participation of observers in conferences, assemblies and meetings of the Union. The amendments consolidate the references to observers in the basic texts of the ITU and set out guidelines for the participation of different observers in various types of ITU conferences, assemblies and meetings. The resolution also incorporates the decisions of PP-02 concerning the participation of certain "observers in an advisory capacity" (including of United Nations specialized agencies such as ICAO) in an advisory capacity in WRCs. The resolution stipulates, *inter alia*, that observers in an advisory capacity, such as ICAO:

1) are admitted to participate in plenary meetings;
2) may, if not otherwise decided by the plenary meeting, be admitted to participate in committees and their subsidiary groups;
3) are entitled to receive all documentation;
4) may submit information documents. These documents shall be clearly referenced as information documents on the appropriate meeting agendas;
5) may request the floor in these meetings in order to provide advice or information on points relevant to their mandates. Such advice shall not include or be treated as proposals;
6) are to be given the floor by the chairman after the last Member State or

Sector Member on the list of speakers;

7) may be asked by the chairman during the course of a meeting to make a statement or to provide relevant information in order to assist the proceedings.

7-III.2.14 Participation of ICAO in the work of the Radiocommunication Sector (ITU-R) is primarily governed by the provisions in Article 19 of the Convention on the participation of entities and organizations other than administrations in the ITU's activities as well as by Resolution 145 on the participation of observers in conferences, assemblies and meetings of the Union as adopted by PP-06.

7-III.2.15 Article 19, subparagraph 6 (No. 236) states that "Any request from an organization referred to in Nos. 269B to 269D of this Convention to participate in the work of a Sector shall be sent to the Secretary-General, and the organization concerned shall be included in the lists referred to in No. 237 below". No. 237 indicates that "The Secretary-General shall compile and maintain lists of all entities and organizations referred to in Nos. 229 to 231 and Nos. 269B to 269D of this Convention that are authorized to participate in the work of each Sector". ICAO, as a specialized agency of the United Nations, is qualified under No. 269D to be added to this list.

7-III.2.16 Under the provisions of Articles 19, 23, 24 and 25 of the Convention and Resolution 145 of PP-06, the full participation of ICAO in the work of the ITU (plenipotentiary conferences, radiocommunication conferences and assemblies as well as sector meetings), including the submission of contributions and the full participation in the debate, is secured.

7-III.2.17 Important to note here is that the ITU-R sector members are admitted as observers to radiocommunication conferences on the basis of provision No. 280 contained in Article 24 of the Convention, thus identifying a different status between a Sector Member and a specialized agency of the United Nations, such as ICAO. Pursuant to Annex 3 of the PP-06 resolution on observers, ITU-R sector members at radiocommunication conferences are admitted to attend plenary meetings and committees, may be asked by the chairman during the course of a meeting to provide relevant information in order to assist the proceedings or to make a statement, but shall not be authorized to participate in the debates.

7-III.3 RADIO REGULATIONS

7-III.3.1 The Radio Regulations are the principal ITU document (with a treaty status) for radio matters. Parts of the Radio Regulations are discussed, agreed and embodied in the Final Acts of WRCs. WRCs are now held every four years in a rolling sequence in which each conference drafts the agenda for the next, and the provisional agenda for the second sequential WRC. The agenda for a WRC is approved by the ITU Council. The Radio Regulations lay down the framework for international spectrum management and contain the Table of Frequency Allocations, which is effectively the worldwide agreement on the deployment and conditions of use of all radio frequencies in the radio frequency spectrum. ICAO develops its material (e.g. SARPs) for radiocommunication and radionavigation systems within the framework set by the Radio Regulations. Changes to this framework introduced by WRCs can severely impede or disrupt the orderly use of spectrum by aviation and thus affect the safety of aviation. This section of the handbook reproduces Radio Regulations of particular importance to aeronautical services, and presents them with background comments which highlight their context and significance.

7-III.3.1.1 Chapter I (Articles 1 to 3) — Terminology and technical characteristics

The three Articles in this chapter contain fundamental material addressing terminology and technical conditions relating to all of the radio services. The chapter defines the interpretations to be placed on the terms and definitions used later in the Regulations to prescribe allocations and their conditions of use. It is designed as follows:

- Article 1 contains terms and definitions;
- Article 2 deals with nomenclature; and
- Article 3 focuses on the technical characteristics of stations.

7-III.3.1.2 Article 1 — Terms and definitions

The terms and definitions of importance to aeronautical services are in Attachment A to this handbook. The following should be noted:

a) the hierarchical structure of radio services (see Figure 3-3) which is repeated in the definitions for stations;

b) the carefully worded definition for radionavigation, in particular the reference to "obstruction warning". The latter is interpretable to apply to primary and secondary radar used for air traffic purposes, airborne weather radar, radio altimeters, ground proximity warning systems, etc., since they support the safe navigation of aircraft;

c) the definition for a safety service (RR 1.59) noting that a service can temporarily become such during periods when the communications fulfill the criteria of safeguarding of human life and property. All air traffic communications and radionavigation used in civil aviation fall under this classification;

d) the various definitions relating to interference (RR 1.166 to RR 1.169) noting that interference is only "harmful" when it is serious or where it endangers the functioning of a radionavigation service or other safety service;

e) the definition of public correspondence (RR 1.116) which is based on the concept of availability to the public of the service of transmission. This definition also appears in the ITU Convention. Air traffic communications do not fall within the classification of public correspondence;

f) the definition of an administration (RR 1.2) which is broad in scope covering any national entity in which the responsibility for discharging ITU obligations is vested. This definition is notable for its imprecision which constantly leads to problems in interpretation; and

g) the highly important definitions for allocation, allotment and assignment at RR 1.16, RR 1.17 and RR 1.18, together with the Table at RR 5.1 reproduced below:

Term	*Frequency distribution to*
Allocation	Service
Allotment	Area
Assignment	Station

The first two, "allocation" and "allotment", are for determination by an ITU conference. Article 5 contains the agreed allocations for the total spectrum. The concept of allotment is only applied in a few instances by ITU, of which Appendix 27, the HF Allotment Plan for the aeronautical mobile (R) service, is a notable example. The third, "assignment", is a matter for national administrations and results in the issue of a license to an operator to authorize the operation or reception of a radio station.

7-III.3.1.3 Service merging

The subject of service merging was proposed by the Voluntary Group of Experts (VGE) in the early nineties (Recommendation 1/7) as a flexible means of allocation in some circumstances. The ICAO position, which was developed at the Special COM/OPS/95, in regard to general application of service merging and in the specific case of mobile-satellite service (*Report of the Special Communications/ Operations Divisional Meeting (1995)* (Doc 9650), pages 7B-7 and 7B-22) states:

General statement

"3.2.7.2 *ICAO position*

a) The merging of all MOBILE and MOBILE-SATELLITE services under a generic title is not acceptable. The aeronautical allocations must be exclusive to satisfy stringent safety, integrity, availability and capacity requirements. The AM(R)S and AMS(R)S are services with a high content of safety of life, whereas the other two (maritime and land mobile) are primarily for public correspondence (see also section 6); and

b) RADIO NAVIGATION cannot be merged with RADIO LOCATION under the service designation of RADIO DETERMINATION. RADIO NAVIGATION is a safety service, and as such requires special measures for protection against harmful interference, as indicated in RR 953. Such merging of (aeronautical) radio navigation may result in the loss of it being recognized as a safety service and the loss of its special status in regard to interference. Furthermore, aeronautical radio navigation allocations must be exclusive for the same reasons as for the AM(R)S and AMS(R)S."

Generic mobile satellite allocation

"6.4 *ICAO position*

6.4.1 At this point in time the envelope and content of any proposal for a generic mobile-satellite allocation and its associated safety service protection mechanism are not of sufficient maturity for general international application. Many difficulties may be predicted such as the availability of sufficient frequencies for services with longer evolution timescales and plans, the problems of establishing levels and regulating interference in a multi-provider, multi-national environment, and in cross border coordination and control. The intangible benefit of greater flexibility of allocation has not been sufficiently demonstrated to aviation to permit departure from its present manageable, highly controlled and predictable situation, in the AMS(R)S allocations.

> 6.4.2 The recommendation which flows from the above analysis and other secondary considerations is that aviation services should not, with the present lack of clarity, accept the re-designation of the present AMS(R)S bands to the generic allocation of MSS or any form of dynamic simultaneous operation with other mobile-satellite services. Further study of technical, operational and regulatory aspects is necessary before different approaches can be considered to be acceptable without compromising safety and regularity of flight."

The ITU Recommendation 34 (WRC-12) also puts forward the idea to allocate frequency bands to the most broadly defined services for consideration by administrations (*Recommends 1*) and calls on ITU-R, in conjunction with ICAO and IMO, to undertake studies of the possibilities (*instructs the Director of the Radiocommunication Bureau and requests the ITU-R study groups 2*)..

7-III.3.1.4 Access to AMS(R)S Spectrum

WRC-97 agreed to convert all spectrum in the bands 1 525–1 559 MHz and 1 626.5–1 660.5 MHz into an allocation to the mobile-satellite service. These bands are now available, primarily on a first-come, first-served basis, to all space system providers and service operators, and with services available to all mobile users, land, sea or air, as commercially practicable. The sub-bands 1 545– 1 555 MHz and 1 646.5–1 656.5 MHz were originally allocated to the AMS(R)S on an exclusive basis and were the key elements of the CNS/ATM system in relation to the implementation of long-distance communications for voice and data. The strong reservations of international civil aviation were not sufficient to stop this conversion process for the AMS(R)S allocations at 1 545–1 555 MHz and 1 646.5–1 656.5 MHz, and a new Footnote 5.357A was agreed which was intended to preserve a measure of assurance that sufficient frequencies for AMS(R)S needs would be available, as well as the requirement for a dynamic priority for ATC messages in a common system. In addition, Resolution 218 (WRC-97) requested ITU-R to study the feasibility of prioritization, real-time pre-emptive access and, if necessary, the interoperability between the mobile services. A report was made to WRC-2000. Responding to strong aviation pressures, WRC-2000 amended Footnote 5.357A with a link to Resolution 222 to provide better assurance that the expanding needs of the AMS(R)S will be met in the future, if necessary by the release of frequencies from other mobile-satellite services.

This situation of generic allocations to the mobile-satellite services could have profound adverse effects on the provision and operation of satellite communications for ATC purposes in the years ahead. Apart from the practicability of non-aeronautical satellite systems to give priority to ATC satellite communications in a multi-user service, it is by no means certain whether aviation's growing needs for interference-free communications satisfying the integrity, reliability and availability requirements developed by the ACP and incorporated in Annex 10 can be met in the long term. Controlled evaluations and operational trials, with the results discussed in both ICAO and ITU-R, are necessary prerequisites to providing the short-term guarantees that are necessary. The aspect of long-term availability of sufficient frequencies is a more difficult question, which will call for new and corroborated estimates of future demand for ATC and AOC and an assessment of the available spectrum, taking into account the predicted total mobile-satellite situation at some point in the future. Aeronautical public correspondence (AAC and APC) would have access to the full mobile-satellite allocation available.

It is not probable that the allocation to the generic mobile service, as agreed at WRC-97, can be easily changed into an exclusive aeronautical allocation, and the likelihood is that all of the spectrum in the generic mobile-satellite frequency band (33 MHz in each direction) will be rapidly implemented and shared between many non-aeronautical space system providers. A new strategy for the future is a priority subject for discussion, as is the careful monitoring and study of the practical situation as it enfolds.

7-III.3.1.5 Articles 2 and 3

Article 2: Nomenclature

This Article defines the convention for the description of frequency bands and other associated information.

Article 3: Technical characteristics of stations

This Article contains important guidelines which have to be observed in the engineering and design of radio stations. Of particular interest to aviation is RR 3.3 which places an obligation on services to take account of the services in adjacent bands. The full text of this Regulation is:

> 3.3 Transmitting and receiving equipment intended to be used in a given part of the frequency spectrum should be designed to take into account the technical characteristics of transmitting and receiving equipment likely to be employed in neighbouring and other parts of the spectrum, provided that all technically and economically justifiable measures have been taken to reduce the level of unwanted emissions from the latter transmitting equipment and to reduce the susceptibility to interference of the latter receiving equipment.

Aircraft receiving equipment is vulnerable to interference over a large geographic area and the requirement placed on transmitters in this Regulation is a beneficial statement of good practice. Conversely, aircraft receivers should be designed with good interference rejection characteristics as a prior condition of seeking emission control from other radio services. Radio Regulation 3.13 has a similar message which qualifies RR 3.3 and introduces a proximity condition implying that very close operation is a special case.

ICAO POLICY ON CHAPTER I:

- No changes should be made to the Regulations of importance to aeronautical services as identified above.
- Service merging of aeronautical radionavigation in the world-wide allocations where an ICAO standard system operates with other radiodetermination services is not practicable without prejudicing the service of the aeronautical system.
- Service merging of aeronautical mobile service allocations with other services is not possible due to the radically different operational requirements.

7-III.3.2 Chapter II (Articles 4 to 6) — Frequencies

7-III.3.2.1 *Article 4: Assignment and use of frequencies*

This Article contains several very important provisions relating to the deployment of frequencies. The following are of special interest to aeronautical services.

> **4.4** Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations.

The objective of this Regulation is to prevent registered assignments which are not in accordance with the Radio Regulations from causing interference to those which are in conformity. It also has the important secondary purpose of establishing rights for "non RR-conforming" registrations on a "non-interference" basis, which then establishes priority rights over those "non-interference" registrations that come later.

It has a highly important conservation role in that it helps to promote and increase spectrum use. It introduces the fundamental ITU principle that individual administrations can use the spectrum in any way they wish, provided interference is not caused to services operating in conformity with the agreements in the Radio Regulations and which are registered in the Master International Frequency Register.

> **4.10** Member States recognize that the safety aspects of radionavigation and other safety services require special measures to ensure their freedom from harmful interference; it is necessary therefore to take this factor into account in the assignment and use of frequencies.

This Regulation establishes a long-standing major principle in the use of frequencies and originates from maritime practices, which were created in their own right with a set of discrete aeronautical radio services before aviation was established in ITU. The previous long-standing practice of not sharing radionavigation allocations with other services, whether primary or secondary, has been discarded and frequency sharing based on technical criteria is now a common, although not desirable practice. The principle of "special measures" in this Regulation still finds application in the action to be taken when interference occurs. This, together with the other provisions dealing with harmful interference, ensures that rapid attention is given by administrations when interference to a safety service takes place. Implicit in the wording of the Regulation is the fact that radionavigation is a safety service (see RR 1.59).

> **4.9** No provision of these Regulations prevents the use by a station in distress, or by a station providing assistance to it, of any means of radio-communication at its disposal to attract attention, make known the condition and location of the station in distress, and obtain or provide assistance.
>
> **4.16** However, in circumstances involving the safety of life, or the safety of a ship or aircraft, a land station may communicate with fixed stations or land stations of another category.
>
> **4.22** Any emission capable of causing harmful interference to distress, alarm, urgency or safety communications on the international distress and emergency frequencies established for these purposes by these Regulations is prohibited. Supplementary distress frequencies available on less than a worldwide basis should be afforded adequate protection.

These Regulations address the situation of distress and safety, and permit and protect the necessary communications in these circumstances. In ITU, distress and safety messages have to be given special treatment in the maritime service, which is characterized by infrequent safety and distress communications on the same channel as public correspondence. These situations are comparable to that of emergency messages in the aeronautical service. Aeronautical procedures for emergency communications, as laid down in Annex 10, Volume II, are the valid rules for civil aviation.

4.19 In certain cases provided for in Articles **31** and **51**, aircraft stations are authorized to use frequencies in the bands allocated to the maritime mobile service for the purpose of communicating with stations of that service (see No. **51.73**). (WRC-07)

4.20 Aircraft earth stations are authorized to use frequencies in the bands allocated to the maritime mobile-satellite service for the purpose of communicating, via the stations of that service, with the public telegraph and telephone networks.

These Regulations are principally relevant to the transmission of public correspondence. The importance of RR 4.20 diminishes with the ITU agreement at WRC-97 to apply generic type allocations to all mobile-satellite communications.

7-III.3.2.2 *Article 5: Frequency allocations*

This Article contains the Table of Frequency Allocations and is the component of the Radio Regulations which receives the constant attention of ITU conferences. It records the agreed use of the entire useable spectrum by all defined radio services over the three ITU world regions. It is extensive (occupying well over 100 pages) and detailed.

Note.— Section 7-II of this handbook addresses the aeronautical aspects of the Table of Frequency Allocations in detail.

In addition to the material addressed in Section 7-II, the following two Regulations in Article 5 are important to aviation:

5.43 1) Where it is indicated in these Regulations that a service or stations in a service may operate in a specific frequency band subject to not causing harmful interference to another service or to another station in the same service, this means also that the service which is subject to not causing harmful interference cannot claim protection from harmful interference caused by the other service or other station in the same service.

5.43A 1*bis*) Where it is indicated in these Regulations that a service or stations in a service may operate in a specific frequency band subject to not claiming protection from another service or from another station in the same service, this means also that the service which is subject to not claiming protection shall not cause harmful interference to the other service or other station in the same service.

Recent ITU conferences have agreed to the sharing of aeronautical allocations with other services either in a situation where the added service operates on an equal primary basis with the existing aviation service, or on a non-interference basis with the aviation service. However, both services must be protected with respect to any secondary allocation in the same band. A footnote applying to the added service usually contains the conditions to be observed. For example, see the band 960–1 215 MHz where the RNSS is added to the ARNS (DME, SSR, ACAS). Radio Regulations 5.43 and 5.43A address and clarify these situations, though in certain situations, 5.43 and/or 5.43A may be exempted through a footnote (e.g. 5.328A, 5.473A, 5.475B and 5.476A). This in effect creates a new category of services that falls between the categories of primary and secondary.

7-III.3.2.3 *Article 6: Special agreements*

Article 6 dealing with special agreements is of interest to aviation since some of the conditions on special agreements may be applied, in particular circumstances, to the agreements on frequency use coordinated within ICAO (see, for example, Nos. 6.2 and 6.3).

ICAO POLICY ON CHAPTER II:

- Article 4: maintain these Regulations, particularly RR 4.10, without any change in substance.
- Article 5: see Section 7-II of this handbook.
- Article 6: maintain these Regulations without change.

7-III.3.3 Chapter III (Articles 7 to 14) — Coordination, notification and recording of frequency assignments and Plan modifications

7-III.3.3.1 The long-standing ITU procedure of introducing registration of frequency assignment in a central document (Master International Frequency Register (MIFR)), so as to obtain prior rights for protection against other registrations being introduced at a later time (see RR 8.3), is embodied in the terms and conditions laid down in this chapter. It may be noted that registration, which is not an absolute requirement, has as its main purpose the establishment of protection rights by countries for their assignments and is exercised at the discretion of each ITU member administration. These rights are dependent on a number of important conditions of which conformity with all of the requirements of the Regulations is the prime factor. Non-conformity provides no protection (RR 8.5) except, perhaps, against another non-conforming registration which appears later.

7-III.3.3.2 With the notable exception of high frequency (HF), non-directional radio beacon (NDB) and satellite communication (SATCOM), assignments to aeronautical services, in exclusive aeronautical bands, are normally coordinated within ICAO and entered in a register maintained under aviation auspices. This process may be considered to amount to a *de facto* form of compliance with the terms of Chapter III, although the consultation is wholly within aviation and technically does not meet the full ITU registration process requirement. HF assignments allotted to major world air route areas (MWARA), regional and domestic air route areas (RDARA), and worldwide use are obtained from Appendix 27 and are, as well as NDB assignments, normally registered in the MIFR.

7-III.3.3.2 Recording of frequency assignments that have been coordinated within ICAO through the Regional Offices with the Master International Frequency Register of the International Telecommunication Union.

Recording of frequency assignments in the ITU Master International Frequency Register (MIFR) represents a very important element of international regulations. Correct and up-to-date information in the MIFR may be critically important for frequency management, including the analysis of occupancy of frequency bands for sharing studies and allocation of spectrum at world radiocommunication conferences.

ICAO and its Regional Offices also maintain databases of coordinated aeronautical frequencies in a number of frequency bands allocated to the aeronautical mobile (R) service and aeronautical radionavigation service. A comparison of the ITU and ICAO databases has shown that only a small part of frequency assignments contained in the ICAO's database is recorded in the MIFR. One possible reason for this situation is that the ICAO's databases are updated by authorized aeronautical authorities of ICAO Contracting States, which could be different from ITU administrations notifying frequency assignments to the MIFR.

The Bureau and the ICAO secretariat made preliminary consultations as for technical and regulatory feasibility of recording in the MIFR of the frequency assignments contained in the ICAO databases. During these consultations a number of technical matters requiring solutions were identified. These matters include handling differences in format and parameters of the ICAO and ITU databases, processing of changes in the ICAO database, which is frequently modified due to changing air traffic requirements, ways of registration of aircraft systems which are not associated with ground-based stations. The initial evaluation of this issue indicate that the data conversion from ICAO to ITU format is feasible. In addition to the data handling, an urgent need to establish a regulatory basis for the relevant activities was emphasized.

WRC-12 reviewed the initiative of the ITU and ICAO and concluded, at the Seventh Plenary Meeting to the following:

> "It was suggested that the Bureau should urge administrations, through a Circular Letter, to notify aeronautical frequency assignments to the MIFR. At the same time, Committee 4 appreciated previous consultations between the ICAO Secretariat and the Radiocommunication Bureau on this matter and expressed the opinion that such consultations should continue with respect to a possible transfer of ICAO database information to the Bureau."

These consultations are on-going, as necessary with the involvement of the ACP WG F. In these consultations, both the technical and the (Radio) Regulatory aspects are reviewed.

ICAO POLICY ON CHAPTER III:

Maintain these Regulations without change.

Continue the assessment on aligning the ITU database of frequency assignments with the ICAO global frequency lists.

7-III.3.4 Chapter IV (Articles 15 and 16) — Interferences

7-III.3.4.1 This chapter on interferences is important in aeronautical terms. It prescribes the conditions under which stations must operate to avoid causing interference, the measures to be applied when interference is detected and the actions to be taken when a resolution cannot be obtained by normal bilateral coordinative actions. The necessary actions prescribed contain a strong emphasis on the importance of removing interference in the case where it occurs to a safety service (RR 15.36 and RR 15.37), or where distress frequencies are involved (RR 15.28).

7-III.3.4.2 It is noted that the procedures in the ITU Radio Regulations for clearing interference have no mandatory force, nor is there any procedure for the referral of disputes for arbitration. Thus, RR 15.22 mentions "goodwill and mutual assistance", and as a final attempt, an administration may request the Radio Regulations Board to help (RR 15.41, RR 15.42 and Section 1 of Article 13).

7-III.3.4.3 Regulations of particular importance to aeronautical service in this chapter are reproduced below.

15.8 Special consideration shall be given to avoiding interference on distress and safety frequencies, those related to distress and safety identified in Article **31**, and those related to safety and regularity of flight identified in Appendix **27**. (WRC-07)

15.28 Recognizing that transmissions on distress and safety frequencies and frequencies used for the safety and regularity of flight (see Article **31** and Appendix **27**) require absolute international protection and that the elimination of harmful interference to such transmissions is imperative, administrations undertake to act immediately when their attention is drawn to any such harmful interference. (WRC-07)

15.32 If further observations and measurements are necessary to determine the source and characteristics of and to establish the responsibility for the harmful interference, the administration having jurisdiction over the transmitting station whose service is being interfered with may seek the cooperation of other administrations, particularly of the administration having jurisdiction over the receiving station experiencing the interference, or of other organizations.

15.36 When a safety service suffers harmful interference the administration having jurisdiction over the receiving station experiencing the interference may also approach directly the administration having jurisdiction over the interfering station. The same procedure may also be followed in other cases with the prior approval of the administration having jurisdiction over the transmitting station whose service is being interfered with.

15.37 An administration receiving a communication to the effect that one of its stations is causing harmful interference to a safety service shall promptly investigate the matter and take any necessary remedial action and respond in a timely manner.

15.40 If there is a specialized international organization for a particular service, reports of irregularities and of infractions relating to harmful interference caused or suffered by stations in this service may be addressed to such organization at the same time as to the administration concerned.

ICAO POLICY ON CHAPTER IV:

This chapter contains Regulations of importance to aeronautical services which provide for the rapid clearance of interference to these services. No changes of substance should be made, and the degree of attention accorded to safety services and distress frequencies should not be lessened.

7-III.3.5 Chapter V (Articles 17 to 20) — Administrative provisions

7-III.3.5.1 Several administrative provisions contained in Articles 18 and 19 of this chapter are of interest to aviation (action may either involve the telecommunications or the aviation authority, or both). Radio Regulations 18.8 and 18.11 have been included at the request of aviation to regularize the licensing of aircraft on delivery from the manufacturer, and aircraft leased to a country other than the country of registry. Radio Regulation 19.10 is a dispensation from the normal rule that radio stations must transmit an identification at all times, and regularizes the ICAO Annex 10 practice with navaids where removal of the identification is an indication of malfunction. In ITU, the term "radiobeacon" has a wider significance than in aviation and can include all ground-based navaids. The most important of these Regulations are reproduced below:

18.8 In the case of a new registration of a ship or aircraft in circumstances where delay is likely to occur in the issue of a licence by the country in which it is to be registered, the administration of the country from which the mobile station or mobile earth station wishes to make its voyage or flight may, at the request of the operating company, issue a certificate to the effect that the station complies with these Regulations. This certificate, drawn up in a form determined by the issuing administration, shall give the particulars mentioned in No. **18.6** and shall be valid only for the duration of the voyage or flight to the country in which the registration of the ship or aircraft will be effected, or for a period of three months, whichever is less.

18.11 In the case of hire, lease or interchange of aircraft, the administration having authority over the aircraft operator receiving an aircraft under such an arrangement may, by agreement with the administration of the country in which the aircraft is registered, issue a licence in conformity with that specified in No. **18.6** as a temporary substitute for the original licence.

19.10 All operational transmissions by radiobeacons shall carry identification signals. However, it is recognized that, for radiobeacons and for certain other radionavigation services that normally carry identification signals, during periods of malfunction or other non-operational service the deliberate removal of identification signals is an agreed means of warning users that the transmissions cannot safely be used for navigational purposes.

19.16 In transmissions carrying identification signals a station shall be identified by a call sign, by a maritime mobile service identity or by other recognized means of identification which may be one or more of the following: name of station, location of station, operating agency, official registration mark, flight identification number, selective call number or signal, selective call identification number or signal, characteristic signal, characteristic of emission or other clearly distinguishing features readily recognized internationally.

7-III.3.5.2 Sections III and VII of Article 19 deal with the formation of call signs in the aeronautical service. The Regulations do not define the distinction between an identification and a call sign very clearly, and both are transmitted essentially to provide others with a means of determining the identity of a radio transmission. The usual interpretation is that identification is primarily required on transmissions by radio beacons for the purpose of identifying interference sources, while call signs have the added purpose of facilitating two-way communications. The greater majority of the requirements laid down in Section III relate to maritime services, with dispensations (as indicated below) in the case of aeronautical stations. To a large extent Annex 10 (Volume II) has been aligned with these Regulations.

Section III — Formation of Call Signs

19.57 *Aircraft stations*

19.58 **—** two characters and three letters.

19.77 1) *Aeronautical stations*

— the name of the airport or geographical name of the place followed, if necessary, by a suitable word indicating the function of the station.

19.78 2) *Aircraft stations*

— a call sign (see No. **19.58**), which may be preceded by a word designating the owner or the type of aircraft; *or*

— a combination of characters corresponding to the official registration mark assigned to the aircraft; *or*

— a word designating the airline, followed by the flight identification number.

19.79 3) In the exclusive aeronautical mobile frequency bands, aircraft stations using radiotelephony may use other methods of identification, after special agreement between governments, and on condition that they are internationally known.

Section VII — Special Provisions

19.127 1) In the aeronautical mobile service, after communication has been established by means of the complete call sign, the aircraft station may use, if confusion is unlikely to arise, an abbreviated call sign or identification consisting of:

19.128 a) in radiotelegraphy, the first character and last two letters of the complete call sign (see No. **19.58**);

19.129 b) in radiotelephony:

— the first character of the complete call sign; *or*

— the abbreviation of the name of the owner of the aircraft (company or individual); *or*

— the type of aircraft;

followed by the last two letters of the complete call sign (see **No.19.58**) or by the last two characters of the registration mark.

19.130 2) The provisions of Nos. **19.127, 19.128** and **19.129** may be amplified or modified by agreement between administrations concerned.

ICAO POLICY ON CHAPTER V:

Chapter V, which addresses identification signals and call signs, is the basic international document for these matters. Alignment with Annex 10 is essential and must be maintained either through similar text or by exemption (e.g. RR 19.10).

7-III.3.6 Chapter VI (Articles 21 to 29) — Provisions for services and stations

The Articles in this chapter address specific procedures and technical practices for radio services and stations that are essential for efficient and orderly operation and for efficient use of spectrum. One of the services of interest to aviation is detailed below.

Article 28: Radiodetermination services

Section 1 is general and is oriented towards the maritime service, which has no international document other than the Radio Regulations in which to prescribe obligatory requirements.

Section II contains a provision dealing with the aeronautical radio-navigation-satellite service (which has not yet received an allocation in the Table of Frequency Allocations).

Section III deals with radio direction-finding stations. Such stations are no longer a standard feature in civil aviation on international services. However, where it applies, there is a dispensing regulation which permits aviation to use ICAO agreements as the rule. This is:

28.17 In the aeronautical radionavigation service, the procedure contemplated for radio direction-finding in this Section is applicable, except where special procedures are in force as a result of arrangements concluded between the administrations concerned.

Section IV deals with radio beacons in a general way. Radio Regulations 28.23 and 28.24 include reference to Appendix 12 which designates field strength and protection requirements for aeronautical radio beacons. The parameters and values defined in Appendix 12 are those used by ICAO in the frequency assignment planning for aeronautical NDB. The text of these Regulations is:

28.23 The power radiated by each radiobeacon properly so-called shall be adjusted to the value necessary to produce the stipulated field strength at the limit of the range required (see Appendix **12**).

28.24 Special rules applicable to aeronautical radio beacons operating in the bands between 160 kHz and 535 kHz and to the maritime radio beacons operating in the bands between 283.5 kHz and 335 kHz are given in Appendix **12**.

ICAO POLICY ON CHAPTER VI:

- The provisions in the chapter are necessary as broad principles for radiodetermination services. They should be maintained and improved, as necessary, by future amendments based on practical experience.
- Appendix 12, together with the enabling provisions 28.23 and 28.24, should be maintained unchanged.

7-III.3.7 Chapter VII (Articles 30 to 34) — Distress and safety communications

Primarily, this chapter addresses the operational use of the global maritime distress and safety system (GMDSS) intended for ships in distress situations. However, aircraft are not precluded from using the system. Radio Regulation 30.9 provides the dispensation for aeronautical radio services to conform to the provisions in Annex 10 in any case where provisions of the Radio Regulations diverge from aeronautical practices. Regulations of relevance are:

Article 30 — General provisions

Section III — Aeronautical Provisions

30.8 The procedure specified in this Chapter is obligatory for communications between stations on board aircraft and stations of the maritime mobile-satellite service, wherever this service or stations of this service are specifically mentioned.

30.9 Certain provisions of this Chapter are applicable to the aeronautical mobile service, except in the case of special arrangements between the governments concerned.

30.10 Mobile stations of the aeronautical mobile service may communicate, for distress and safety purposes, with stations of the maritime mobile service in conformity with the provisions of this Chapter.

30.11 Any station on board an aircraft required by national or international regulations to communicate for distress, urgency or safety purposes with stations of the maritime mobile service that comply with the provisions of this Chapter, shall be capable of transmitting and receiving class J3E emissions when using the carrier frequency 2 182 kHz, or class J3E emissions when using the carrier frequency 4 125 kHz, or class G3E emissions when using the frequency 156.8 MHz and, optionally, the frequency 156.3 MHz.

Article 33: Operational procedures for urgency and safety communications in the global maritime distress and safety system (GMDSS)

Medical transports are defined in the 1949 Geneva Convention and the definition is repeated in RR 33.19. They may be aircraft or ships involved in areas of armed conflict. Section III — *Medical transports* sets down the special identification measures, which include the use of secondary surveillance radar (SSR) for aircraft.

ICAO POLICY ON CHAPTER VII:

Chapter VII concerns primarily the global maritime distress and safety system (GMDSS), but affects aircraft indirectly. These provisions (identified above) should be maintained, or improved as necessary, based on operational practices.

7-III.3.8 Chapter VIII (Articles 35 to 45) — Aeronautical services

7-III.3.8.1 This chapter deals exclusively with aeronautical matters and addresses licensing and regulatory aspects of allocations as well as service operational matters. These matters are applicable to all aircraft operations, whether for civil, national defense or governmental purposes. This chapter contains the following articles (with the type of regulation indicated in brackets):

Article 35 *Introduction*

Article 36 *Authority of the person responsible for the station* (operational)

Article 37 *Operator's certificates* (licensing)

Article 38 *Personnel* (licensing)

Article 39 *Inspection of stations* (licensing)

Article 40 *Working hours of stations* (operational)

Article 41 *Communications with stations in the maritime services* (regulatory)

Article 42 *Conditions to be observed by stations* (regulatory)

Article 43 *Special rules relating to the use of frequencies* (regulatory)

Article 44 *Order of priority of communications* (operational)

Article 45: *General communication procedure* (operational)

Radio Regulation 35.1.1 recognizes, with the exception of Articles 36, 37, 39, 42, 43 and 44.2, the application of ICAO Annexes to civil aircraft provided their implementation does not cause harmful interference to the radio services of other countries.

7-III.3.8.2 Particular regulations of interest and importance in Chapter VIII are:

Article 37: Operator's certificates

This important Article lays down the requirement for operator's certificates to be issued for aircraft personnel in relation to the control and use of the radio as a transmitting device. The requirement is also reflected in Article 30 (b) of the ICAO Convention, and the requirements for the air safety aspects are laid down in Annexes 1 and 10. Several of the provisions in this Article take account of practices in civil aviation as specified in ICAO Annexes. Of relevance to aviation are:

— RR 37.1 which requires that every aeronautical radio station be certified by an "operator holding a certificate issued or recognized by the government to which the station is subject". The wording of this Regulation permits the certificate to be issued by the authority with responsibility for civil aviation.

— RR 37.2 which provides a dispensation for the use of ICAO requirements in lieu of those in the Regulations in the aspects where ICAO has specified conditions, qualifications or other relevant material. The text of this Regulation is:

37.2 In order to meet special needs, special agreements between administrations may fix the conditions to be fulfilled in order to obtain a radiotelephone operator's certificate intended to be used in aircraft radiotelephone stations and aircraft earth stations complying with certain technical conditions and certain operating conditions. These agreements, if made, shall be on the condition that harmful interference to international services shall not result therefrom. These conditions and agreements shall be mentioned in the certificates issued to such operators.

— RR 37.4 and RR 37.5 which permit administrations to decide if a certificate is necessary for frequencies above 30 MHz, but not on frequencies assigned for international use.

— RR 37.14 which permits the issue of a restricted certificate in lieu of a general certificate where the frequencies used are from exclusive aeronautical bands, and operation of the equipment requires only the use of simple external switching devices. This applies to all HF and VHF radio equipment carried in modern civil aircraft.

Article 42: Conditions to be observed by stations

Of note in this Article is RR 42.4 which prohibits the operation of a broadcasting service by an aircraft station while over the sea. An associated RR 23.2 prohibits the establishment and use of broadcasting services outside national territory.

Article 43: Special rules relating to the use of frequencies

This Article lays down conditions of use for aeronautical frequencies.

RR 43.1 is often referred to in an aeronautical mobile and aeronautical mobile-satellite context in ITU discussions. It distinguishes the civil aviation use of frequencies from other aircraft uses, notably national defense use (i.e. the (OR) service). The inclusion of the words "safety and regularity" has been a deliberate transfer from the ICAO Convention. The service definitions at RR 1.33 and RR 1.36 were inserted recently to consolidate the concept insofar as the Table of Frequency Allocations is concerned. RR 43.4 prohibiting public correspondence is of long-standing and still is applicable to AM(R)S and AM(OR)S services. There is no longer an exclusive allocation to the AMS(R)S.

43.1 Frequencies in any band allocated to the aeronautical mobile (R) service and the aeronautical mobile-satellite (R) service are reserved for communications relating to safety and regularity of flight between any aircraft and those aeronautical stations and aeronautical earth stations primarily concerned with flight along national or international civil air routes.

RR 43.4 has the objectives of maintaining civil aviation frequencies exclusively for safety messages, as well as preventing their exploitation for purposes which can lead to inefficient use of spectrum. It only applies to exclusive bands and is invalid for satellite services to aircraft operating in the generic mobile-satellite bands.

43.4 Administrations shall not permit public correspondence in the frequency bands allocated exclusively to the aeronautical mobile service or to the aeronautical mobile-satellite service.

Article 44: Order of priority of communications

The order of priority of communications in this article (reproduced below) has been carefully aligned with that in Annex 10, Volume II, Chapter 5, 5.1.8 for Categories 1 to 6 below. These have been accorded priority over other communications by footnotes in the Table of Frequency Allocations, particularly in the allocations in the mobile-satellite bands where other communications, e.g. public correspondence, are also transmitted on the same channel. Footnote, 5.357Aplaces only the priority Categories 1 to 6 of Article 44 as a condition to be observed by mobile-satellite service operators in the frequency bands 1545 – 1555 MHz and 1646.5 – 1656.5 MHZ which are allocated to the (generic) Mobile Satellite Service.

44.1 §1. The order of priority for communications[1] in the aeronautical mobile service and the aeronautical mobile-satellite service shall be as follows, except where impracticable in a fully automated system in which, nevertheless, Category 1 shall receive priority:

1. Distress calls, distress messages and distress traffic.

2. Communications preceded by the urgency signal.

3. Communications relating to radio direction-finding.

4. Flight safety messages.

5. Meteorological messages.

6. Flight regularity messages.

7. Messages relating to the application of the United Nations Charter.

8. Government messages for which priority has been expressly requested.

9. Service communications relating to the working of the telecommunication service or to communications previously exchanged.

10. Other aeronautical communications.

44.2 §2. Categories 1 and 2 shall receive priority over all other communications irrespective of any agreement under the provisions of No. **35.1**.

[1] **44.1.1** The term *communications* as used in this Article includes radiotelegrams, radiotelephone calls and radiotelex calls.

ICAO POLICY ON CHAPTER VIII:

- Resolution 713 (WRC-95) calls for study of the operational provisions in the Radio Regulations. Although not explicitly stated, the implication that ICAO documents could become the international agreement on certain operational matters is present. ICAO policy supports this idea for these Regulations which relate purely to operational practices.
- Maintain Article 35 except for any consequential amendment.
- Maintain Article 43 without change.
- Maintain the order of priority in Article 44 for Categories 1 to 6 aligned with that in Annex 10.
- Maintain other parts of Chapter VIII without change until the studies under Resolution 713 (WRC-95) are completed and discussed.

Annex 10, Volume II, contains the order of priority of communications to be applied in the Aeronautical Mobile Service. (for voice communications). These priorities are aligned with the priorities as established by the ITU Radio Regulation in Article 44.

In addition, Annex 10 Volume III contains a mapping of ATN network priorities to the mobile sub-network priorities. Essentially, these priorities are also aligned with those of the Radio Regulations. Some of the (air-ground data link) systems incorporate a slightly different order of priorities while meeting the general requirements placed by the Radio Regulations.

Note: the order of priorities for the Aeronautical Mobile Service do not apply to the order of priorities in the Aeronautical Fixed Service (AFTN, ATN)

7-III.3.9 Chapter IX (Articles 46 to 58) — Maritime services

7-III.3.9.1 Articles 46 to 58 provide the regulatory framework for maritime services in a similar way to that in Chapter VIII for the aeronautical services.

7-III.3.9.2 Aeronautical services receive mention at isolated places within Chapter IX. The most important are identified below.

Article 51: Conditions to be observed in the maritime services

The provisions in Section III — *Stations on board aircraft communicating with stations of the maritime mobile service and the maritime mobile-satellite service* relate only to the situation where the frequencies used are those allocated to maritime services.

ICAO POLICY ON CHAPTER IX:

Maintain the aeronautical provisions in this chapter without change.

7-III.4 APPENDICES TO THE RADIO REGULATIONS

7-III.4.1 Comments on Appendices of special significance to aeronautical services are given below.

7-III.4.2 Appendix 12. Section I — Aeronautical radiobeacons

The material in this Appendix defines the protection requirements for aeronautical radiobeacons (non-directional beacons and locators). It achieves full Radio Regulation status through RR 28.24. (Prior to the VGE Report, the Appendix 12 provisions were contained within the main body of the Regulations.)

ICAO POLICY ON APPENDIX 12:

No changes should be made to the provisions for aeronautical radio beacons in this Appendix.

7-III.4.3 Appendix 13. Distress and safety communications (non-GMDSS) (suppressed at WRC-07; see Chapter VII of the Radio Regulations)

7-III.4.4 Appendix 16. Documents with which stations on board ships and aircraft shall be provided

Appendix 16 was amended at WRC-07 to align its provisions with those of Chapter VII of the Radio Regulations. The section addressing documents with which stations on board aircraft need to be provided was amended as follows:

Section IV — Stations on board aircraft

These stations shall be provided with:

1. the documents mentioned in items 1 and 2 of Section I;

2. a log, unless administrations have adopted other arrangements for recording all information which the log should contain;

3. those published documents, in either printed or electronic formats, containing official information relating to stations which the aircraft station may use for the execution of its service.

The documents referenced in paragraph 1 are:

— the radio station license (which is prescribed by Article 18 of the Radio Regulations)

— the certificates of the operator. These are normally included in the pilot license.

ICAO POLICY ON APPENDIX 16:

Retain without change.

7-III.4.5 Appendix 27. Frequency Allotment Plan for the AM(R)S and related information

7-III.4.5.1 Appendix 27 was agreed to at the World Administrative Radio Conference (WARC) for the Aeronautical Mobile (R) Service in 1978 when the use of the HF spectrum was converted from double sideband (DSB) to single sideband (SSB). The main technical provisions have been reproduced in Annex 10, Volume III, Part II, Chapter 2, 2.4. Appendix 27 is notable as the single case where aeronautical frequency planning is carried out in the ITU. The registration of HF frequencies in the Master International Frequency Register is necessary. There is no established amendment procedure for Appendix 27, although it is recognized in provision 27/20, that frequencies not in conformity with the Allotment Plan may be selected and registered by ITU provided that they do not reduce the protection to the frequency allotments in the Plan..

7-III.4.5.2 Some frequency management aspects of importance are covered in Annex 10, Volume V, Chapter 3.

7-III.4.5.3 Of notable importance are the allotments made for aeronautical operational control (see Annex 10, Volume V, Chapter 3, 3.1.3) and the terms of No. 27/217 authorizing their use for this purpose. The full text of this important provision is at Section 7-II of this handbook under the band 2 850–22 000 kHz.

7-III.4.5.4 Appendix 27 is notable also for the recognition given to ICAO for its coordinating role in the operational use of radio frequencies (see No. 27/19 of the above-mentioned reference). In this context it has been clarified, however, that the registration of assignments in the Master International Frequency Register as a requirement covered by the Radio Regulations is effected through ITU member administrations (national telecommunication administrations). Due to these provisions, ICAO cannot play any role in the registration of Appendix 27 frequencies.

ICAO POLICY ON APPENDIX 27:

- Appendix 27 may only be amended by an ITU aeronautical conference or by an agenda item for a WRC to which aeronautical expertise is specifically invited. The present Allotment Plan is becoming incapable of meeting requirements, which appear to exceed the possibilities under provision 27/20.
- ICAO supports any action which could lead to an increase of the frequency bands for use by the aeronautical mobile (route) service (AM(R)S) in the bands between 2 850 and 22 000 kHz.

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SECTION 7-IV. REVIEW OF ITU RESOLUTIONS AND RECOMMENDATIONS

A standard item in the agenda of all WRCs is the review of past Resolutions and Recommendations and decision as to their continuing applicability. The review is normally made in the closing stages of WRC action and account is taken of the conference decisions and the new Resolutions and Recommendations agreed at the conference.

During its WRC preparation, ICAO reviews in accordance with ITU Resolution 95 (WRC-03) Resolutions and Recommendations of previous ITU conferences. The results are contained in Attachment F of this document.

Chapter 8

ICAO SPECTRUM STRATEGY and FUTURE SPECTRUM REQUIREMENTS

8.1 INTRODUCTION

8.1.1 Air transport plays a major role in social and economic development of communities, regions and the world. The demand for passenger and freight operations is expanding geographically and growing in response to markets and demographics. Studies conducted in North America, Europe and the Pacific areas predict very similar patterns of activity in the years ahead, with air traffic movements expected to increase at an average annual rate of 4.6 per cent up to the year 2025.

8.1.2 The ICAO spectrum strategy presented in section 8.2 below is based on the recognition that adequate and appropriate spectrum availability is essential to aviation safety and to support efficient aircraft operations. This fundamental principle has been the long-standing basis for ICAO policy in spectrum matters, as recognized in Assembly Resolution 36-25 and more recently in Recommendation 1/12 of the 12th Air Navigation Conference.

8.1.3 The ICAO spectrum strategy is consistent with the Fourth Edition of the *Global Air Navigation Plan* (GANP, ICAO Doc 9750) and in particular with the Technology Roadmaps contained in Appendix 3 to the Plan. Future developments of the plan will be taken into account as part of the strategy update process, as discussed in section 8.3 below, which addresses future systems and strategy evolution.

8.1.4 Section 8.4 below discusses a number of current and future challenges to civil aviation's use of the radiofrequency spectrum.

8.2. ICAO SPECTRUM STRATEGY

8.2.1 Introduction

8.2.1.1 The safety aspects on the use of radio frequency spectrum by aviation require spectrum to be available on an exclusive basis or, when shared with non-aeronautical radio services, with regulatory and technical conditions that recognize aeronautical safety requirements. The overall ICAO spectrum policy includes the ICAO spectrum strategy presented here and the ICAO policy statements contained in Chapter 7. Both the spectrum strategy and the policy statements are approved by the ICAO Council.

8.2.1.2 Implementation of the spectrum strategy will enable the advancement of technological developments and innovation to enhance safe and efficient global air transport. This is to be achieved through the development of ICAO SARPs as necessary.

8.2.1.3 The radio frequency spectrum capacity for aviation must be sufficient to meet the growing needs for aeronautical communication, navigation and surveillance systems, including any new systems that are being considered in ICAO to meet future CNS/ATM requirements. This is essential to adequately support changing trends air traffic management such as foreseen in the *Global Air Navigation Plan* (Doc 9750) and the ICAO Regional Plans.

8.2.1.4 Spectrum for aeronautical radiocommunication and radionavigation (including surveillance) is allocated by the International Telecommunication Union (ITU) with the recognition of the safety aspects identified above. The ICAO spectrum policy aims at ensuring that aeronautical spectrum capacity requirements are satisfied during the frequency allocation process, taking into consideration the trends in future air traffic management.

8.2.2 Basis for the ICAO spectrum strategy

8.2.2.1 The ICAO spectrum strategy in this chapter has been developed on the basis of current global and regional plans for implementing CNS systems in the period until about 2035. It identifies the spectrum necessary for each of the CNS elements and each relevant frequency band, including specific regional requirements which are part of the overall ICAO spectrum strategy.

8.2.2.2 It consists of a high-level ICAO spectrum strategy (section 8.2.3) and of a set of specific strategy statements for each frequency band (section 8.2.4). The high-level strategy is applicable to all frequency bands, and should be regarded as the basis for the band-by-band strategy statements, and for the relevant ICAO policy statements contained in Section 7-II.

8.2.2.3 In many cases, aeronautical radiocommunication, radiodetermination and radionavigation systems currently in use will continue to operate well beyond 2035, either on a global basis or in certain Regions. The strategy identifies requirements for the medium term as until and beyond 2035. Spectrum requirements identified for the long term indicate that such spectrum is expected to be necessary for an undetermined period, extending to well beyond 2035.

8.2.2.4 The strategy, including the time scale, will be updated on a regular basis taking into consideration developments in the use of current and new CNS systems, as reflected in the *Global Air Navigation Plan* (Doc 9750) Technology Roadmaps.

8.2.3 ICAO high-level spectrum strategy

ICAO HIGH-LEVEL SPECTRUM STRATEGY

- To secure the continuing availability of adequate radio frequency spectrum to support the current and planned aeronautical CNS infrastructure requirements as laid out in the Global Air Navigation Plan and in the Regional Air Navigation Plans
- To enable the advancement of technological innovation to maintain and enhance the safety of the global air transport system as well as increased efficiency in spectrum utilization
- To ensure that proposals for new or modified allocations must be supported by sharing studies on the use of frequency bands by aviation and take full account of the possible impact on the aeronautical safety case; these studies need to encompass the total technical, operational and economic aspects of aeronautical system use.
- To conduct ICAO studies on the compatibility of ICAO standard systems with other existing or planned ICAO standard systems.
- To support the ITU studies on the compatibility of ICAO standard systems with non-ICAO standard systems.
- To oppose proposals for new or modified allocations that place undue or unreasonable constraints on the continued use of current aeronautical CNS systems or affect the safety of aviation.
- To support efficient use of the frequency bands allocated to relevant aeronautical services by developing globally harmonized terrestrial-system frequency assignment planning criteria and a global frequency assignment plan in support of the ICAO Global Air Navigation Plan, while recognizing that the actual use of spectrum by aviation may vary between different Regions where different system requirements and corresponding spectrum requirements exist.
- To ensure that aeronautical CNS systems which provide safety-of-life services to aviation operate in frequency bands that are properly allocated for use by aviation, with the objective of operating in spectrum allocated to an appropriate aeronautical safety service, and suitably protected from harmful interference that can be caused by other systems using the same or nearby frequency bands.

8.2.4 – ICAO specific band-by-band spectrum strategy for the frequency bands used by civil aviation

ICAO spectrum strategy for aeronautical communication systems (Reference: ICAO Doc 9750, Appendix 3, Roadmaps 1 and 2)			
Frequency band	Aeronautical use	Time scale	ICAO spectrum strategy
2850 – 22000 kHz	HF air/ground communications (voice and data)	Long term	Secure the continuing availability of the HF frequency bands 2850 – 22000 kHz which are allocated to aeronautical mobile (R) service for use by air/ground communications on a global basis. *Note: until such time when mobile satellite systems can provide efficient and cost-effective communication services in spectrum that is appropriately allocated for use by aviation, the HF frequency bands will continue to provide the primary means for long distance communications for aviation.*
108 – 117.975 MHz	GBAS; VDL Mode 4	Long term	Secure the continuing availability of the frequency band 112 – 117.975 MHz (108 – 117.975 for GBAS) which is allocated to the aeronautical mobile (R) service for use by GBAS and VDL Mode 4 on a global basis. Consider, subject to spectrum availability and spectrum requirements, the use of this band to accommodate VHF air/ground communication systems
117.975 – 137 MHz	VHF air/ground; voice, VDL Mode 2 and	Long term	Secure the continuing availability of the frequency band 117.975 – 137 MHz, which is allocated to the aeronautical mobile

ICAO spectrum strategy for aeronautical communication systems (Reference: ICAO Doc 9750, Appendix 3, Roadmaps 1 and 2)			
Frequency band	Aeronautical use	Time scale	ICAO spectrum strategy
	VDL Mode 4		(R) service, for use by VHF air/ground voice and data link on a global basis.
960 – 1164 MHz	Air/ground UAT LDACS 1090 ES	Long term	Support the implementation of new systems in the aeronautical mobile (R) service in the frequency band 960 – 1164 MHz (LDACS) Secure the continuing availability of the frequency band 960 – 1164 MHz which is allocated to the aeronautical mobile (R) service for use by air/ground and air/air data link systems, by ADS-B via 1090 Extended Squitter and UAT. Implementation of these data links must take place under the express condition that no interference is caused to the aeronautical radionavigation service operating in this frequency band (e.g. DME and SSR).
5000-5030 MHz 5091-5150 MHz 5030-5091 MHz	 AeroMACS UAS terrestrial and satellite C2/C3 communications	Long term	Secure the continuing availability of the frequency band 5091 – 5150 MHz which is allocated to the aeronautical mobile (R) service for use by airport communications (AeroMACS) on a global basis. *Note: While not in the ITU Radio Regulations, some States may on a National basis allocate the 5000-5030 MHz band to the AM(R)S for use by AeroMACS*

ICAO spectrum strategy for aeronautical communication systems (Reference: ICAO Doc 9750, Appendix 3, Roadmaps 1 and 2)			
Frequency band	Aeronautical use	Time scale	ICAO spectrum strategy
			Secure future implementation of the aeronautical mobile (R) service and the aeronautical mobile satellite (R) service in the frequency band 5030 – 5091 MHz to support air/ground communications for unmanned aircraft systems while satisfying the spectrum requirements for MLS.
1545-1555 MHz and 1646.5-1656.5 MHz	Air/ground satellite communications (Inmarsat, MTSAT)	Long term	Support retention of RR No. 5.357A in order to ensure sufficient access on a global basis by the aeronautical mobile satellite (R) service in the bands 1545 – 1555 MHz and 1646.5 – 1656.5 MHz to support the requirements for aeronautical satellite communications. *Note: In these frequency bands priority access should be provided for aeronautical satellite communications.* Ensure that any new or existing uses of these frequency bands will not cause harmful interference to the use of the bands by the aeronautical mobile satellite (R) service. *Note: in the United States in the bands 1555 – 1559 MHz and 1656.5 – 1660.5 MHz the aeronautical mobile satellite (R) service has*

ICAO spectrum strategy for aeronautical communication systems (Reference: ICAO Doc 9750, Appendix 3, Roadmaps 1 and 2)			
Frequency band	Aeronautical use	Time scale	ICAO spectrum strategy
			priority and immediate access over other mobile-satellite communications within a network.
1610-1626.5 MHz	Air/ground satellite communications (Iridium)	Long term	Support the continuing retention of the allocation to the aeronautical mobile satellite (R) service (E-s, s-E) in the frequency band 1610 – 1626.5 MHz *Note: this frequency band has been allocated to the aeronautical mobile satellite (R) service on a primary basis as per footnote 5.367 in the Radio Regulations.*
3400 – 4200 MHz	VSAT for aeronautical networks and AMS(R)S feeder links	Long term	Support the continuing retention of the allocation to the FSS and adequate protection from other co band and adjacent band services

ICAO spectrum strategy for aeronautical navigation systems (Reference: ICAO Doc 9750, Appendix 3, Roadmap 5)			
Frequency band	Aeronautical use	Time scale	ICAO spectrum strategy
130-535 kHz	NDB	Global: medium term Regional: long term	Secure the continuing availability of the frequency band 130 – 535 kHz parts of which are allocated to the aeronautical radionavigation service on a global basis for use by NDB systems for at least the medium term and, in the long term, on a Regional basis. *Note: long term use may be required to support national requirements.*
74.8-75.2 MHz	Marker beacon	Long term	Secure the continuing availability of the frequency band 74.8 – 75.2 MHz which is allocated to the aeronautical radionavigation service for use by Marker Beacons on a global basis.
108-112 MHz	ILS - Localizer		Secure the continuing availability of the frequency band 108 – 117.975 MHz which is allocated to the aeronautical radionavigation service for use by ILS-Localizer on a global basis.
328.6-335.4 MHz	Glide Path		Secure the continuing availability of the frequency band 328.6 – 335.4 MHz which is allocated to the aeronautical radionavigation service for use by ILS – Glide Path on a global basis.
108-117.975 MHz	VOR	Long term	Secure the continuing availability of the frequency band 108 – 117.975 MHz which is allocated to the aeronautical radionavigation service for use by VOR on a global basis.
960-1215 MHz	DME	Long term	Secure the continuing availability of the frequency band 960 – 1215 MHz, which is allocated to the aeronautical radionavigation

ICAO spectrum strategy for aeronautical navigation systems (Reference: ICAO Doc 9750, Appendix 3, Roadmap 5)			
Frequency band	Aeronautical use	Time scale	ICAO spectrum strategy
			service, for use by DME on a global basis term
1559-1610 MHz	---	---	This band is primarily used to support GNSS systems This band is also allocated to the aeronautical radionavigation service. No strategy has been developed for the future use of this band by the aeronautical radionavigation service.
5030-5091 MHz	MLS	Long term	Secure for the continuing availability of the frequency band 5030 – 5091 MHz which is allocated to the aeronautical radionavigation service for use by the Microwave Landing System (MLS) on a global basis to meet the spectrum requirements for the MLS. Assess, on a Regional basis, requirements for the long term implementation of MLS to establish the spectrum requirements for MLS

ICAO spectrum strategy for Global Navigation Satellite Systems (Reference: ICAO Doc 9750, Appendix 3, Roadmap 5)			
Frequency band	Aeronautical use	Time scale	ICAO spectrum strategy
1164-1215 MHz	GNSS	Long term	Secure the continuing availability of the frequency band 1164 – 1215 MHz which is also allocated to the radionavigation satellite service for use by GNSS systems on a global basis, taking into consideration the radio regulatory conditions for using this band.
1559-1610 MHz	GNSS	Long term	Secure the continuing availability of the frequency band 1559 – 1610 MHz which is allocated to the aeronautical radionavigation and the radionavigation satellite services for use by aeronautical GNSS systems, including augmentation systems, on a global basis. Secure deletion of the fixed service from the frequency band 1559 – 1610 MHz and cessation of operation of any station in the fixed service in this band by 1 January 2015. Support the development of regulatory measures to enforce prevention and removal of occurrences of in-band and out-of-band interference

ICAO spectrum strategy for aeronautical surveillance systems (Reference: ICAO Doc 9750, Appendix 3, Roadmaps 3 and 4)			
Frequency band	Aeronautical use	Time scale	ICAO spectrum strategy
1030 MHz and 1090 MHz	SSR	Long term	Secure the continuing availability of the frequency band 960 – 1215 MHz, which is allocated to the aeronautical radionavigation service, for use by SSR on a global basis.
1215-1350 MHz	Primary surveillance radar	Long term	Secure the continuing availability of the frequency band 1215 – 1350 MHz which is allocated to the radionavigation and aeronautical radionavigation service for use by Primary Surveillance Radar on a global basis.
2700-2900 MHz	Primary surveillance radar	Long term	Secure continuing availability of the frequency band 2700 – 2900 MHz which is allocated to the aeronautical radionavigation service for use by primary surveillance radar on a global basis Where in adjacent frequency bands mobile systems are in use (e.g. WIMAX and LTE), secure protection of radar stations from harmful interference from mobile systems operating in adjacent bands
9000-9200 MHz	Primary surveillance radar	Long term	Secure the continuing availability of the frequency band 9000 – 9200 MHz which is allocated to the aeronautical radionavigation service for use by ground based radar systems on a global basis
9300-9500 MHz	Primary surveillance radar	Long term	Secure the continuing availability of the frequency band 9300 – 9500 MHz which is allocated to the aeronautical radionavigation service for use by airborne weather radar and ground based radar on a global basis.
15.4-15.7	Primary	Long	Secure for the continuing availability of the

ICAO spectrum strategy for aeronautical surveillance systems (Reference: ICAO Doc 9750, Appendix 3, Roadmaps 3 and 4)			
Frequency band	Aeronautical use	Time scale	ICAO spectrum strategy
	surveillance radar	term	frequency band 15.4 – 15.7 GHz which is allocated to the aeronautical radionavigation service for use by ground based radar systems on a global basis
31.8-33.4 GHz	Primary surveillance radar	Long term	Secure the continuing availability of the frequency band 31.8 – 33.4 GHz which is allocated to the radionavigation service and used by primary surveillance radar to support airport surveillance detection equipment (ASDE radar) on a global basis

ICAO spectrum strategy for aeronautical airborne (stand-alone) [radar] systems			
Frequency band	Aeronautical use	Time scale	ICAO spectrum strategy
4200-4400 MHz	Radio altimeter	Long term	Secure the continuing availability of the frequency band 4200 – 4400 MHz which is allocated to the aeronautical radionavigation service for use by airborne radio altimeters on a global basis.
5350-5470 MHz	Airborne weather radar	Long term	Secure the continuing availability of the frequency band 5350 – 5470 MHz which is allocated to the aeronautical radionavigation service for use by airborne weather radar on a global basis.
8750-8850 MHz	Airborne Doppler and ground mapping radar	Long term	Secure the continuing availability of the frequency band 8750 – 8850 MHz which is allocated to the aeronautical radionavigation service for use by airborne Doppler radar and ground mapping radar on a global basis.
9300-9500 MHz	Airborne weather radar	Long term	Secure the continuing availability of the frequency band 9300 – 9500 MHz which is allocated to the aeronautical radionavigation service for use by airborne weather radar and ground based radar on a global basis.
13.25-13.4 GHz	Airborne Doppler and ground mapping radar	Long term	Secure the continuing availability of the frequency band 13.25 – 13.4 GHz which is allocated to the aeronautical radionavigation service for use by airborne Doppler radar and ground mapping radar on a global basis.

8.3 FUTURE SYSTEMS AND STRATEGY EVOLUTION

8.3.1 Growth in air traffic requires new ways of planning and enhanced ground, airborne, and satellite infrastructure in order to reduce ATM costs, maintain safety, reduce the environmental impact of each flight, and enhance the passenger experience. A process of international discussion and agreement, normally involving a minimum of five years for operational and technical finalization of system parameters followed by an adoption process taking several additional years (as prescribed in the ICAO Convention), is necessary to ensure that any new systems introduced as part of the infrastructure evolution are appropriate and safe. Other aeronautical systems not requiring international agreement to this degree can often be developed and implemented in a shorter timescale, but still require a minimum of several years to reach maturity and acceptance. In all these cases, the actual implementation of these systems requires additional time for implementation (e.g. Regional agreement) in aircraft and on the ground, and a positive business case justifying the commitment of adequate financial resources.

8.3.2 In general, the standardization and the introduction of new systems will have to be consistent with the framework laid out in the *Global Air Navigation Plan* (Doc 9750), and may require updates to one or more of the Technology Roadmaps included in the Plan. This, in turn, may translate into updates to specific elements of the ICAO band-by-band spectrum strategy.

8.3.3 The impact on the ICAO spectrum strategy of the introduction of a new system will depend, *inter alia*, on which of the three following general categories the system falls into with respect to its spectrum requirements:

a) aviation systems that can be accommodated in existing allocations, with necessary footnote modifications, or less commonly, with modification to the allocation status or description;

b) aviation systems that require additional spectrum allocations for reasons of compatibility or frequency availability; and

c) other systems with multi-service application capability whose aviation requirements can be integrated with the other applications, entailing changes to allocation, modification of band limits or footnotes, or less commonly, a completely new allocation.

8.3.4 In any case, the allocation of spectrum for new services and systems in frequency bands already allocated for aeronautical use will have to be consistent with the high level ICAO spectrum strategy and will need to take place within the framework set by the relevant ICAO Standards and Recommended Practices

(SARPs) for communication, navigation and surveillance systems, as well as other (industry) Standards that apply to current operational systems.

Note: Requirements for spectrum for meteorological radar and meteorological satellite systems are addressed by the World Meteorological Organization (WMO). However, specific requirements for airborne weather radar systems are included in the ICAO spectrum policy.

8.4 CHALLENGES

8.4.1 For many years aeronautical radio frequency spectrum has been targeted for use by non-aeronautical services, in particular to satisfy requirements for mobile (terrestrial) and mobile satellite communications. This has for example, led to the loss of spectrum that was once allocated exclusively for aeronautical mobile satellite communications (1.5 / 1.6 GHz) and to the introduction of non-aeronautical services in bands previously allocated for aeronautical use on an exclusive basis (e.g. the fixed satellite service in the frequency band 5091 – 5250 MHz, the non-safety aeronautical mobile service for telemetry in the frequency band 5091 – 5150 MHz and the radionavigation satellite service in the frequency band 5000 – 5030 MHz). This has created the potential of interference and / or loss of spectrum capacity to satisfy current and future aeronautical requirements for CNS system.

8.4.2 There is currently pressure to release significant amounts of spectrum to support future commercial mobile communications and broadband wireless applications. Between 500 and 1200 MHz of bandwidth is being sought, mainly in the range from 300 MHz to 6 GHz. This range includes frequency bands used by a large number of safety critical aeronautical systems, including Instrument Landing System (ILS) glide-path, Distance Measuring System (DME), Primary and Secondary Radar, Airborne Collision Avoidance System (TCAS), AMS(R)S, VSAT aeronautical networks and Radio Altimeters.

8.4.4 Another new element that may affect the future availability of radio frequency spectrum for aviation is the possible introduction of "Spectrum Pricing" which may have a significant economic impact on the aviation industry as a whole.

8.4.5 The ICAO spectrum strategy recognizes the challenges outlined above and provides the framework within which ICAO develops the international civil aviation ICAO Position on issues of interest to international civil aviation to be decided at ITU World Radiocommunication Conferences, which are the fora where these challenges typically face aviation.

Chapter 9

INTERFERENCE PROTECTION CONSIDERATIONS

9.1 INTRODUCTION

The regulation and control of interference is essential to the safe and efficient operation of aeronautical radio services. An agreed framework of rules and preventative measures is thus an essential requirement. This framework is laid down in the Radio Regulations for observance by ITU members when cross-border cases of interference arise. National legislation then provides each State with the regulatory means to effect the discharge of the international obligation within its territory. This chapter describes the elements in this framework and contains the following specific sections:

— **9.2 Regulatory aspects**

— **9.3 Management and control of interference**

— **9.4 Assessment of protection for aeronautical radio services**

— **9.5 Some special cases (e.g. VSAT, ISM)**

— **9.6 General protection limits for aeronautical radio**

9.2 REGULATORY ASPECTS

The basic definitions of interference and harmful interference

9.2.1 The international framework of agreements for dealing with interference to radio services is contained in the ITU Radio Regulations. The provisions in these Regulations govern the circumstances and the procedures for seeking clearance action from other ITU administrations when interference occurs. The basic qualification for claiming protection is "conformity with the Radio Regulations" which implies that the radio service which is being interfered with is operating in an agreed frequency band and with characteristics which are specified in the Regulations, including its Appendices.

9.2.2 The basic definition for interference in the Radio Regulations is:

1.166 *Interference*

The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy.

9.2.3 It is to be noted that interference is defined by the way in which the interfered system operation is affected. Thus, any performance degradation, misinterpretation or loss of information which would not occur in its absence constitutes interference. The definition does not imply that it is measurable in a quantitative sense, although it may well be in certain instances, but that there has been an adverse change of some detectable character. The change may be detectable by primary means, either aurally (voice signals) or visually (radar or TV), or by measurement (loss of data, inaccurate information, etc.). In some cases, it may be easier or preferable to instrument and record, or use the changed condition to give warning or to apply corrective measures. It is assumed also that interference in the sense employed in the Radio Regulations arises in all cases from sources outside the receiving system itself.

9.2.4 This basic definition of interference as stated in the Radio Regulations makes no reference to whether it is acceptable, but merely to the condition of its existence and its recognition. It is in the category of interference classed as harmful interference that the concept of unacceptability appears as a qualification or condition. This is clearly stated in the Radio Regulations as follows:

1.169 *Harmful Interference*

Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with Radio Regulations (CS).

9.2.5 This regulation introduces the concept of unacceptability and defines criteria with which to make the decision. It is notable that the definition has two quite separate elements, one for radionavigation and safety services, and one for all other radio services. The former requires only proof of endangerment of the functioning, but the latter must demonstrate that a serious degradation or disruption has occurred which is at a higher level of disturbance. Again, as in the case of interference above, the means of assessment is not prescribed and could be either subjective or quantitative. It is important to observe that for interference to be considered harmful, it must be to a service that is operating in accordance with the Radio Regulations. In this respect, accordance with the Radio Regulations means the totality of the Radio Regulations, including the Appendices. A service which does not operate in accordance with the Radio Regulations cannot claim protection as a right under the Radio Regulations, although administrations may often respond positively to the best of their ability**.** It is to be noted that all aviation safety services are operating on frequencies according to allocations to the service concerned, either the aeronautical mobile (R) service, the aeronautical mobile satellite (R) service or the (aeronautical) radionavigation service, and to agreed characteristics, and are operating in accordance with the Radio Regulations, as normally specified in Annex 10. This framework recognizes that interference, in its general sense, is a condition whereby a parameter of a received signal is affected in some way but not necessarily to the extent of being damaging to the reception. The interfering service must cease the interference when it creates a situation in which the operator of the interfered service decides that the service cannot be used for its intended purpose. The action to be taken is to remove interference which can include the reduction of radiated power or closing of the transmitter.

The treatment of harmful interference

9.2.6 Harmful interference is the condition recognized throughout the Radio Regulations as establishing a case for complaint and for the removal of the sources causing the problem. Procedures, obligations and rules related to interference are given detailed attention in **Chapter IV** of the Radio Regulations. The reporting and clearance of harmful interference to a radio service is one of the rights established by a registration in the MIFR and is a right conferred in general terms in **RR 8.1** and **RR 8.3**. In international terms, it creates an obligation for the country operating the interfering service to take action. The Regulations do not, however, carry mandatory force, and negotiation is the only course of action to resolve difficulties.

9.2.7 Safety services, such as a radionavigation service or an aeronautical mobile (R) service, or in certain cases the aeronautical mobile-satellite (R) service, are safety services as defined in:

> **1.59** *Safety Service*
>
> Any radiocommunication service used permanently or temporarily for the safeguarding of human life and property.

9.2.8 Harmful interference to a safety service always requires urgent attention, and this is recognized by all ITU administrations. Safety services include not only the aeronautical services, but also maritime and land mobile services when the messages have safety-of-life content.

9.2.9 Of particular interest to aeronautical services in this context are the provisions mentioned at Section 7-III-3.4 of this handbook. Also, the permission to operate without an identification for the testing of navaids is to be noted as at **RR 15.16.** These measures provide a framework of regulatory actions which ensure that interference judged as harmful is cleared in an effective and expeditious manner.

Radiation and emission

9.2.10 The above terms are mentioned in the definition of interference, and it is important to understand their ITU interpretations in discussions on interference and its effects. Reference to **RR 1.137** indicates that "radiation" is the generic category for any radio wave energy that is propagated either deliberately or inadvertently. As a subset, **RR 1.138** states that "emission" is the case of radiation produced by a radio transmitting station and only by that source. Thus, radiation could either be the radio wave energy coming from a local oscillator in a receiver, or an instrument or machine used in medical or industrial purposes, while emission is exclusively the radio energy from a transmitting antenna.

Unwanted emissions

9.2.11 Generation of radio energy for RF transmission purposes generally includes signals other than those required for the efficient transmission and reception of the necessary information. When radiated, these have the potential to interfere. In the Radio Regulations, these unwanted emissions are defined as:

1.146 *Unwanted emissions*

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

The definitions of these two elements are given below.

> **1.145** *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*.
>
> **1.144** *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.*

9.2.12 The understanding of these definitions is completed by the definition of the term "necessary bandwidth":

> **1.152** *Necessary Bandwidth*
>
> For a given *class of emission*, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

9.2.13 With increased congestion in spectrum utilization, this set of interlinking Regulations has become a highly important starting point for dealing with interactions between adjacent services, between services sharing the same frequency band, and in any other situation of frequency use conflict. A depiction of these relationships is in Figure 9-1.

9.2.14 The Regulations in Appendix 3 specify a Table of Maximum Permitted Spurious Emission Power Levels. These refer to the power supplied to the antenna transmission line from the transmitter and are "never to be exceeded values". It is recognized that more stringent levels may be laid down by Conference agreement or by special agreement between administrations. For system performance reasons, ICAO SARPs often specify more stringent levels, in effect, meeting the spirit of the "special agreement" requirements of the Regulations.

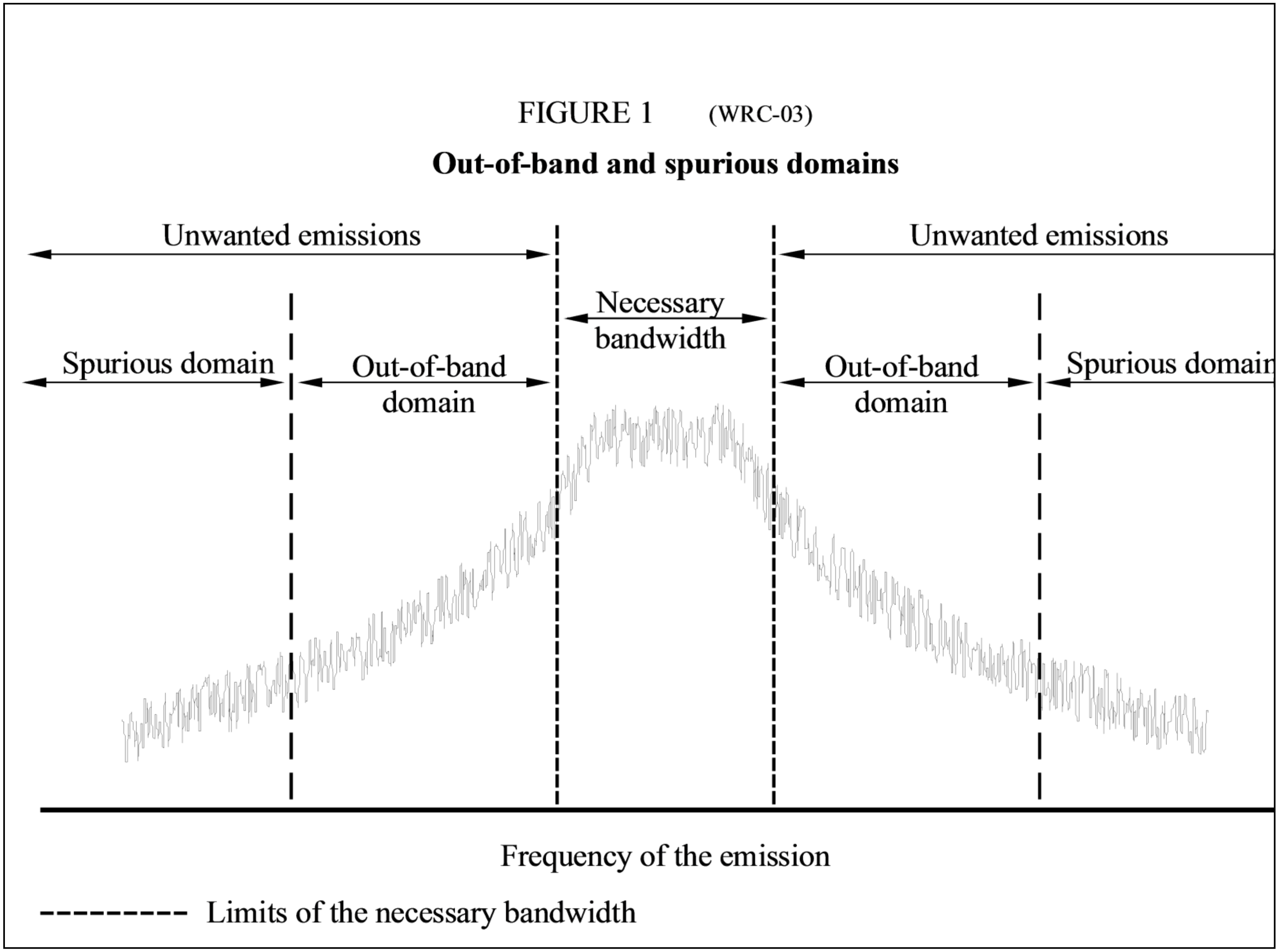

Figure 9-1. Unwanted emissions

Permissible interference and accepted interference

9.2.15 The Regulations specify these two further classes of interference:

> **1.167** *Permissible Interference**
>
> *Observed or predicted interference* which complies with quantitative *interference* and sharing criteria contained in these Regulations or in ITU-R Recommendations or in special agreements as provided for in these Regulations.
>
> **1.168** *Accepted Interference**
>
> *Interference at a higher level than that defined as permissible interference* and which has been agreed upon between two or more administrations without prejudice to other administrations.
>
> ***1.167.1 and 1.168.1** The terms "permissible interference" and "accepted interference" are used in the coordination of frequency assignments between administrations.

9.2.16 These definitions have been developed to provide a basis for planning, and they highlight the fact that frequency planning is essentially a process involving the control of interference.

9.2.17 This concept of acceptability, based on quantitative criteria, can only be a conditional one since it cannot negate the freedom to state a complaint of harmful interference by a service suffering harmful interference. It would provide, nevertheless, a basis for review and adjustment of the criteria as a condition for the agreement to continue. In such a situation, it would be assumed that an aeronautical safety service would be permitted to continue to operate, with the prime obligation being on the interfering service to adjust, close down or take other immediate action to resolve the situation.

Frequency sharing

9.2.18 Assignment planning within a service is the most notable example of the concept of permissible interference and is the application of an agreed protection criterion to ensure that the strength of the unwanted signal from a like facility, or a similar facility in the same service (e.g. voice and data in the VHF communications band), is the agreed number of decibels below that of the wanted signal. In these cases, the acceptable performance change is normally minimal and quite often is a change in the noise floor or the received signal-to-noise ratio. This is highly important for systems such as VOR or ILS, or navigation systems in general, where the changes to the received signal are not easily detectable by the user. All of these quantitative criteria for in-service planning are developed by ICAO for harmonized worldwide application.

9.2.19 Frequency sharing has recently developed a new context with the addition of services other than aeronautical services to previously exclusive aeronautical bands. The criteria for acceptability in these cases are normally developed by the Study Groups of ITU-R and embodied in their recommendations. Bands where this procedure has already been applied are the aeronautical radionavigation bands at 5 000–5 250 MHz, 9 000–9 500 MHz and 15.4–15.7 GHz. As the spectrum is increasingly exploited and greater demands appear for further uses, the principle of sharing of allocations between two compatible services is likely to become more extensively relied on. In such discussions, the aviation service justifies its protection requirements. Final decisions are made at ITU conferences, sometimes against the best advice from the aviation community.

9.2.20 Sharing an allocation between two services normally places constraints on any future expansion and implementation of both services. This can ultimately be detrimental to aeronautical services whose expansion rate is slower than other, more commercially-based services, in effect resulting in a first-come, first-served situation. As mentioned above, the application of sharing criteria, whether covered by an ITU-R Recommendation or not, cannot negate the right to claim protection from harmful interference. Where the service interfered with has safety-of-life functions, harmful interference would normally require immediate termination or reduction of power of the interfering service until a permanent resolution has been found.

Multiple interference inputs

9.2.21 Assessments of interference effects and of acceptable levels tend to be conducted in isolation from one another. In any given practical situation, the net effect of many potentially interfering sources must be considered and due allowance made. An extra margin of between 3 dB is recommended in general, with higher values in particular cases where a number of interference sources are known to exist (for example, see ITU-R Recommendation M.1343).

Aviation safety factor

9.2.22 Aeronautical safety applications are required to have continued operation through worst case interference, so all factors which contribute to harmful interference should be considered in analyses involving those applications. An aviation safety margin is included in order to address the risk that some such factors cannot be foreseen (for example impacts of differing modulation schemes). This margin is applied to the system protection criteria to increase the operational assurances to the required level. Traditionally for aviation systems/scenarios an aviation safety margin of 6-10 dB is applied. Until established on the basis of further study on a case-by-case basis, an aviation safety margin of not less than 6 dB should be applied.

Electromagnetic compatibility (EMC)

9.2.23 EMC is defined as the ability of a system to function satisfactorily in an electromagnetic environment without introducing intolerable electromagnetic disturbance to any other system in that environment.

9.2.24 Two elements, basically receiver rejection and transmitter unwanted emissions, are fundamental design parameters in the specification and engineering of radio systems to operate in their typical operating environment. They are normally addressed by national legislation, such as FCC Rules in the United States or ETSI Standards in Europe. In many countries, they are a prerequisite to the approval of any equipment that generates radio frequency energy as a main functional source. This includes not only communications and navigation equipment but also computing equipment, industrial equipment, etc. The limiting values chosen are normally selected on the basis of best judgment and on the practical and economic factors applying in particular systems.

9.2.25 A good example of the essential need for EMC is in the case of the multiple radio systems (and, more recently, the digital control systems) used on board aircraft. In a modern transport aircraft, these can amount to systems operating in about 18 different frequency bands, with typically 35 antennas. Great care in the placement of antennas and in the internal cabling, and severe limitation of both output power and spurious products are necessary to maintain all installed systems within performance limits. Provisions addressing this point may be found in the specifications for airborne equipment produced by RTCA/EUROCAE and ARINC.

Other important radio regulations

9.2.26 Article 15 of the Radio Regulations lays down procedures and priorities for the actions to be taken in identifying, reporting and clearing interference. This material should be referred to for the detailed rules governing the circumstances, scope for reporting, and actions to be taken. Important provisions in the Radio Regulations are summarized below.

RR 15.16: Provides, in the aeronautical radionavigation service, for the removal of identification signals when tests or adjustments are being carried out.

RR 15.36: When the service being interfered with is a safety service, provides for direct communication to the administration having jurisdiction over the transmitting station causing the interference.

RR 15.40: Where there is a specialized agency (such as ICAO), reports of interference may be copied to that agency coincident with notifying the administration responsible for the station causing the interference.

RRs 15.41 to 15.46: Describe the procedure for the reference of disputes to the Radiocommunication Bureau. It should be noted that the Bureau has no power of enforcement, and its actions are solely those of investigation, reporting and arbitration.

The registration of frequencies

9.2.27 The Master International Frequency Register (MIFR) is held at the headquarters of the ITU in Geneva and is the document in which administrations may register their national frequency use. Following a request to the Radiocommunication Bureau, which is charged with the recording process, the assignment will be checked against the requirements of the Radio Regulations, and if in compliance, the frequency is recorded with the date of request. Later requests must protect any assignment with an earlier date. If a request is not in accordance with the Regulations, an entry may still be made, provided it does not interfere with a registered service, but the assignment will enjoy no protection from later registrations meeting the requirements. This is the so-called "non-interference basis". In the Radio Regulations, the status of recorded assignments is defined in **Article 8,** and the notification procedure followed in the recording process is laid down in **Article 11.**

9.2.28 Recorded assignments are the highest category of assignment and must always be protected. However, administrations normally accept an interference complaint provided the service is operating in accordance with the Regulations.

9.2.29 Apart from frequencies used for NDB or HF communications, aviation assignments are not registered with ITU on a systematic basis, although administrations may do so if they wish. The ICAO coordination, or the bilateral coordination in some world areas, has traditionally been accepted as a quasi-registration process. In these cases, the ICAO Regional Air Navigation Plan assumes the same role as the MIFR.

Summary of regulatory processes

9.2.30 The protection of aeronautical radio services is an end-to-end process, covered at all points by agreed technical protection criteria and by regulatory provisions, all of which are embodied in ITU Regulations, ITU-R Recommendations and aviation documents. Considerable attention is given in these to the needs of safety services, of which aeronautical services are examples. Exercise of the regulatory functions is the responsibility of national telecommunication administrations which have the necessary powers to license equipment which conforms to agreed specifications and to take action within their own jurisdiction, and with other administrations, to clear harmful interference. Important elements in these processes are:

— the existence of national and international agreements on safe planning criteria and practices;

— agreed mandatory equipment specifications which embody the necessary control of unwanted emissions and radiations;

— an assignment planning process which is safely applied and which is coordinated to the extent necessary with other services and administrations;

— the efficient and effective monitoring and reporting of interference;

— immediate attention to clearing cases of harmful interference to aeronautical radio services.

9.3 MANAGEMENT AND CONTROL OF INTERFERENCE

9.3.1 Interference of all kinds is an ever-present feature of all radio frequency bands, arising from the transmissions from a multiplicity of different radio services, increasing in quantity and in power almost daily. The higher power services, such as broadcasting, radar and some specialized defense systems, have a potential to cause considerable disruption and must be carefully controlled. In addition to radio services, there are many other sources of interfering radio energy, such as industrial and medical machinery, motor vehicles, power transmission lines and many other electrical and electronic sources. Over cities and industrial areas particularly, the ambient radio noise can attain quite high levels making the detection of weak signals difficult, and on occasion impossible, affecting in particular the reception of radio in aircraft.

9.3.2 The management and control of the interference present in the radio environment is a highly important supplementary activity to that of the management of the radio spectrum itself. As with spectrum management, the overall process is a layered activity with international agreement on fundamentals in the upper layer, followed by national legislation and enforcing machinery. Good management and minimization of harmful products also increases the effective utilization of frequencies.

9.3.3 The basic elements in the process are:

International agreement on the regulatory basis. The elements of the basic regulatory framework are contained in the Radio Regulations and have been described above. These define a set of principles and actions which are designed to provide administrations with agreed understandings for use with other administrations and internally within their own countries. This activity is international in character and is centered on the ITU in the first instance. ITU Regulations are treaty obligations and in respect of interference clearance are conscientiously followed. Where normal negotiation fails to resolve an issue, there is scope for reference of problems to the ITU Radio Regulations Board. However this is not a compulsory arbitration procedure, and in the unlikely event that this fails, the service suffering the interference may have to take independent action.

System and equipment standards. Development of standards and specifications for systems and equipment is the second step in the process. The standards and specifications must contain essential performance requirements relating to the maximum permitted levels of unwanted emissions. Internationally developed standards, such as those in aviation agreed by ICAO and RTCA or in ITU-R Recommendations, and in Europe those of Eureka and ETSI, have to incorporate clauses addressing these aspects. The Spurious Emission Limits at Appendix 3 of the Radio Regulations are "never to be exceeded" limits and negotiations are often necessary to analyze individual situations and specify levels below those in the Regulations. Most Annex 10 SARPs for adjacent channel frequency planning specify levels that are lower than those in Appendix 3. A recent example of individual negotiation may be found in the case of mobile-satellite equipment operating in bands adjacent to that of GNSS with the potential to interfere with approach and landing of aircraft. In this case, it was necessary to have agreement in both ITU-R and ETSI.

Licensing of radio services. Within national territory, legislation is necessary to provide the enforcement powers to manage and control the processes at the operating level. National telecommunication authorities hold this responsibility for the licensing of all radio services within their jurisdiction. In this process, the authority must ensure that the radio system is approved to agreed standards, that its EMC performance is adequate, and that it operates with characteristics which are in accordance with international agreements. The national telecommunication authority remains the regulating body for its operation in regard to interference with other radio services. The most important international obligation is to the Radio Regulations and ITU-R Recommendations; others may be regional standards such as those developed in Europe by ETSI. In the case of radio for civil aviation safety purposes, both ground and airborne, other requirements may be applied emanating from ICAO SARPs, RTCA and EUROCAE specifications, and for airworthiness purposes, the TSO laid down by the FAA in the United States and the JAA in Europe.

Control and clearance of interference. As with radio licensing, the responsibility for control and clearance of interference will normally rests with the national telecommunication authority under the same national legislation which addresses the detecting, the resolving and, if necessary, the closing down of sources of interference. This will include, in addition to radio stations, licensed or unlicensed, any equipment or system capable of radiating and causing interference. Many industrial, scientific, computer and line transmission systems have the potential for interference. If the service is a safety service, action must be taken on an urgent basis. Identification of an interference source is a difficult and often time-consuming activity. Some aviation authorities have found it beneficial in effecting a speedy clearance to assist the national telecommunication organization by local detection actions in which local knowledge is used to good advantage.

9.4 ASSESSMENT OF PROTECTION FOR AERONAUTICAL RADIO SERVICES

The nature of interference and its detection

9.4.1 Interference may not result in a change in the receiver output signal. Particular care is necessary with systems in which the output is neither aural nor visual, such as digital systems or systems where the output is used to operate control systems, where interference may not be detected for some time. The task of assessing the threat posed by other signals so as to make a decision of acceptability, for example in allocation sharing, must however have a basis which is logical and amenable to analysis.

9.4.2 For the assessment of compatible sharing with other radio services (a situation becoming more common), or where the threat is unwanted emissions from a known non-aviation system, a quantitative criterion has to be stated and used as a reference for decision making. For this purpose, a maximum interference threshold limit is normally chosen which has been selected on the basis of acceptable degradation, taking into account all other environmental conditions. In the absence of other data, the usual planning ratio for wanted-to-unwanted signals within the aviation service should be enhanced to give a margin for uncertainties which cannot be quantified (see paragraph 9.2.22).

9.4.3 At higher frequencies in the GHz ranges, and for wide-band low signal services, the criterion often used is the acceptable increase in the noise floor, or the noise temperature, of the receiving system. Antenna gains or losses are included to replicate real-life conditions. The final approach and landing phase is accepted as being the most important of the safety-critical services. The model described below is recommended for this analysis.

The concept of a generalized assessment method

9.4.4 Many interference predictions have to be assessed on the basis of theoretical analysis. An agreed standard model and methodology is used as a basis for comparing the results of separate analysis and in formulating a conclusion on acceptability. The need to predict interference will arise in many different situations and, particularly, in the case where a decision on acceptable sharing of an allocation by two services is the issue. Real-life conditions are not accurately predictable, and theoretical analysis will invariably have to be verified under actual operational conditions before full acceptance is given to any proposal for sharing.

9.4.5 The effects of interference and the particular form of the signal degradation that it causes are usually dependent on the characteristics of the interfering signal. Pulsed and continuous-type signals often produce different results, with one or the other having more objectionable effects, or with more invasion of the demodulating process. Whenever data relating to the effects of specific modulations are available, these should be used to provide near realistic analysis of the interference situation. Tests and experiments should carefully replicate the actual interference situation as closely as possible, and quantitative analysis should clearly indicate the relevance of the criteria to the case in question.

Variables

9.4.6 In the minimization of the effects of interference there are four main areas on which to concentrate efforts to make improvements:

The source of the interfering signals. Control of the source is often the only practical means of protecting aviation radio services. This can take many forms depending on the nature of the potentially interfering signal. For radio transmitters, close control of unwanted emissions is essential, and the use of only necessary transmitting power to meet the requirements stated in **RR 15.2** is also a discipline for operators of stations. Control at source is dependent on effective measures at a national licensing level, and these measures themselves should be aligned with standards agreed internationally, either globally or regionally.

A particular example is that of industrial, scientific and medical (ISM) equipment which use the heating effect of radio wave energy, are potential sources of interference, and are required to operate only in designated bands and exercise control and monitoring in accordance with **RR 15.13** (see 9.5 below).

Another recent example is that of mobile satellite terminals operating in bands close to GNSS services, for which ITU-R and ETSI standards have been developed.

Frequency separation. Where the interfering source operates on a discrete frequency, the provision of a frequency separation, or guard band, between the source and the receiver may be employed to provide the requisite protection. In using this, account can be taken of the receiver's rejection response to reduce the overall effect.

Distance separation between the interference source and the aviation receiver. Distance separation to reduce the energy of the potentially interfering signal to an acceptable level is a standard method of establishing the protection necessary in many practical applications. It is the method normally employed in assignment planning, for which purpose agreed protection and propagation path criteria are used in the calculation. In coordination between two services, a limiting value of separation, based on worst-case evaluation beyond which no coordination is required, is often employed. Another notable example is the analysis of final approach situations where a typical minimum separation distance between source and receiver may be chosen and used in calculations to establish the acceptability of proposed maximum spurious levels. (An ITU-R standard model for approach and landing has been developed.)

The aviation receiver. Receivers having a good interference rejection performance are now, in an ever-increasingly crowded spectrum, an essential requirement. No service user can claim protection until the receiving equipment employed in that service has been designed and built with full regard to this requirement. The Radio Regulations in RR **3.3** make mention of this obligation to take all measures which are economically and technically justifiable to minimize the effects of transmissions, particularly in adjacent bands, and RRs **3.12** and **3.13** require that radio receivers should have adequate performance to minimize the effects of signals outside the occupied bandwidth. The principle applied is based on the joint responsibility of both the service that is vulnerable and the potential interferer to share equally the burden of compatibility. Where the affected service is a safety service, such as aeronautical radionavigation or communications, the same general considerations apply, and receivers are expected to be resistant to expected interferences. An example of this is the case of VOR and ILS receivers operating adjacent to FM broadcasting.

9.4.7 Consideration of the above four elements leads to the concept of a “standard model” for use as a tool in theoretical assessments. This is described below.

The standard model

9.4.8 The source-path-receiver model is a three-element simulation of actual conditions that is commonly used for assessing on a quantitative basis the acceptability of specific limits on the production of interfering products. The analysis may be a single evaluation or an iterative simulation depending on the data and facilities available. The model is deterministic in its application to the analysis of aeronautical radio services protection. That is, the receiver susceptibility mask, the antenna losses or gains, and the propagation path and its variabilities are all considered at their worst-case limits. From these considerations the ideal radio frequency interference (RFI) source mask may be estimated and tested for practical realism. A process of adjustment of the variables, particularly distance separation, would follow to arrive at agreed standards, which if necessary may then be embodied in regulatory material.

9.4.9 Important points in the analysis are:

Service volume. The aeronautical protection point and the service volume chosen must take account of agreed and specified service volumes as stated in the ICAO Annexes or in other defining documentation. Normally this would be the nearest service volume extremity to the interfering source. This is the case where the source is outside the service volume. Where the source is close to the receiver, such as during a landing operation, a carefully prepared scenario should be used. That recommended in ITU-R Recommendation M.1343 has been prepared by ICAO Panels and may be used in many cases.

Receiver susceptibility. The receiver criterion for acceptable degradation has to be carefully chosen. It must relate as appropriate to a detected change in a measurable parameter, or in perceived aural or visual reference, or in increase in error rate or other relevant characteristic, depending on the form and content of the receiver output. The receiver must under all conditions, with and without normal signal input, operate within its standard performance envelope, including measurement error limits, taking account also of the real-life environment and other known interfering sources, in arriving at the limits for receiver susceptibility. Unacceptable change to the noise floor may be used as the datum for systems in the higher frequency bands, for example in assessing interference to radar.

Propagation data. The best available propagation data, usually that documented in CCIR and ITU-R Reports, should be used. Account must be taken of the variability which applies to all propagation modes, and particularly where the separation distances are at the limits, near or beyond the radio horizon, or where seasonal phenomena, such as night effect at LF/MF, ducting at VHF, or ionosphere conditions at HF, exist. Natural features or shielding, such as that provided by terrain or by the aircraft body, may be included if they are permanent features present in all cases of interest. In many cases, free space attenuation may be used as the reference level in calculations, especially above 1 GHz and where the distance separation exceeds 20 km.

Installation conditions. Variables such as antenna system losses, antenna gain in particular directions, terrain shielding or, in the case of aircraft installations, the effects of the aircraft body, may be included as variations from standard scenarios to produce more refined results in particular cases. Similarly the interfering source conditions may be treated in the same way as a means to arrive at practical results.

The institutional processes for protection discussions and agreements

9.4.10 The ITU Radiocommunication Assembly adopts Recommendations dealing with all aspects of radio. This includes the interference aspects and sharing between services. Increasing congestion and sharing of two services on the same frequency has caused this activity to increase in intensity and depth. As spectrum congestion spreads, this activity is likely to increase further. Adjacent band services with a high differential in power levels, such as FM broadcast and mobile-satellite terminals are typical real-life problem areas encountered by aviation services. The strategic siting of services in the Table of Frequency Allocations to minimize adjacent band problems is no longer practicable because of the pressures to meet requirements wherever they can be fitted in.

9.4.11 ITU-R Recommendations, resulting from the work of Study Groups, are the normal means of documenting the conclusions and agreements on technical bases. While these are generally only voluntary in their application, they are nevertheless applied conscientiously by administrations and by industry. The exceptions are a few special category subjects — NDB signal levels is one — where a linking reference placed in the Radio Regulations gives a Recommendation the same treaty status as a Regulation.

9.4.12 ITU-R Study Groups 4 and 5 are the most important for aviation and deal with all mobile services, satellite and terrestrial, and with radionavigation of all kinds. WP5B and WP4C are the principal subcomponents.

9.5 SOME SPECIAL CASES

Industrial, scientific and medical (ISM) equipment

Definition and description

9.5.1 The definition for ISM applications appears at Radio Regulation 1.15 and is:

> **1.15** *Industrial, Scientific and Medical (ISM) applications* (of radio frequency energy): Operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of *telecommunications.*

9.5.2 This definition is intended to include a wide range of equipment in which the heating effect of RF energy is utilized to perform industrial and medical processes. High powers can be generated especially for such processes as metal hardening (e.g. car engine crankshafts), but the application area is local to the RF head. Measurement standards are often difficult to define, and this is particularly true in the case of large equipment assembled on site. Electromagnetic screening measures must be efficient in constraining the escape of energy and effective in maintaining that level of protection.

Radio Regulations

9.5.3 In the Radio Regulations, ISM does not fall within the definition of a radio service and is hence not subject to any of the provisions of the Regulations. Nevertheless, frequencies are designated for ISM use with the condition that radio services must accept interference if they are operated on the same frequencies. The text of the Regulation concerned is:

> **5.150** The following bands:
>
> **13 553–13 567 kHz (centre frequency 13 560 kHz),**
> **26 957–27 283 kHz (centre frequency 27 120 kHz),**
> **40.66–40.70 MHz (centre frequency 40.68 MHz),**
> **902–928 MHz in Region 2 (centre frequency 915 MHz),**
> **2 400–2 500 MHz (centre frequency 2 450 MHz),**
> **5 725–5 875 MHz (centre frequency 5 800 MHz), and**
> **24–24.25 GHz (centre frequency 24.125 GHz)**
>
> are also designated for industrial, scientific and medical (ISM) applications. Radiocommunication services operating within these bands must accept harmful interference which may be caused by these applications. ISM equipment operating in these bands is subject to the provisions of No. **15.13**.

The text of RR **15.13** is:

> **15.13** 9. Administrations shall take all practicable and necessary steps to ensure that radiation from equipment used for industrial, scientific and medical applications is minimal and that, outside the bands designated for use by this equipment, radiation from such equipment is at a level that does not cause harmful interference to a radiocommunication service and, in particular, to a radionavigation or any other safety service operating in accordance with the provisions of these Regulations.

9.5.4 In the above list (RR 5.150), particular attention has to be given to the frequencies in the 13 MHz and 27 MHz bands, since harmonics of these fall into both the ILS/VOR and the VHF COM bands with the potential in each case to affect a number of assignment points within each harmonic spread (as indicated in Figure 9-2).

Control of ISM equipment

9.5.5 International action to agree on standards and conditions for the radio frequency radiations from ISM equipment takes place under the aegis of the

International Special Committee on Radio Interference (CISPR), which is a component of the International Electrotechnical Commission (IEC). These standards are voluntary, and it is the responsibility of national authorities to decide on the extent and the nature of their national legislation required for the control of interference from these systems.

ITU-R Recommendations and CISPR publications

9.5.6 Recommendation ITU-R SM-1056 recommends the use of CISPR Publication 11 as a guide for the application of limits and methods of measurement for ISM equipment.

Very small aperture terminals (VSAT) and satellite news gathering (SNG) systems

9.5.7 VSAT/SNG systems or other small satellite terminal (e.g. SIT) systems are portable satellite earth terminals used by news agencies and other similar organizations for immediate deployment at any site which requires on-the-spot relay of news and information. Their operating frequencies are in the bands between 18 and 40 GHz. Their use in the environs of airports can cause interference to aeronautical radio and control systems on board aircraft, and strict control is necessary.

9.5.8 The Aeronautical Communications Panel (ACP) is studying this issue with a view to formulating an ICAO policy. This policy would recommend maximum levels or distances from critical areas to be applied by regulatory authorities.

9.5.9 Discussions on this subject with radio regulatory authorities are continuing in the United States and Europe.

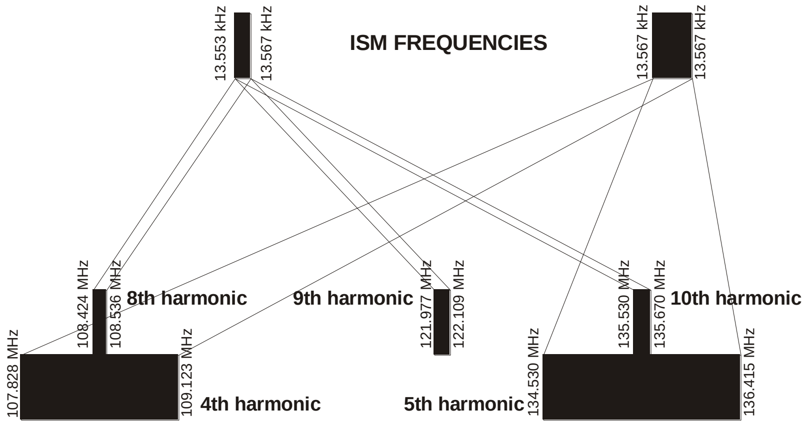

Figure 9-2. ISM frequencies

9.6 GENERAL PROTECTION LIMITS FOR AERONAUTICAL RADIO

The limits displayed in Table 9-1 are intended to give general guidance. For individual analysis, reference should be made to the complete definitive texts in the authoritative documents. Particular attention in these cases needs to be given to the specific spectral characteristics of the interfering systems.

These limits can ONLY be applied to assess inter system interference and CANNOT be used to assess compatibility between systems with different RF or spectral characteristics

Table 9-1. General protection limits

Not to be used for assessing compatibility with dissimilar systems

	Use	Frequency Band	Minimum Signal dB (uV/m)	Intra System Planning Protection Ratio DB	
1	Omega	10–14 KHz			
2	NDB	190–850 KHz	37 (1)	15	
3	HF Comms	2.8–22 MHz		15	
4	ILS Mkr Beacon	74.8–75.2 MHz	46 (1)	20	
5	ILS Localizer	108–112 MHz	40 (1)	20	
6	VOR	108–118 MHz	39 (1)	20	
7	VHF Comms	118–137 MHz	37 (1)	14	
8	ILS Glide Path	328.6–335.4 MHz	52 (1)	20	
9	ELT	406 MHz			
10	DME	960–1 215 MHz	71 (1)	8	
11	SSR	1 030–1 090 MHz			
12	Primary Radar (23 cm)	1 215–1 350 MHz			
13	Satcom (S to E)	1 545–1 555 MHz			
14	GPS	1 559–1 610 MHz	–160 dBW (3)		
15	GLONASS	1 559–1 610 MHz	–160 dBW (3)		
16	Satcom (E to S)	1 645.5–1 655.5 MHz			
17	PSR (10 cm)	2 700–3 300 MHz			
18	Radio Altimeter	4 200–4 400 MHz			
19	MLS	5 030–5 150 MHz	58	20	
20	Air Weather Radar	5 350–5 460 MHz			
21	Air Weather Radar	9 345–9 375 MHz			
22	Primary Radar (3 cm)	9 000–9 500 MHz			
23	Air Doppler Nav	13.25–13.4 GHz			
24	ASDE	15.4–15.7 GHz			
25	RSMS	15.4–15.7 GHz			

Notes.—

1. *Signal levels specified in Annex.*
2. *137 dBW/m^2/MHz (wide-band signals) –147 dBW/m^2/MHz (narrow-band signals) (Source: NSP).*
3. *At receiver terminals.*

Attachment A

DEFINITIONS AND TERMS USED IN THE ITU RADIO REGULATIONS RELEVANT TO AVIATION

1. INTRODUCTION

Article 1 of the Radio Regulations contains all of the definitions used in the Radio Regulations in relation to their interpretation. Some of the most important definitions for aeronautical services have been extracted and are reproduced in this attachment. Reference should be made to the full catalogue of definitions in Article 1 in cases where there is a need to appreciate their hierarchical structure.

1.1 For the purposes of these Regulations, the following terms shall have the meanings defined below. These terms and definitions do not, however, necessarily apply for other purposes. Definitions identical to those contained in the Annex to the Constitution or the Annex to the Convention of the International Telecommunication Union (Geneva, 1992) are marked "(CS)" or "(CV)" respectively.

Note.— If, in the text of a definition below, a term is printed in italics, this means that the term itself is defined in this Article.

SECTION I — GENERAL TERMS

1.2 *Administration:* Any governmental department or service responsible for discharging the obligations undertaken in the Constitution of the International Telecommunication Union, in the Convention of the International Telecommunication Union and in the Administrative Regulations (CS 1002).

1.3 *Telecommunication:* Any transmission, *emission* or reception of signs, signals, writings, images and sounds or intelligence of any nature by wire, *radio*, optical or other electromagnetic systems (CS).

1.4 *Radio:* A general term applied to the use of *radio waves*.

1.6 *Radiocommunication: Telecommunication* by means of *radio waves* (CS)(CV).

1.7 *Terrestrial Radiocommunication:* Any *radiocommunication* other than *space radiocommunication* or *radio astronomy*.

1.9 *Radiodetermination:* The determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters, by means of the propagation properties of *radio waves*.

1.10 *Radionavigation: Radiodetermination* used for the purposes of navigation, including obstruction warning.

SECTION II — SPECIFIC TERMS RELATED TO FREQUENCY MANAGEMENT

1.16 *Allocation* (of a frequency band): Entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more terrestrial or space *radiocommunication services* or the *radio astronomy service* under specified conditions. This term shall also be applied to the frequency band concerned.

1.17 *Allotment* (of a radio frequency or radio frequency channel): Entry of a designated frequency channel in an agreed plan, adopted by a competent conference, for use by one or more administrations for a terrestrial or space *radiocommunication service* in one or more identified countries or geographical areas and under specified conditions.

1.18 *Assignment* (of a radio frequency or radio frequency channel): Authorization given by an administration for a radio *station* to use a radio frequency or radio frequency channel under specified conditions.

SECTION III — RADIO SERVICES

1.19 *Radiocommunication Service:* A service as defined in this Section involving the transmission, *emission* and/or reception of *radio waves* for specific *telecommunication* purposes.

In these Regulations, unless otherwise stated, any radiocommunication service relates to *terrestrial radiocommunication*.

1.20 *Fixed Service:* A *radiocommunication service* between specified fixed points.

1.24 *Mobile Service:* A *radiocommunication service* between *mobile* and *land stations*, or between *mobile stations* (CV).

1.25 *Mobile-Satellite Service:* A *radiocommunication* service:

— between *mobile earth stations* and 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* necessary for its operation.

1.32 *Aeronautical Mobile Service:* A *mobile service* between *aeronautical stations* and *aircraft stations*, or between *aircraft stations*, in which *survival craft stations* may participate; *emergency position-indicating radiobeacon stations* may also participate in this service on designated distress and emergency frequencies.

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

1.35 *Aeronautical Mobile-Satellite Service:* A *mobile-satellite service* in which *mobile earth stations* are located on board aircraft; *survival craft stations* and *emergency position-indicating radiobeacon stations* may also participate in this service.

1.36 *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.

1.40 *Radiodetermination Service:* A *radiocommunication service* for the purpose of *radiodetermination*.

1.42 *Radionavigation Service:* A *radiodetermination service* for the purpose of *radionavigation*.

1.43 *Radionavigation-Satellite Service:* A *radiodetermination-satellite service* used for the purpose of *radionavigation*.

This service may also include *feeder links* necessary for its operation.

1.46 *Aeronautical Radionavigation Service:* A *radionavigation service* intended for the benefit and for the safe operation of aircraft.

1.47 *Aeronautical Radionavigation-Satellite Service:* A *radionavigation-satellite service* in which *earth stations* are located on board aircraft.

1.59 *Safety Service:* Any *radiocommunication service* used permanently or temporarily for the safeguarding of human life and property.

* (R): Route

SECTION IV — RADIO STATIONS AND SYSTEMS

1.61 *Station*: One or more transmitters or receivers or a combination of transmitters and receivers, including the accessory equipment, necessary at one location for carrying on a *radiocommunication service*, or the *radio astronomy service*.

Each station shall be classified by the service in which it operates permanently or temporarily.

1.62 *Terrestrial Station:* A *station* effecting *terrestrial radio-communication*.

In these Regulations, unless otherwise stated, any *station* is a terrestrial station.

1.63 *Earth Station:* A *station* located either on the Earth's surface or within the major portion of the Earth's atmosphere and intended for communication:

— with one or more *space stations*; or

— with one or more *stations* of the same kind by means of one or more reflecting *satellites* or other objects in space.

1.65 *Survival Craft Station:* A *mobile station* in the *maritime mobile service* or the *aeronautical mobile service* intended solely for survival purposes and located on any lifeboat, life-raft or other survival equipment.

1.66A *High Altitude Platform Station:* A station located on an object at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth.

1.67 *Mobile Station:* A *station* in the *mobile service* intended to be used while in motion or during halts at unspecified points.

1.68 *Mobile Earth Station:* An *earth station* in the *mobile-satellite service* intended to be used while in motion or during halts at unspecified points.

1.81 *Aeronautical Station:* A *land station* in the *aeronautical mobile service*.

In certain instances, an aeronautical station may be located, for example, on board ship or on a platform at sea.

1.82 *Aeronautical 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*.

1.83 *Aircraft Station:* A *mobile station* in the *aeronautical mobile service*, other than a *survival craft station*, located on board an aircraft.

1.84 *Aircraft Earth Station:* A *mobile earth station* in the *aeronautical mobile-satellite service* located on board an aircraft.

1.87 *Radionavigation Mobile Station:* A *station* in the *radionavigation service* intended to be used while in motion or during halts at unspecified points.

1.88 *Radionavigation Land Station:* A *station* in the *radionavigation service* not intended to be used while in motion.

1.92 *Radiobeacon Station:* A *station* in the *radionavigation service* the *emissions* of which are intended to enable a *mobile station* to determine its bearing or direction in relation to the radiobeacon station.

1.93 *Emergency Position-Indicating Radiobeacon Station:* A *station* in the *mobile service* the *emissions* of which are intended to facilitate search and rescue operations.

1.94 *Satellite Emergency Position-Indicating Radiobeacon:* An *earth station* in the *mobile-satellite service* the *emissions* of which are intended to facilitate search and rescue operations.

1.100 *Radar:* A *radiodetermination* system based on the comparison of reference signals with radio signals reflected, or retransmitted, from the position to be determined.

1.101 *Primary Radar:* A *radiodetermination* system based on the comparison of reference signals with radio signals reflected from the position to be determined.

1.102 *Secondary Radar:* A *radiodetermination* system based on the comparison of reference signals with radio signals retransmitted from the position to be determined.

1.103 *Radar Beacon (racon):* A transmitter-receiver associated with a fixed navigational mark which, when triggered by a *radar*, automatically returns a distinctive signal which can appear on the display of the triggering *radar*, providing range, bearing and identification information.

1.104 *Instrument Landing System (ILS):* A *radionavigation* system which provides aircraft with horizontal and vertical guidance just before and during landing and, at certain fixed points, indicates the distance to the reference point of landing.

1.105 *Instrument Landing System Localizer:* A system of horizontal guidance embodied in the *instrument landing system* which indicates the horizontal deviation of the aircraft from its optimum path of descent along the axis of the runway.

1.106 *Instrument Landing System Glide Path:* A system of vertical guidance embodied in the *instrument landing system* which indicates the vertical deviation of the aircraft from its optimum path of descent.

1.107 *Marker Beacon:* A transmitter in the *aeronautical radionavigation service* which radiates vertically a distinctive pattern for providing position information to aircraft.

1.108 *Radio Altimeter: Radionavigation* equipment, on board an aircraft or *spacecraft*, used to determine the height of the aircraft or the *spacecraft* above the Earth's surface or another surface.

1.109A *Adaptive System:* A radiocommunication system which varies its radio characteristics according to channel quality.

SECTION V — OPERATIONAL TERMS

1.116 *Public Correspondence:* Any *telecommunication* which the offices and *stations* must, by reason of their being at the disposal of the public, accept for transmission (CS).

SECTION VI — CHARACTERISTICS OF EMISSIONS AND RADIO EQUIPMENT

1.137 *Radiation:* The outward flow of energy from any source in the form of *radio waves*.

1.138 *Emission: Radiation* produced, or the production of *radiation*, by a radio transmitting *station*.

For example, the energy radiated by the local oscillator of a radio receiver would not be an emission but a *radiation*.

1.144 *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*.

1.145 *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*.

1.146 *Unwanted Emissions*:* Consist of *spurious emissions* and *out-of-band emissions*.

1.147 *Assigned Frequency Band:* The frequency band within which the *emission* of a *station* is authorized; the width of the band equals the *necessary bandwidth* plus twice the absolute value of the *frequency tolerance*. Where *space stations* are concerned, the assigned frequency band includes twice the maximum Doppler shift that may occur in relation to any point of the Earth’s surface.

1.148 *Assigned Frequency:* The centre of the frequency band assigned to a *station*.

1.153 *Occupied Bandwidth:* The width of a frequency band such that, below the lower and above the upper frequency limits, the *mean powers* emitted are each equal to a specified percentage β/2 of the total *mean power* of a given *emission*.

Unless otherwise specified in an ITU-R Recommendation for the appropriate *class of emission*, the value of β/2 should be taken as 0.5%.

1.161 *Equivalent Isotropically Radiated Power (e.i.r.p.):* The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (*absolute or isotropic gain*).

1.162 *Effective Radiated Power (e.r.p)* (in a given direction): The product of the power supplied to the antenna and its *gain relative to a half-wave dipole* in a given direction.

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* The terms associated with the definitions given by Nos. **1.144, 1.145** and **1.146** shall be expressed in the working languages as follows:

Numbers	In French	In English	In Spanish
1.144	Emission hors bande	Out-of-band emission	Emisión fuera de banda
1.145	Rayonnement non essentiel	Spurious emission	Emisión no esencial
1.146	Rayonnements non désirés	Unwanted emissions	Emisiones no deseadas

SECTION VII — FREQUENCY SHARING

1.166 *Interference:* The effect of unwanted energy due to one or a combination of *emissions*, *radiations*, or inductions upon reception in a *radiocommunication* system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy.

1.167 *Permissible Interference*:* Observed or predicted *interference* which complies with quantitative *interference* and sharing criteria contained in these Regulations or in ITU-R Recommendations or in special agreements as provided for in these Regulations.

1.168 *Accepted Interference*: Interference* at a higher level than that defined as *permissible interference* and which has been agreed upon between two or more administrations without prejudice to other administrations.

1.169 *Harmful Interference: Interference* which endangers the functioning of a *radionavigation service* or of other *safety services* or seriously degrades, obstructs, or repeatedly interrupts a *radiocommunication service* operating in accordance with Radio Regulations (CS).

1.170 *Protection Ratio (R.F.):* The minimum value of the wanted-to-unwanted signal ratio, usually expressed in decibels, at the receiver input, determined under specified conditions such that a specified reception quality of the wanted signal is achieved at the receiver output.

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* **1.167.1** and **1.168.1** The terms “permissible interference” and “accepted interference” are used in the coordination of frequency assignments between administrations.

Attachment B

ACRONYMS AND ABBREVIATIONS

AAC: Aeronautical administrative communications
ACAS: Airborne collision avoidance system
ACP: Aeronautical Communications Panel (ICAO)
ADF: Automatic direction finder
ADS: Automatic dependent surveillance
ADS-B: Automatic dependent surveillance-broadcast
ADSP: Automatic Dependent Surveillance Panel (ICAO)
AEEC: Airlines Electronic and Engineering Committee
ALS: Aircraft landing system
AM(OR)S: Aeronautical mobile (off-route) service (ITU)
AM(R)S: Aeronautical mobile (route) service (ITU)
AMS(R)S: Aeronautical mobile-satellite (route) service (ITU)
AMSS: Aeronautical mobile-satellite service
AMT: Aeronautical mobile telemetry
ANC: Air Navigation Commission (ICAO)
AOC: Aeronautical operational control
APC: Aeronautical passenger communications
APT: Asia-Pacific Telecommunity
ARINC: Aeronautical Radio, Inc.
ARNS: Aeronautical radionavigation service (ITU)
AS: Aeronautical security
ASDE: Airport surface detection equipment
ATC: Air traffic control
ATM: Air traffic management
ATS: Air traffic service
ATU: African Telecommunications Union
AWOP: All Weather Operations Panel (ICAO)
AWR: Airborne weather radar
CAT: Category (of landing)
CCIR: International Radio Consultative Committee
CDMA: Code division multiple access
CEPT: Conférence Europèene des Administrations des Postes et des Télécommunications (the European Conference for Posts and Telecommunications)
CISPR: International Special Committee on Radio Interference

CITEL: Comisión Interamericana de Telecomunicaciones (Inter-American Telecommunication Commission)
CNS: Communications, navigation and surveillance
COSPAS/SARSAT: International satellite system for search and rescue
CPM: Conference Preparatory Meeting (ITU)
DGNSS: Differential global navigation satellite system
DME: Distance measuring equipment
DME/N: Distance measuring equipment-normal
DME/P: Distance measuring equipment-precision
DSB: Double sideband
DSB-AM: Double sideband-amplitude modulation
EESS: Earth exploration-satellite service
e.i.r.p.: Equivalent isotropically radiated power
ELT: Emergency locator transmitter
EMC: Electromagnetic compatibility
EPIRB: Emergency position-indicating radio beacon (ITU)
e.r.p.: Effective radiated power
ETSI: European Telecommunications Standards Institute
EUROCAE: European Organization for Civil Aviation Electronics
FAA: Federal Aviation Administration
FANS: Future air navigation systems
FCC: Federal Communications Commission
FDMA: Frequency division multiple access
FIS-B: Flight information service-broadcast
FM: Frequency modulation
FMSG: Frequency Management Study Group (ICAO) (now ACP WG/F (frequency))
FSS: Fixed-satellite service (ITU)
GBAS: Ground-based augmentation system
GLONASS: Global orbiting navigation satellite system
GMDSS: Global maritime distress and safety system
GNSS: Global navigation satellite system
GPS: Global positioning system
GPWS: Ground proximity warning system
GSO: Geostationary orbit
HF: High frequency
HFDL: High frequency data link
IATA: International Air Transport Association
IEC: International Electrotechnical Commission
ILS: Instrument landing system
IMO: International Maritime Organization
IMT: International mobile telecommunications
ISM: Industrial, scientific and medical

ITU-R: International Telecommunication Union — Radiocommunication Sector
ITU-T: International Telecommunication Union — Telecommunication Standardization Sector
JAA: Joint Aviation Authorities
LADGPS: Local area differential global positioning system
LF: Low frequency
MASPS: Minimum aviation system performance standards
MES: Mobile earth station
MF: Medium frequency
MIFR: Master International Frequency Register
MLS: Microwave landing system
MOPS: Minimum operational performance standards
MOU: Memorandum of Understanding
MPR: Multi-purpose radar
MPS: Minimum performance specification
MSS: Mobile-satellite service (ITU)
MWARA: Major world air route area (ITU)
NDB: Non-directional radio beacon
NGSO: Non-geostationary orbit
NM: Nautical mile(s)
NSP: Navigation Systems Panel (ICAO)
OR: Off-route
PAR: Precision approach radar
PRF: Pulse repetition frequency
PSR: Primary surveillance radar
R: Route (or en route)
RAS: Radio astronomy service (ITU)
RDARA: Regional and domestic air route area (ITU)
RDSS: Radiodetermination-satellite service (ITU)
RF: Radio frequency
RLS: Radiolocation service
RNAV: Area navigation
RNS: Radionavigation service
RNSS: Radionavigation-satellite service
RR: Radio Regulations (ITU)
RSMS: Radar sensing and measurement system
RTCA: RTCA Inc. (Radio Technical Commission for Aeronautics)
SARPs: Standards and Recommended Practices
SIT: Shipborne interrogator-transponder
SMGCS: Surface movement guidance and control system
SRD: Short-range device
SSB: Single sideband
SSR: Secondary surveillance radar

TACAN: Tactical air navigation
TIS-B: Traffic information service-broadcast
TSO: Technical Standard Order
UAS: Unmanned aircraft systems
UAT: Universal access transceiver
UHF: Ultra-high frequency
UWB: Ultra-wideband
VDL: Very high frequency digital link
VGE: Voluntary Group of Experts (ITU)
VHF: Very high frequency
VLF: Very low frequency
VOR: VHF omnidirectional radio range
VSAT: Very small aperture terminal
WAAS: Wide area augmentation system
WARC: World Administrative Radio Conference (ITU)
WP: Working Party (ITU)
WRC: World Radiocommunication Conference (ITU)

Attachment C

THE REGULATION OF RADIO IN AIRCRAFT

1. INTRODUCTION

This attachment describes the processes for the regulation of the radio equipment carried by civil aircraft. It identifies and highlights, in particular, the essential role of the agreements made in the ITU as they affect the radio systems carried by aircraft for air navigation. In this examination, it separates the two distinctive and complementary areas of regulation, the first for telecommunications, and the second for aviation safety. Compliance with both is necessary before any international flight can be undertaken. It shows that the constituent parts of these regulatory processes have some functions arrived at through the process of international agreements, which are then incorporated into national regulations, and others (particularly the development of performance standards) which are developed by voluntary agreement between all interested parties and then adopted by national law as the basis of the regulation.

2. BACKGROUND

2.1 Modern aircraft are equipped with many radio systems operating in a possible seventeen different frequency bands ranging from 9 kHz to 15 GHz. Approximately half of the systems have both transmit and receive functions, and the remainder are receive only. Three are for primary communications purposes, and up to twelve are for radionavigation functions, including three which have integral and complementary data links. In the course of a flight, an aircraft may traverse territory other than that of its State of Registry and must therefore be regulated within a systematic framework of internationally agreed rules. These rules must ensure that the flight is safe for passengers and crew, and free from risk of damage to persons and property on the ground. As a part of this regulatory process, the radio installations must conform to agreed performance standards, must operate in correct frequency bands, must be licensed by appropriate authorities, and be operated by licensed personnel.

2.2 The regulatory framework to ensure these requirements has, as its basis, two quite separate international agreements which are implemented at the national level by two sets of national regulatory bodies. An outline description of the organizational elements of this framework is given below.

3. THE REGULATORY FRAMEWORK

Telecommunications regulation

3.1 ITU World Radiocommunication Conferences agree upon the allocation of radio frequency bands to be used for aeronautical communications and radionavigation which are then incorporated in the Radio Regulations as part of Chapter II, Frequencies. In this chapter, Article 5, Frequency Allocations, contains the frequency allocation limits, the geographical scope and the status of the allocation, the sharing with other services, and any special conditions which apply. Chapter VIII of the Radio Regulations, on Aeronautical Services, deals with licensing, inspection, infringements, interference and related matters for aeronautical radio stations. The basic technical parameters for frequency stability, permitted levels of spurious emissions and other spectrum use parameters are agreed by ITU-R and embodied in ITU-R Recommendations which are then incorporated by reference in the main body of the Regulations. Taken together, these form a body of regulations for use by national telecommunications authorities to control ground and airborne radio stations in regard to their basic transmit and receive functioning and their use. The use of radio in an aircraft when outside its State of Registry must conform to these basic licensing conditions.

Aviation regulation

3.2 The safety aspects of the operation of civil aircraft are governed by the terms of the *Convention on International Civil Aviation* (Doc 7300). In the context of the carriage and operation of radio, Article 30 of the Convention requires an aircraft on international carriage to carry radio transmitting apparatus only if a licence to install and operate such equipment has been issued by the appropriate authorities of the State of Registry. The Convention does not define the national body to exercise the function, which is normally that body with responsibility for telecommunications. In addition, Article 31 requires that all of the radio equipment on board shall be covered by a certificate of airworthiness, invariably issued by the authority with responsibility for aviation safety. Article 37 calls for the adoption of international Standards and Recommended Practices (SARPs) dealing with, *inter alia*, communications and navigation aids. SARPs normally address all interface parameters, including radio frequency (RF), performance, coding, etc., to ensure worldwide interoperability. These provisions form the major part of the international framework for aviation safety in regard to the radio systems carried by aircraft. It should be noted that ICAO SARPs are only agreed for systems which are standardized on a worldwide basis, and hence do not include such self-contained systems as radio altimeters and airborne weather radar, carried as a mandatory requirement by many aircraft, and which also meet the certificate of airworthiness requirements.

National regulations

3.3 The respective national authorities for telecommunications and for aviation in the State of Registry of an aircraft are responsible for ensuring compliance with the international agreements within their competence and jurisdiction. It is common for the telecommunications license to be issued by that authority only when the aviation safety requirements have been approved and a certificate of airworthiness has been granted by the aviation authorities. The total authorization thus embodies the permission to transmit and receive radio signals (the telecommunications part), and the certification that the systems are satisfactory for the navigation of the aircraft (the air safety part). Aircraft are frequently transferred from one country to another on delivery after manufacture or by wet or dry lease during their lifetime. The country of acceptance may agree to transfer the certificate of airworthiness with the aircraft as a practical means of compliance with international agreements. This latter procedure is recognized in Article 33 of the ICAO Convention and in Article 18 of the Radio Regulations.

4. AIRWORTHINESS APPROVAL AND THE ISSUE OF A CERTIFICATE OF AIRWORTHINESS

4.1 The process of airworthiness approval of the radio in aircraft includes requiring the assurance of the correct functioning of the equipment after its installation in the aircraft, which includes its performance as a working communications or radionavigation system, as well as its compatibility with other on-board radio and electronic systems. Prior to its installation, the equipment must have received approval under a Technical Standard Order (TSO) issued by a responsible body such as the Federal Aviation Administration (FAA) in the United States or the Joint Aviation Authorities (JAA) in Europe.

4.2 A TSO defines the performance and environmental requirements for the airborne radio system concerned and is traditionally based on the minimum performance specifications (MPS) developed in voluntary bodies such as RTCA in the United States and EUROCAE in Europe. This voluntary collaborative process, in which all the interested parties (administrators, radio system manufacturers, aircraft constructors, airlines, etc.) participate, has the advantage of facilitating the achievement of performance parameters that are realistic and which can be manufactured at economic cost levels.

4.3 Standardization of aircraft wiring and physical details (form and fit) is further carried out through the Aeronautical Radio, Inc. (ARINC) Characteristic — a document developed by the Airlines Electronic and Engineering Committee (AEEC), an international body for which ARINC provides the secretarial service. The ARINC Characteristic also includes all the performance requirements, sometimes enhanced over those of the TSO, and is the specification that is generally used for the procurement of radio for commercial aircraft.

4.4 The processes of airworthiness for most aviation radio systems recognize that some environmental and performance requirements can be relaxed for aircraft used only for private or pleasure purposes, outside the airspace used by commercial aviation and on short flights. The telecommunications requirements remain the same as those for commercial aircraft.

4.5 Airworthiness requirements for radio not used for navigation or air traffic needs, e.g. passenger telephones, are usually limited to an assurance that it is not a safety hazard and does not, in any way, affect the correct functioning of the other radio and electronic systems carried for safety purposes.

5. SUMMARY

The above describes the main regulatory features which apply to the use of radio in aircraft. They are characterized by:

a) the requirement to observe two sets of international treaty obligations, ITU and ICAO;

b) the participation of two national regulatory bodies, one for telecommunications aspects and one for air safety approval requirements; and

c) a voluntary collaborative process for the preparation of performance specifications.

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Attachment D

REVIEW AND UPDATE

1. Section 7-II identifies the prime objectives of this document, of which the most important is that of providing an up-to-date record of ICAO policy on the provisions in the ITU Radio Regulations for use by ICAO and its Member States. With ITU WRCs being held, in general, every four years, and numerous ITU-R preparatory activities and other studies taking place in the intervals, there is continuous activity in which aviation must actively participate. Appropriate responses to these activities include:

a) the timely development of the ICAO position for WRCs; and

b) the development of updates to this handbook, including the relevant policy statements, in the light of the amendments to the Radio Regulations as agreed by ITU and the ICAO position for future conferences.

A practical procedure for update of this handbook, including the policy statements and the development of the ICAO position, is outlined below and sequenced to include the requirements for internal ICAO approval, consultation with States, divisional meetings when they occur and general publishing and dissemination requirements.

2. The review and update cycle, based on the four-year interval between WRCs, is believed to provide the best compromise between the twin goals of expediency and accuracy. It embodies important milestones such as the approval of the Air Navigation Commission (ANC) and Council of ICAO and the provision of advice to Member States in timescales that are achievable and suitable (see Figure D-1).

3. The sequence of events for the development of the ICAO position for the next WRC, as well as necessary amendments to this handbook including the policy statements, in such a process incorporates the following:

- Review by ICAO of the Final Acts of the most recent WRC, including a review of the agenda for the next WRC and the preparation of policy proposals (ICAO position for the next WRC and revised policy statements in this handbook by the appropriate ICAO body). In this process the focal point for developing proposals in ICAO is ACP Working Group F. The Navigation System Panel is involved in this activity with regard to issues relating to radio navigation systems.

- Update of the technical and regulatory material in this handbook;

- Initial review of ICAO position for the next WRC and policy statements in this handbook by the ANC;

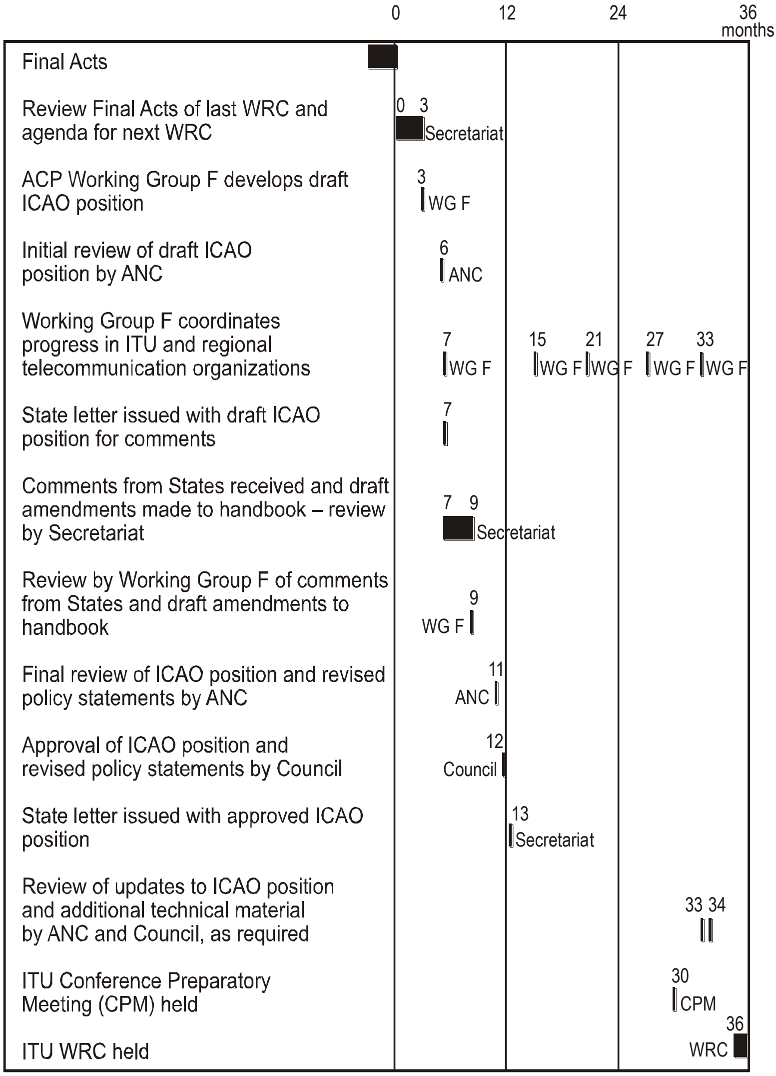
- Issue of State letter with draft ICAO position for the next WRC inviting comments from States and international organizations on the proposals sent to States and international organizations;

- Final review of States' comments and consequential updated policy statements in this handbook by the ANC;

- Approval of ICAO position for the next Conference and updated policy statements by the Council. Shortly before the next WRC, a last review of any necessary update of the ICAO position will be undertaken by the ANC and Council, as required;

- Final discussions and informal briefings on the latest information; and

- Commencement of next WRC.



Note.— Bars indicate approximate timing of event.

Figure D-1. Review and update cycle of ICAO position and the RF handbook

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Attachment E

STRATEGY FOR ESTABLISHING AND PROMOTING THE ICAO POSITION FOR FUTURE ITU WORLD RADIOCOMMUNICATION CONFERENCES

1. INTRODUCTION

This attachment presents a long-term strategy for establishing and promoting the ICAO position for future ITU World Radiocommunication Conferences (WRCs) with a view to securing support for the ICAO position from ITU administrations and relevant international organizations.

2. BASIS FOR THE ICAO POSITION

2.1 The ICAO position is developed on the basis of current and future aviation requirements for radio frequency spectrum, taking into account the expected growth in air traffic and the development of new technologies.

2.2 The long-term implementation strategy contained in the *Global Air Navigation Plan* (Doc 9750) forms the basis for the spectrum requirements.

2.3 The ICAO policy on radio frequency spectrum requirements, as approved by the Council, is contained in this handbook.

2.4 The framework for the development and support of the ICAO position is contained in Assembly Resolution A36-25.

3. DEVELOPMENT OF THE ICAO POSITION

3.1 The ICAO position for a WRC is established as early as possible after the agenda for that WRC is established. The position presents the ICAO views on all agenda items of interest to international civil aviation on the agenda of the WRC, with particular regard to the impact on safety, regularity and efficiency of flight. Technical and operational information is provided as required to support the position.

3.2 The focal point on all aspects related to the development of the ICAO position for WRCs is the Aeronautical Communications Panel (ACP), through its Working Group F. The NSP is responsible for developing material related to the use of GNSS elements, in coordination with the ACP as required.

3.3 Throughout the development of the position, proper coordination with and involvement of the ICAO regional offices is required. Their involvement enables the incorporation of specific regional requirements and helps achieve improved support at the regional and national level.

3.4 The draft ICAO position developed by the ACP is reviewed by the ANC and sent to States and relevant international organizations for comment. The comments are reviewed by the ANC, and a consolidated ICAO position is submitted by the ANC to the Council for approval.

3.5 After approval by the Council, the ICAO position is sent to States for use in the coordination process leading to the development of national positions. The ICAO position is also submitted as an information paper to the WRC.

3.6 Following the development of the ICAO position, consequential amendments to policy statements contained in this handbook are developed for approval by the Council.

3.7 Any subsequent developments arising from ICAO and ITU activities in preparation for the WRC are considered by the Council with a view to updating the ICAO position as necessary.

4. SUPPORT FOR THE ICAO POSITION

4.1 Assembly Resolution A36-25 shall be fully implemented so as to secure support from States for the ICAO position and ensure that the resources necessary to support increased participation by ICAO to international and regional spectrum management activities are made available.

4.2 In addition to being submitted to States (paragraph 3.5 refers), the ICAO position is also disseminated, as early as possible, to the regional telecommunication organizations involved in the development of regional positions for WRCs. Presentation of the position and follow-up is provided by the relevant ICAO regional offices, with assistance from Headquarters as required.

4.3 ICAO contributes to WRC preparatory activities conducted by ITU (meetings of relevant ITU-R Study Groups and ITU Conference Preparatory Meetings) by submitting additional technical papers supporting the ICAO position.

4.4 Close coordination and cooperation with other aviation organizations participating in the conference, such as IATA, need to be maintained. Also, coordination with other specialized agencies of the UN on issues of common interest is required to broaden the support for specific elements of the ICAO position.

4.5 Regional ICAO coordination meetings to present and discuss the ICAO position should be organized as required. These meetings could be held in conjunction with the meetings of ACP Working Group F.

5. NEW TRENDS IN SPECTRUM MANAGEMENT

5.1 In the application of the strategy outlined above, a number of new trends influencing the allocation of spectrum today and in the future need to be taken into account. Such trends, which may affect the availability of adequate and protected spectrum for aviation, include:

a) the increased role of the private sector in the work of the ITU;

b) the increased economic value of spectrum for certain applications;

c) the increased availability of radio devices that do not require licensing by radiocommunication authorities; and

d) the increased pressure for sharing aeronautical spectrum with non-aeronautical services.

5.2 The increased role of the private sector in the ITU has had an adverse impact on the influence of inter-governmental bodies such as ICAO. This situation was addressed at the 2002 ITU Plenipotentiary Conference (PP-02), with a view to strengthening the role of ICAO in ITU.

5.3 The economic value of spectrum allocated to certain applications can exceed by far the economic value of aeronautical applications of the same spectrum. This has recently been demonstrated by the results of the “spectrum auctions” conducted in several countries to support future commercial mobile multimedia systems. This situation requires aviation to identify clearly the need and economic value of required spectrum in certain bands and to consider innovative approaches to guarantee the required level of safety service availability.

5.4 Technical trends such as the ones mentioned in sub-paragraphs 5.1 c) and d) have the potential of increasing interference levels to aeronautical systems and must therefore be carefully assessed on a case-by-case basis. A comprehensive investigation of interference levels and available margins in all aeronautical bands needs to be conducted urgently.

6. ASSEMBLY RESOLUTION A36-25

The ICAO Assembly approved Resolution A36-25 on the "Support of the ICAO policy on radio frequency spectrum matters" as follows:

" *Whereas* ICAO is the specialized agency of the United Nations responsible for the safety, regularity and efficiency of international civil aviation;

Whereas ICAO adopts international Standards and Recommended Practices (SARPs) for aeronautical communications systems and radio navigation aids;

Whereas ITU is the specialized agency of the United Nations regulating the use of the radio frequency spectrum;

Whereas the ICAO position, as approved by the Council, for ITU World Radiocommunication Conferences (WRCs) is the result of the coordination of international aviation requirements for radio frequency spectrum;

Recognizing that the development and the implementation of the communications, navigation, and surveillance/air traffic management (CNS/ATM) systems and the safety of international civil aviation could be seriously jeopardized unless aviation requirements for allocations of radio frequency spectrum are satisfied and protection of those allocations is achieved;

Recognizing that support from ITU member administrations is required to ensure that the ICAO position is supported by the WRC and that aviation requirements are met;

Considering the urgent need to increase such support due to the growing demand for spectrum and aggressive competition from commercial telecommunications services;

Considering the increased level of ITU WRC preparation activities associated with the growing demand for bandwidth from all users of the radio frequency (RF) spectrum, as well as the increased importance of the development of regional positions by regional telecommunications bodies such as APT, ASMG, ATU, CEPT, CITEL and RCC[1];

Considering Recommendations 7/3 and 7/6 of the Special Communications/ Operations Divisional Meeting (1995) (SP COM/OPS/95) as well as Recommendation 5/2 of the Eleventh Air Navigation Conference (2003);

The Assembly:

1. *Urges* Contracting States and international organizations to support firmly the ICAO position at WRCs and in regional and other international activities conducted in preparation for WRCs by the following means:

a) undertaking to provide for aviation interests to be fully integrated in the development of their positions presented to regional telecommunications fora involved in the preparation of joint proposals to the WRC;

b) including in their proposals to the WRC, to the extent possible, material consistent with the ICAO position;

c) supporting the ICAO position and the ICAO policy statements at ITU WRCs as approved by Council and incorporated in the *Handbook on Radio Frequency Spectrum Requirements for Civil Aviation* (Doc 9718);

d) undertaking to provide experts from their civil aviation authorities to fully participate in the development of States' and regional positions and development of aviation interests at the ITU; and

e) ensuring, to the maximum extent possible, that their delegations to regional conferences, ITU study groups and WRCs include experts from their civil aviation authorities or other officials who are fully prepared to represent aviation interests;

2. *Requests* the Secretary General to bring to the attention of ITU the

1. APT: Asia-Pacific Telecommunity; ASMG: Arab Spectrum Management Group; ATU: African Telecommunications Union; CEPT: the European Conference of Postal and Telecommunications Administrations; CITEL: Inter-American Telecommunication Commission; RCC: Regional Commonwealth in the field of Communications.

importance of adequate radio frequency spectrum allocation and protection for the safety of aviation; and

3. *Instructs* the Council and the Secretary General, as a matter of high priority within the budget adopted by the Assembly, to ensure that the resources necessary to support increased participation by ICAO in international and regional spectrum management activities are made available.

4. *Declares* that this resolution supersedes Resolution A32-13."

Attachment F

DRAFT

ICAO POSITION FOR THE INTERNATIONAL TELECOMMUNICATION UNION (ITU) WORLD RADIOCOMMUNICATION CONFERENCE 2015 (WRC-15)

SUMMARY

This paper reviews the agenda for the ITU WRC-15, discusses points of aeronautical interest and provides the ICAO Position for these agenda items.
The ICAO Position aims at protecting aeronautical spectrum for radiocommunication and radionavigation systems required for current and future safety-of-flight applications. In particular, it stresses that safety considerations dictate that exclusive frequency bands must be allocated to safety critical aeronautical systems and that adequate protection against harmful interference must be ensured. It also includes proposals for new aeronautical allocations to support new aeronautical applications.
Support of the ICAO Position by Contracting States is required to ensure that the position is supported at the WRC-15 and that aviation requirements are met.

CONTENTS

1. 1 Introduction
2. ICAO and the international regulatory framework
3. Spectrum requirements for international civil aviation
4. Aeronautical aspects on the agenda for WRC-15

1. INTRODUCTION

1.1 The ICAO Position on issues of interest to international civil aviation to be decided at the 2015 ITU World Radiocommunication Conference

(WRC-15) is presented below. The agenda of this Conference is contained in the attachment. The ICAO Position is to be considered in conjunction with sections 7-II and 8 of the *Handbook on Radio Frequency Spectrum Requirements for Civil Aviation, Volume I, which incorporates the ICAO Spectrum Strategy and Policies and related information.* (Doc 9718, Vol.1, 6th Edition-2013) Doc 9718 is available on website http://legacy.icao.int/anb/panels/acp (see webpage: Repository). Also available at the above-mentioned website are the WRC-15 relevant ITU Resolutions referenced in the ICAO Position.

1.2 ICAO supports the working principle which was utilized in studies for WRC-07 and WRC-12. This working principle recognizes that the compatibility of ICAO standard systems with existing or planned aeronautical systems operating in accordance with international aeronautical standards will be ensured by ICAO. Compatibility of ICAO standard systems with non-ICAO standard aeronautical systems (or non-aeronautical systems) will be addressed in ITU.

2. ICAO AND THE INTERNATIONAL REGULATORY FRAMEWORK

2.1 ICAO is the specialized agency of the United Nations providing for the International regulatory framework for Civil Aviation. The Convention on International Civil Aviation is an international treaty providing the required provisions for flights over the territories of the 191 ICAO Member States and over the high seas. It includes measures to facilitate air navigation, including international Standards and Recommended Practices, commonly referred to as SARPs.

2.2 The ICAO standards constitute rule of law through the ICAO Convention and form a regulatory framework for aviation, covering personnel licensing, technical requirements for aircraft operations, airworthiness requirements, aerodromes and systems used for the provision of communications, navigation and surveillance, as well as other technical and operational requirements.

3. SPECTRUM REQUIREMENTS FOR INTERNATIONAL CIVIL AVIATION

3.1 Air transport plays a major role in driving sustainable economic and social development in hundreds of nations. Since the mid-1970s, air traffic growth has consistently defied economic recessionary cycles, expanding two-fold once every 15 years. In 2012, air transport directly and indirectly supported the employment of 56.6 million people, contributing over $2 trillion to global Gross Domestic Product (GDP), and carried over 2.5 billion passengers and $5.3 trillion worth of cargo annually.

3.2 The safety of air operation is dependent on the availability of reliable communication and navigation services. Current and future communication, navigation and surveillance/air traffic management (CNS/ATM) provisions are highly dependent upon sufficient availability of radio frequency spectrum that can support the high integrity and availability requirements associated with aeronautical safety systems, and demand special conditions to avoid harmful interference to these systems. Spectrum requirements for current and future aeronautical CNS systems are specified in the ICAO Spectrum Strategy[1], as approved by the ICAO Council.

3.3 In support to the safety aspects related to the use of radio frequency spectrum by aviation **Article 4.10** of the Radio Regulations states that "*ITU Member States recognize that the safety aspects of radionavigation and other safety services require special measures to ensure their freedom from harmful interference; it is necessary therefore to take this factor into account in the assignment and use of frequencies"*. In particular, compatibility of aeronautical safety services with co-band or adjacent band aeronautical non-safety services or -non-aeronautical services must be considered with extreme care in order to preserve the integrity of the aeronautical safety services.

3.4 The continuous increase in air traffic movements as well as the additional requirement for accommodating new and emerging applications such as Unmanned Aircraft Systems (UAS[2]) is placing increased demand on both the aviation regulatory and air traffic management mechanisms. As a result the airspace is becoming more complex and the demand for frequency assignments (and consequential spectrum allocations) is increasing. While some of this demand can be met through improved spectral efficiency of existing radio systems in frequency bands currently allocated to aeronautical services, it is inevitable that these frequency bands may need to be increased or additional aviation spectrum allocations may need to be agreed to meet this demand.

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[1] The ICAO spectrum strategy is incorporated in the ICAO *Handbook on radio frequency spectrum requirements for civil aviation*, Volume 1 (Doc. 9718 – 6th Edition).

[2] UAS is referred to in ICAO as Remotely Piloted Aircraft Systems (RPAS)

3.5 The ICAO Position for the ITU WRC-15 was developed in 2012 and 2013 with the assistance of the Aeronautical Communications Panel (ACP) Working Group F (frequency) and was reviewed by the Air Navigation Commission (ANC) at the seventh meeting of its 191st session on 30 October 2012. Following the review by the ANC, it was submitted to ICAO Contracting States and relevant international organizations for comment. After final review of the ICAO Position and the comments by the ANC on 30 March 2013, the ICAO position was reviewed and approved by the ICAO Council on [27 May 2013]. When the ICAO Position was established, studies on a number of agenda items for WRC-15 were still on-going in the ICAO Navigation Systems Panel (NSP), the ICAO Aeronautical Communications Panel (ACP), in the ITU and in regional telecommunication organizations. These studies are to be completed prior to the WRC-15 and, if/as necessary, the ICAO position will be refined or updated taking into account the results of this on-going work.

3.6 States and international organizations are requested to make use of the ICAO Position, to the maximum extent possible, in their preparatory activities for the WRC-15 at national level, in the activities of the regional telecommunication organizations[3] and in the relevant meetings of the ITU.

4. AERONAUTICAL ASPECTS ON THE AGENDA FOR WRC-15

Note 1.— The statement of the ICAO Position on an agenda item is given in a text box at the end of the section addressing the agenda item, after the introductory background material.

*Note 2.— No impact on aeronautical services has been identified from WRC-15 Agenda Items **1.2**, **1.3**, **1.8**, **1.9**, **1.13**, **1.14, 1.15**, **1.18, 3**, **5**, **6**, **7, 9.2, 9.3** and **10** which are therefore not addressed in this position.*

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3 African Telecommunication Union (ATU), Asia-Pacific Telecommunity (APT), European Conference of Postal and Telecommunications Administrations (CEPT), Inter-American Telecommunication Commission (CITEL), Arab Spectrum Management Group (ASMG) and the Regional Commonwealth in the Field of Communications (RCC).

WRC-15 Agenda Item 1.1

Agenda Item Title:
To consider additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for International Mobile Telecommunications (IMT) and related regulatory provisions, to facilitate the development of terrestrial mobile broadband applications, in accordance with Resolution 233 (WRC-12);

Discussion:

This agenda item seeks to identify additional spectrum for use by terrestrial mobile communication systems to facilitate the development of terrestrial broadband applications. While the agenda item is not specific about the required RF spectrum bandwidth or the frequency bands targeted, the United States and Europe have both declared that they are intending to make at least 500 MHz of additional spectrum available for international mobile telecommunications (IMT), ideally below 6 GHz. Resolution **233** (WRC-12) identifies, in the *considering*, a number of frequency bands below 6 GHz where studies have previously been undertaken in ITU-R. Two of these frequency bands (2 700 – 2 900 MHz and 3 400 – 3 700 MHz) are of concern to aviation. It has been assumed that frequency bands below 100 MHz (and probably below 400 MHz) will not be of interest due to the cost of implementation, variability in propagation and throughput capacity

A number of aviation systems used for the assurance of safety of flight are operating below 6 000 MHz and it is therefore essential to ensure that any new allocation to the mobile service does not adversely impact the operation of these systems. Based on recent experience with the introduction of mobile systems in the frequency band below 2 690 MHz and the remediation that was required to avoid interference to primary surveillance radar systems in the adjacent frequency band (2 700 – 2 900 MHz), care needs to be taken not only with any proposal for co-frequency band sharing of aeronautical services with non-aeronautical services but also with proposals for the introduction of new allocations in adjacent frequency bands.

The following aeronautical systems operate in the frequency range 400 – 6 000 MHz:

406 – 406.1 MHz

Emergency Locator Transmitter: Emergency locator transmitters, referred to as emergency position-indicating radio beacons (EPIRB) in the ITU, when activated transmit a distress signal which can be received by the COSPAS/SARSAT satellites and suitably equipped aircraft and vessels to facilitate search and rescue operations. Whilst there have been no recent compatibility studies, Resolution **205** was updated at WRC-12 to call for regulatory, technical and operational studies with a view to identify any required regulatory action that can be identified in the Director's report to WRC-15.

960 – 1 215 MHz

Distance measuring equipment (DME): DME is the ICAO standard system for the determination of the position of an aircraft based on the distance between that aircraft and ground-based DME beacons within radio line of sight. Studies in Europe with respect compatibility with adjacent frequency band (below 960 MHz) IMT systems, and within ICAO with regard to co-frequency band sharing of the aeronautical mobile (R) service (AM(R)S) within the frequency band 960 – 1 164 MHz, show that any co-frequency band sharing with IMT systems would be difficult.

1 030 & 1 090 MHz

Secondary surveillance radar (SSR): SSR is the ICAO standard system that operates on two frequencies (1 030 and 1 090 MHz), used to identify the position of an aircraft based on an aircrafts' response to an interrogation by the ground based element of the SSR system.

1 090 Extended Squitter (1 090ES): 1 090 ES is an ICAO standard system to support automatic dependent surveillance-broadcast (ADS-B); automatically broadcasting the position and other parameters of the aircraft in order to allow other aircraft and ground facilities to track that aircraft.

Multilateration (MLAT): MLAT is the ICAO standard system used to identify the position of an aircraft based on an aircraft's transmission of a squitter or as response to an interrogation by a ground based ~~the~~ SSR or by active MLAT.

Airborne collision avoidance system (ACAS): ACAS is the ICAO standard system operating on the same frequencies as SSR, used for the detection and avoidance of airborne conflict situations.

These systems provide for essential surveillance functions on a global basis. Although detailed studies would be required to fully assess any sharing proposals, the fact that two frequencies are used to support all of these safety of life systems would indicate that any sharing is unlikely to be acceptable to ICAO on safety grounds.

Universal access transceiver (UAT): UAT is an ICAO standardised system operating on 978 MHz intended to support automatic dependant surveillance-broadcast as well as ground uplink services to aircraft such as situational awareness and flight information services.

Global navigation satellite systems: The global allocation to the radionavigation satellite service in the frequency band~~s~~ 1 164 – 1 215 MHz is intended to provide civil precision navigational services for various users, including aviation. Compatibility of the radionavigation satellite service and the aeronautical radionavigation service in the frequency range 960 – 1 215 MHz has been established through footnote **5.328A** and Resolutions **609** and **610**.

Aeronautical Communications Future Communication System: The frequency band 960 – 1 164 MHz was allocated to the AM(R)S for the development by ICAO of a significant component of the aeronautical future communication system. Report ITU-R **M.2235** presents compatibility studies of AM(R)S systems operating in the band 960 – 1 164 MHz with systems operating in the same frequency band, and in the adjacent frequency bands, both on-board the aircraft and on the ground.

1 215 – 1 350 MHz

Primary radar: This band, especially frequencies above 1 260 MHz, is extensively used for long-range primary surveillance radar to support air traffic control in the en-route and terminal environments. No recent studies have been undertaken with respect to compatibility with terrestrial mobile systems. Given the similarity between these radars and those operating in the frequency band 2 700 – 2 900 MHz, the results of studies in that frequency band should be applicable.

1 559 – 1 610 MHz

Global navigation satellite systems: These systems are used by the ICAO standardised satellite navigation systems for navigation in the en-route, terminal and airport environments. A number of recent studies have been undertaken within United States with respect to the compatibility between terrestrial mobile systems operating in an adjacent frequency band and satellite navigation systems. Those studies indicated that sharing was not possible.

1.5 / 1.6 GHz

Aeronautical mobile satellite communication systems: The frequency bands 1 545 – 1 555 and 1 646.5 – 1 656.5 MHz as well as the frequency band 1 610 – 1 626.5 MHz are used for the provision of ICAO standardised satellite communication services. A number of recent studies have been undertaken within Europe and United States with respect to the compatibility between terrestrial mobile systems and satellite systems in a frequency range that covers these assignments. Those studies indicated that sharing was not possible.

2 700 – 3 100 MHz

Approach primary radar: This band is extensively used to support air traffic control services at airports especially approach services. There have been a number of studies undertaken within the ITU, Europe and the United States on sharing with respect to compatibility with terrestrial mobile systems. The more recent studies are related to the introduction of mobile systems below 2 690 MHz and compatibility with radars operating above 2 700 MHz. These studies have shown significant compatibility issues which would suggest that co-frequency band sharing would be impractical. Additionally, previous technical studies in the ITU, in particular on co-channel compatibility between primary radars operating in the frequency range 2 700 – 3 100 MHz and mobile service showed that co-frequency compatibility between the terrestrial mobile service and radar systems was not feasible.

3 400 – 4 200 MHz and 4 500 – 4 800 MHz

Fixed Satellite Service (FSS) systems used for aeronautical purposes: FSS systems are used in the frequency range 3 400 – 4 200 MHz and the frequency band 4 500 – 4 800 MHz as part of the ground infrastructure for transmission of critical aeronautical and meteorological information (see Resolution **154** (WRC-12) and agenda item 9.1.5). FSS systems in the 3.4 – 4.2 GHz frequency range are also used for feeder links to support AMS(R)S systems. ITU-R Report **M.2109** contains sharing studies between IMT and FSS in the frequency range 3 400 – 4 200 MHz and frequency band 4 500 – 4 800 MHz and ITU-R Report **S.2199** contains studies on compatibility of broadband wireless access systems and FSS networks in the frequency range 3 400 – 4 200 MHz. Both studies show a potential for interference from IMT and broadband wireless access stations into FSS Earth stations at distances of up to several hundred km. Such large separation distances would impose substantial constraints on both mobile and satellite deployments. The studies also show that interference can occur when IMT systems are operated in the adjacent frequency band.

4 200 – 4 400 MHz

Radio altimeters: This frequency band is used by radio altimeters. Radio altimeters provide an essential safety-of-life function during all phases of flight, including the final stages of landing where the aircraft has to be maneuvered into the final landing position or attitude.

5 000 – 5 250 MHz

Microwave Landing System (MLS): The frequency band 5 030 – 5 091 MHz is to be used for the Microwave Landing System. MLS provides for precision approach and landing of aircraft. Future implementation of MLS is expected to be limited, mainly due to the prospect of GNSS (GBAS) offering equivalent capabilities, but where deployed, the MLS needs to be protected from harmful interference.

UAS Terrestrial and UAS Satellite communications: At WRC-12, an allocation~~s~~ to the AM(R)S was introduced and a footnoted aeronautical mobile satellite (R) service allocation was brought into the table of allocations in the frequency range 5 000-5 150 MHz with the view to provide spectrum for command and non-payload communications with unmanned aircraft systems. The development and implementation of these systems, taking into account the need to protect other uses in the frequency range 5 000 – 5 150 MHz is currently being considered in ICAO.

AeroMACS: Provisions for introducing systems for communications with aircraft on the surface of an airport (AeroMACS) were introduced in the Radio Regulations in 2007 in the frequency band 5 091 – 5 150 MHz. Currently ICAO is developing SARPs for implementing AeroMACS.

Aeronautical Telemetry: Provisions for introducing systems for Aeronautical telemetry were introduced in the Radio Regulations in 2007 in the frequency range 5 091 – 5 250 MHz. Aeronautical telemetry systems are currently being implemented.

5 350 – 5 470 MHz

Airborne Weather Radar: The frequency range 5 350 – 5 470 MHz is globally used for airborne weather radar. The airborne weather radar is a safety critical instrument assisting pilots in deviating from potential hazardous weather conditions and detecting wind shear and microbursts. This use is expected to continue for the long term.

5 850 – 6 425 MHz

Fixed Satellite Service (FSS) systems used for aeronautical purposes: The frequency range 5 850 – 6 425 MHz is used by aeronautical VSAT networks for transmission (E-s) of critical aeronautical and meteorological information.

As this agenda item could impact a variety of frequency bands used by aeronautical safety services below 6 GHz it will be important to ensure that agreed studies validate compatibility prior to considering additional allocations.

ICAO Position:

To oppose any new allocation to the mobile service in or adjacent to:

- frequency bands allocated to aeronautical safety services (ARNS, AM(R)S, AMS(R)S); or

- frequency bands used by fixed satellite service (FSS) systems for aeronautical purposes as part of the ground infrastructure for transmission of aeronautical and meteorological information or for AMS(R)S feeder links,

unless it has been demonstrated through agreed studies that there will be no impact on aeronautical services.

WRC-15 Agenda
Item 1.4

Agenda Item Title:
To consider possible new allocation to the amateur service on a secondary basis within the band 5 250-5 450 kHz in accordance with Resolution 649 (WRC-12);

Discussion:

The frequency band 5 450 – 5 480 kHz is allocated on a primary basis to the aeronautical mobile (R) service (AM(R)S) in Region 2. The use of this band for long distance communications (HF) by aviation is subject to the provisions of Appendix 27. Any allocation made to the amateur service in the frequency band 5 250 – 5 450 kHz under this agenda item must ensure the protection of aeronautical systems operating in the adjacent frequency band 5 450 – 5 480 kHz from harmful interference.

ICAO Position:

To ensure that any allocation made to the amateur service shall not cause harmful interference to aeronautical systems operating under the allocation to the aeronautical mobile (R) service in the adjacent frequency band 5 450 – 5 480 kHz in Region 2.

WRC-15 Agenda Item 1.5

Agenda Item Title:
To consider the use of frequency bands allocated to the fixed-satellite service not subject to Appendices 30, 30A and 30B for the control and non-payload communications of unmanned aircraft systems (UAS) in non-segregated airspaces, in accordance with Resolution 153 (WRC-12);

Discussion:

ICAO Standard systems to support safe and efficient aircraft operations on a global basis are developed in accordance with the provisions of the ITU Radio Regulations. Of significant importance to aviation is that the frequency bands that support radio communication and navigation for aircraft are allocated to recognized safety services (such as the AM(R)S, the AMS(R)S or the ARNS).

This agenda item calls for studies to determine whether a system operating under an allocation to the Fixed Satellite Service (FSS), which is regarded as a non-safety service, can be used to support unmanned aircraft system (UAS[4]) control and non-payload communications (CNPC[5]) which has been determined to be a safety application. If such use is found feasible, then any resultant technical and regulatory actions should be limited to the case of UAS using satellites, as studied, and not set a precedent that puts other aeronautical safety services at risk.

The 12th Air Navigation Conference (AN-Conf/12) was held in November 2012, and the main theme was to redraft the global Air Navigation Plan based on the concept of Aviation System Block Upgrades (ASBU). Worldwide ICAO Air Navigation Conferences are held approximately every 10 years, and their primary goal is to establish and promote a common vision or path to ensure a safe, coherent and harmonized modernization of the Air Transport System. There was substantive discussion on spectrum, resulting in two AN-Conf/12 Recommendations (1/12 and 1/13) relevant to this WRC-15 agenda item.

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4 UAS is referred to in ICAO as Remotely Piloted Aircraft Systems (RPAS)

5 CNPC is referred to in ICAO as Command and Control (C2) or Command, Control and ATC Communications (C3)

At WRC-12 no new satellite allocations were made to support beyond-line-of-sight (BLOS) UAS CNPC. However the aeronautical mobile satellite (R) service (AMS(R)S) in the frequency range 5 000 – 5 150 MHz, previously allocated through footnote **5.367**, is now a table allocation and the co-ordination requirements in the frequency band 5 030 – 5 091 MHz were changed from **9.21** to **9.11A**.

The requirement for BLOS (satellite) communications (54 MHz) cannot be fulfilled in the limited spectrum available in the frequency bands 1.5/1.6 GHz, and no AMS(R)S satellite system currently operates in the frequency range 5 000 – 5 150 MHz to support current/near-term UAS CNPC.

Existing systems operating in the FSS in the unplanned frequency bands 4/6 GHz, 12/14 GHz and 20/30 GHz have spectrum capacity available that can meet the requirements for BLOS communications and could be used for UAS CNPC provided that the principles detailed below are fulfilled. However the FSS is not recognised in the ITU as a safety service. Some of these systems have been notified for registration under article **11.41**.

Standards and Recommended Practices (SARPs) for CNPC are developed in ICAO. CNPC links must meet specific Required Communications Performance (RCP) to satisfy the aviation safety requirements as identified during this development. UAS CNPC links operated on frequencies in FSS allocations would have to be validated to meet those SARPs. Actual UAS operations with satellite-based CNPC systems using FSS allocations are performed to date in segregated airspace. This gives some indication that FSS satellite systems operating in the frequency bands 4/6 GHz, 12/14 GHz and 20/30 GHz may have the capability of supporting UAS CNPC in non-segregated airspace as well. However regulatory measures will be required to address the conditions for UA CNPC links. In addition regulatory measures will be required to address some of the safety related conditions as detailed below.

AMS(R)S is the appropriate type of service allocation to support the satellite component for UAS command and control and ATC relay in non-segregated airspace. However, WRC-15 AI 1.5 asks for studies for the use of FSS allocations for UAS applications.

Article 15 of the Radio Regulations states that special consideration shall be given to avoiding interference on distress and safety frequencies.

In order to satisfy the requirements for BLOS communications for UAS, the use of satellite CNPC links will have to comply with the following conditions:

1. That the technical and regulatory actions should be limited to the case of UAS using satellites, as studied, and not set a precedent that puts other aeronautical safety services at risk.

2. That all frequency bands which carry aeronautical safety communications need to be clearly identified in the Radio Regulations.

3. That the assignments and use of the relevant frequency bands have to be consistent with article 4.10 of the Radio Regulations which recognizes that safety services require special measures to ensure their freedom from harmful interference.

4. Knowledge that any assignment operating in those frequency bands:

   - is in conformity with technical criteria of the Radio Regulations,
   - has been successfully co-ordinated, including cases where co-ordination was not completed but the ITU examination of probability of harmful interference resulted in favourable finding, or any caveats placed on that assignment have been addressed and resolved such that the assignment is able to satisfy the requirements to provide BLOS communications for UAS, and
   - has been recorded in the International Master Frequency Register.

5. That interference to systems is reported in a transparent manner and addressed in the appropriate timescale.

6. That realistic worst case conditions, including an appropriate safety margin, can be applied during compatibility studies.

7. That any operational considerations for UAS will be handled in ICAO and not in the ITU.

ICAO Position:

Unmanned aircraft systems (UAS) have great potential for innovative civil applications, provided that their operation does not introduce risks to the safety of life.

Taking into account Recommendations 1/12 and 1/13 of the 12th Air Navigation Conference (November 2012) "*That ICAO … develop and implement a comprehensive aviation frequency spectrum strategy … which includes the following objectives: … clearly state in the strategy the need for aeronautical systems to operate in spectrum allocated to an appropriate aeronautical safety service*"; and "*That ICAO support studies in the International Telecommunication Union Radio Communication Sector (ITU-R) to determine what ITU regulatory actions are required to enable use of frequency bands allocated to the fixed satellite service for remotely piloted aircraft system command and control (C2) links to ensure consistency with ICAO technical and regulatory requirements for a safety service.*", in order to support the use of FSS systems for UAS CNPC links in non-segregated airspace, the technical and regulatory actions identified by studies under **Resolution 153** (WRC-12) must be consistent with the above Recommendations, and satisfy the following conditions:

That the technical and regulatory actions should be limited to the case of UAS using satellites, as studied, and not set a precedent that puts other aeronautical safety services at risk.

1. That the technical and regulatory actions should be limited to the case of UAS using satellites, as studied, and not set a precedent that puts other aeronautical safety services at risk.

2. That all frequency bands which carry aeronautical safety communications need to be clearly identified in the Radio Regulations.

3. That the assignments and use of the relevant frequency bands have to be consistent with article **4.10** of the Radio Regulations which recognizes that safety services require special measures to ensure their freedom from harmful interference.

4. Knowledge that any assignment operating in those frequency bands:

- is in conformity with technical criteria of the Radio Regulations,
- has been successfully co-ordinated, including cases where co-ordination was not completed but the ITU examination of probability of harmful interference resulted in a favourable finding, or any caveats placed on that assignment have been addressed and resolved such that the assignment is able to satisfy the requirements to provide BLOS communications for UAS, and
- has been recorded in the International Master Frequency Register.

5. That interference to systems is reported in a transparent manner and addressed in the appropriate timescale.

6. That realistic worst case conditions, including an appropriate safety margin, can be applied during compatibility studies.

7 That any operational considerations for UAS will be handled in ICAO and not in the ITU.

WRC-15 Agenda Item 1.6

Agenda Item Title:
To consider possible additional primary allocations:

- **to the fixed-satellite service (Earth-to-space and space-to-Earth) of 250 MHz in the range between 10 GHz and 17 GHz in Region 1;**
- **to the fixed-satellite service (Earth-to-space) of 250 MHz in Region 2 and 300 MHz in Region 3 within the range 13 – 17 GHz;**

and review the regulatory provisions on the current allocations to the fixed-satellite service within each range, taking into account the results of ITU-R studies, in accordance with Resolutions 151 (WRC-12) and 152 (WRC-12), respectively;

Discussion:

This agenda item seeks to address the spectrum needs of the fixed satellite service to support projected future needs. Whilst the scope of this agenda item is limited in terms of frequency bands within which studies can take place there are a number of aeronautical systems such as Doppler navigation aids (13.25 – 13.4 GHz) and airport surface detection equipment/airborne weather radar (15.4 – 15.7 GHz) which need to be appropriately protected. Any allocation to the fixed satellite service should not adversely impact on the operation of aeronautical services in this frequency range.

ICAO Position:

To oppose any new fixed satellite service allocation unless it has been demonstrated through agreed studies that there will be no impact on aviation use of the relevant frequency band.

WRC-15 Agenda Item 1.7

Agenda Item Title:
To review the use of the band 5 091 – 5 150 MHz by the fixed-satellite service (Earth-to-space) (limited to feeder links of the non-geostationary mobile-satellite systems in the mobile-satellite service) in accordance with Resolution 114 (Rev.WRC-12);

Discussion:

In 1995 the allocation in the frequency band 5 091 – 5 150 MHz to the fixed satellite service (FSS) (Earth-to-space), limited to feeder links of the non-geostationary mobile satellite systems in the mobile satellite service, was added in order to address what at the time was perceived to be a temporary shortage of spectrum for such feeder links. To recognize the temporary nature of the allocation two clauses were added to the allocation at that time limiting the introduction of new assignments to the period up to 1 January 2008 and making the FSS secondary after the 1 January 2010. Subsequent conferences have modified these dates with the current dates being 1 January 2016 (no new frequency assignments) and 1 January 2018 (revert FSS to a secondary status) respectively.

Resolution **114** (WRC-12) calls for a review of allocations to both the aeronautical radionavigation service (ARNS) and the FSS in this band. ICAO is specifically invited to further review the detailed spectrum requirements and planning for international standard aeronautical radionavigation systems in the band. Initially this band was reserved to meet requirements for microwave landing system (MLS) assignments which could not be satisfied in the frequency band 5 030 – 5 091 MHz.

Aviation is implementing a new airport communication system under the recently allocated aeronautical mobile (R) service (AM(R)S) in the frequency band 5 091 – 5 150 MHz. Deployment and the capacity of this airport communication system is limited by the restrictions on the aggregate signal level permissible under the co-ordination arrangements established as part of agreeing to the AM(R)S allocation. Those arrangements allowed an increase in FSS satellite noise temperature ($\Delta Ts / Ts$) for the AM(R)S of 2% under the assumption that ARNS and aeronautical telemetry in the band would be contributing an additional 3% and 1% respectively. While the ARNS allocation should be maintained for the future, ARNS systems are not expected to operate in that band in the near-term, so as part of the review of the FSS allocation ICAO would wish to see a more flexible allocation of the $\Delta Ts\ /Ts$ between the various aeronautical services. Instead of limiting AM(R)S to 2% and ARNS to 3%, the regulations should be revised to restrict the combination of AM(R)S plus ARNS to a total of 5% $\Delta Ts\ /Ts$. This would allow increased flexibility for the AM(R)S while retaining the overall noise temperature increase caused by aeronautical systems operating in the band to 6%. Hence, the removal of the date limitation of the FSS can be supported, provided that stable sharing conditions with the ARNS and AM(R)S in the band are maintained and flexibility is improved in regards to $\Delta Ts\ /Ts$.

ICAO Position:

Support the removal of date limitations on the fixed satellite service (FSS) allocation in the frequency band 5091 – 5150 MHz subject to:

- the retention of the aeronautical protections contained in Resolution **114** (WRC-12).
- improving the flexibility for managing the allowed FSS satellite noise temperature increase by the aeronautical mobile (R) and aeronautical radionavigation services operating in the band 5 091-5 150 MHz.

WRC-15 Agenda Item 1.10

Agenda Item Title:
To consider spectrum requirements and possible additional spectrum allocations for the mobile-satellite service in the Earth-to-space and space-to-Earth directions, including the satellite component for broadband applications, including International Mobile Telecommunications (IMT), within the frequency range from 22 GHz to 26 GHz, in accordance with Resolution 234 (WRC-12);

Discussion:

A shortfall is predicted in the amount of mobile satellite spectrum available to support the satellite component of IMT, partly due to the failure to identify any spectrum that could be allocated to the mobile satellite service (MSS) below 16 GHz at WRC-12. This agenda item seeks to address these spectrum needs by identifying suitable spectrum for assignment to the MSS in the frequency range 22 – 26 GHz. Whilst the scope of this agenda item is limited in terms of frequency bands within which studies can take place, aviation does operate a number of airport surface detection systems in the frequency range 24.25 – 24.65 GHz in Regions 2 and 3 that need to be appropriately protected. Any allocation to the MSS should not adversely impact on the operation of aeronautical services in this frequency range.

ICAO Position:

> To oppose any new mobile satellite service allocation unless it has been demonstrated through agreed studies that there will be no impact on aviation use in the 24.25 – 24.65 GHz frequency band in Regions 2 and 3.

WRC-15 Agenda Item 1.11

Agenda Item Title:
To consider a primary allocation for the Earth exploration-satellite service (Earth-to-space) in the 7-8 GHz range, in accordance with Resolution 650 (WRC-12);

Discussion:

Limited spectrum is available for tracking, telemetry and control systems operating in the Earth exploration-satellite service (EESS) and the available spectrum is currently in use by hundreds of satellites. This agenda item seeks to identify suitable additional spectrum for allocation to the Earth exploration-satellite service in the frequency range 7 – 8 GHz to complement the existing allocation at 8 025 – 8 400 MHz. Whilst the scope of this agenda item is limited in terms of frequency bands within which studies can take place, aviation does operate a number of airborne Doppler navigation systems in the frequency band 8 750 – 8 850 MHz that need to be appropriately protected. Any allocation to the EESS should not adversely impact on the operation of aeronautical services in the frequency band 8750 – 8850 MHz.

ICAO Position:

To oppose any new allocation to the Earth exploration-satellite service, unless it has been demonstrated through agreed studies that there will be no impact on aviation use in the frequency band 8 750 – 8 850 MHz.

WRC-15 Agenda Item 1.12

Agenda Item Title:
To consider an extension of the current worldwide allocation to the Earth exploration-satellite (active) service in the frequency band 9 300 – 9 900 MHz by up to 600 MHz within the frequency bands 8 700 – 9 300 MHz and/or 9 900 – 10 500 MHz, in accordance with Resolution 651 (WRC-12);

Discussion:

The frequency band 9 000 – 9 200 MHz is used by aeronautical radar systems (ground and airborne), including Airport Surface Detection Equipment (ASDE), Airport Surface Movement Radar (ASMR) and Precision Approach Radar (PAR) sometimes combined with Airport Surface Radar (ASR). They cater for short-range surveillance and precision functions up to a 50 km (approx. 25 NM) range. In aviation, these systems are used for precision monitoring, approach and surface detection functions and in airborne weather radar systems where their shorter wavelength is suitable for the detection of storm clouds. These radars are due to remain in service for the foreseeable future. The on-going protection of the aeronautical uses of this frequency band needs to be assured.

Within ITU-R it has been argued that the impact on the aeronautical services has already been proven since the technical data is mainly identical to the outcome of studies performed prior to the allocation for the Earth exploration-satellite service (EESS) above 9 300 MHz by WRC-07. However the equipment types considered in the past were only un-modulated pulse Radars, rather than newer solid-state-based Radars that utilize pulse-compression modulation. The compatibility of these new Radar technologies with the EESS has not yet been analyzed, however they are being addressed in current ITU studies.

Whilst understanding that an increase in EESS synthetic aperture radar transmission bandwidth will increase the resolution with which objects can be measured, aviation would wish to understand the tangible benefits brought by such an increase in resolution before considering any allocation to the EESS. Additionally any proposals for the sharing of the aeronautical radionavigation frequency band 9 000 – 9 200 MHz by the EESS can only be considered on the basis of agreed studies, which take into account the present and expected future use of the band by aviation, and the constraints applied to this use. Such an allocation to EESS shall be subject to the provision that no harmful interference is caused to, nor protection is claimed from, or otherwise constraints are imposed on the operation and future development of aeronautical systems operating in the aeronautical radionavigation service in the frequency band 9 000 - 9 200 MHz. This provision protects the aeronautical utilization against harmful interference that may be caused when assignments are made with system characteristics different from those assumed in the compatibility analysis and interference mechanisms which were not foreseen in the compatibility analysis (for example the studies done for the 9 300 – 9 500 MHz allocation did not consider the radar systems with pulse compression).

ICAO Position:

Oppose any allocation to the Earth exploration-satellite service in the frequency band 9 000 – 9 200 MHz unless:-

- it has been demonstrated through agreed studies that there will be no impact on aviation use.
- no additional constraints are placed on the use of the frequency band by aeronautical systems

No change to Nos. **5.337**, **5.427**, **5.474** and **5.475**.

WRC-15 Agenda Item 1.16

Agenda Item Title:
To consider regulatory provisions and spectrum allocations to enable possible new Automatic Identification System (AIS) technology applications and possible new applications to improve maritime radiocommunication in accordance with Resolution 360 (WRC-12);

Discussion:

The maritime automatic identification system is fitted in search and rescue aircraft to allow co-ordination of search and rescue activities in which both vessels and aircraft are involved. It is essential to ensure that any change to the regulatory provisions and spectrum allocations resulting from this agenda item do not adversely impact on the capability of search and rescue aircraft to effectively communicate with vessels during disaster relief operations.

ICAO Position:

To ensure that any change to the regulatory provisions and spectrum allocations resulting from this agenda item do not adversely impact on the capability of search and rescue aircraft to effectively communicate with vessels during disaster relief operations.

WRC-15 Agenda
Item 1.17

Agenda Item Title:
To consider possible spectrum requirements and regulatory actions, including appropriate aeronautical allocations, to support wireless avionics intra-communications (WAIC), in accordance with Resolution 423 (WRC-12);

Discussion:

The civil aviation industry is developing the future generation of aircraft. This future generation is being designed to enhance efficiency and reliability while maintaining, current required levels of safety as a minimum. The use of wireless technologies in the aircraft may reduce the overall weight of systems, reducing the amount of fuel required to fly and thus benefiting the environment.

Wireless Avionics Intra-Communications (WAIC) systems provide one way to derive these benefits. WAIC systems provide for radiocommunication between two or more points on a single aircraft and constitute exclusive closed on board networks required for the operation of an aircraft. WAIC systems do not provide air-to-ground, air-to-satellite or air-to-air communications. WAIC systems will only be used for safety-related aircraft applications.

Resolution **423** calls for consideration to be initially given to frequency bands currently allocated to aeronautical services (AMS, AM(R)S and ARNS) on a worldwide basis. If existing aeronautical bands cannot support the WAIC spectrum requirements, then new aeronautical allocations should be considered.

WAIC is a communication system which carries aeronautical safety related content and should therefore be seen as an application of the aeronautical mobile (route) service (AM(R)S). Initially the spectrum requirements for WAIC need to be identified to evaluate the possible use of existing AM(R)S allocations, and as such, if the spectrum requirements cannot be met then additional AM(R)S allocations are required.

Provided that technical studies show that WAIC systems will not cause harmful interference to existing or planned aeronautical systems in the aeronautical bands, ICAO supports any necessary additional AM(R)S allocations required to support the implementation of WAIC.

ICAO Position:

Support any necessary additional global aeronautical mobile (route) service allocation required to facilitate the implementation of WAIC, provided technical studies show that WAIC systems will not cause harmful interference to existing or planned aeronautical systems operating in frequency bands allocated to aeronautical safety services.

WRC-15 Agenda Item 4

Agenda Item Title:
In accordance with Resolution 95 (Rev.WRC-07), to review the resolutions and recommendations of previous conferences with a view to their possible revision, replacement or abrogation;

ICAO Position:

Resolutions:

Resolution No.	***Title***	***Action recommended***
18 *(Rev WRC-12)*	Relating to the procedure for identifying and announcing the position of ships and aircraft of States not parties to an armed conflict	No change
20 *(Rev. WRC-03)*	Technical cooperation with developing countries in the field of aeronautical telecommunications	No change
26 *(Rev. WRC-07)*	Footnotes to the Table of Frequency Allocations in Article 5 of the Radio Regulations	No change
27 *(Rev. WRC-12)*	Use of incorporation by reference in the Radio Regulations	No change
28 *(Rev. WRC-03)*	Revision of references to the text of ITU-R recommendations incorporated by reference in the Radio Regulations	No change
63 *(Rev. WRC-12)*	Protection of radiocommunication services against interference caused by radiation from industrial, scientific and medical (ISM) equipment	No change
67	Updating and rearrangement of the Radio Regulations	Modify as necessary based on the results of

Resolution No.	***Title***	***Action recommended***
		studies carried out under WRC-15. Agenda Item 9.1
95 *(Rev. WRC-07)*	General review of the resolutions and recommendations of world administrative radio conferences and world radiocommunication conferences	No change
114 *(Rev. WRC-12)*	Studies on compatibility between new systems of the aeronautical radionavigation service and the fixed-satellite service (Earth-to-space) (limited to feeder links of the non-geostationary mobile-satellite systems in the mobile-satellite service) in the frequency band 5 091 – 5 150 MHz	Modify as necessary based on the results of studies carried out under WRC-15. Agenda Item 1.7
151	Additional primary allocations to the fixed-satellite service in frequency bands between 10 and 17 GHz in Region 1	Delete after WRC-15
152	Additional primary allocations to the fixed-satellite service in the Earth-to-space direction in frequency bands between 13 – 17 GHz in Region 2 and Region 3	Delete after WRC-15
153	To consider the use of frequency bands allocated to the fixed-satellite service not subject to Appendices 30, 30A and 30B for the control and non-payload communications of unmanned aircraft systems in non-segregated airspaces	Modify as necessary based on the results of studies carried out under WRC-15. Agenda Item 1.5

Resolution No.	***Title***	***Action recommended***
154	Consideration of technical and regulatory actions in order to support existing and future operation of fixed-satellite service earth stations within the band 3 400 – 4 200 MHz, as an aid to the safe operation of aircraft and reliable distribution of meteorological information in some countries in Region 1	Modify as necessary based on the results of studies carried out under WRC-15 Agenda Item 9.1.5. Based on the outcome of the Agenda Item, potentially extend the scope to other concerned regions (Caribbean, South America, Asia Pacific)
205 *(Rev. WRC-12)*	Protection of the systems operating in the mobile satellite service in the band 406 – 406.1 MHz	Modify as necessary based on the result of studies carried out under WRC-15. Agenda Item 9.1.1
207 *(Rev. WRC-03)*	Measures to address unauthorized use of and interference to frequencies in the bands allocated to the maritime mobile service and to the aeronautical mobile (R) service	No change
217 *(WRC-97)*	Implementation of wind profiler radars	No change
222 *(Rev. WRC-12)*	Use of the frequency bands 1 525 – 1 559 MHz and 1 626.5 – 1 660.5 MHz by the	No change

Resolution No.	***Title***	***Action recommended***
	mobile-satellite service, and procedures to ensure long-term spectrum access for the aeronautical mobile-satellite (R) service	
225 *(Rev .WRC-12)*	Use of additional frequency bands for the satellite component of IMT	No change
339 *(Rev. WRC-07)*	Coordination of NAVTEX services	No change
354 (WRC-07)	Distress and safety radiotelephony procedures for 2 182 kHz	No change
356 (WRC-07)	ITU maritime service information registration	No change
360	Consideration of regulatory provisions and spectrum allocations for enhanced Automatic Identification System technology applications and for enhanced maritime radiocommunication	Modify as necessary based on the results of studies carried out under WRC-15. Agenda Item 1.16
405	Relating to the use of frequencies of the aeronautical mobile (R) service	No change
413 *(WRC-12)*	Use of the band 108 – 117.975 MHz by aeronautical service	No change
417 (WRC-12)	Use of the frequency band 960 – 1 164 MHz by the aeronautical mobile (R) service	No change
418 (*Rev. WRC-12*)	Use of the band 5 091 – 5 250 MHz by the aeronautical mobile service for telemetry applications	Modify as necessary based on the results of studies carried out under WRC-15.

Resolution No.	***Title***	***Action recommended***
		Agenda Item 1.7
422	Development of methodology to calculate aeronautical mobile-satellite (R) service spectrum requirements within the frequency bands 1 545 – 1 555 MHz (space-to-Earth) and 1 646.5 – 1 656.5 MHz (Earth-to-space)	Modify or suppress as necessary, subject to the completion of the work.
423	Consideration of regulatory actions, including allocations, to support Wireless Avionics Intra-Communications	Modify as necessary based on the results of studies carried out under WRC-15. Agenda Item 1.17
608 *(WRC-03)*	Use of the frequency band 1 215 – 1 300 MHz by systems of the radionavigation satellite service	Delete after studies completed
609 *(WRC-07)*	Protection of aeronautical radionavigation systems from the equivalent power flux-density produced by radionavigation satellite service networks and systems in the 1 164 – 1 215 MHz band	No change
610 *(WRC-03)*	Coordination and bilateral resolution of technical compatibility issues for radionavigation satellite networks and systems in the band 1 164 – 1 300 MHz, 1 559 – 1 610 MHz and 5 010 – 5 030 MHz	No change
612 (*Rev. WRC-12*)	Use of the radiolocation service between 3 and 50 MHz to support oceanographic radar operations	No change

Resolution No.	***Title***	***Action recommended***
644 *(Rev. WRC-12)*	Radiocommunication resources for early warning, disaster mitigation and relief operations	No change
705 *(MOB-87)*	Mutual protection of radio services operating in the band 70 – 130 kHz	No change
729 *(WRC-07)*	Use of frequency adaptive systems in the MF and HF bands	Delete after WRC-15
748 (*Rev. WRC-12*)	Compatibility between the aeronautical mobile (R) service and the fixed satellite service (Earth-to-space) in the band 5 091 – 5 150 MHz	Modify as necessary based on the results of studies carried out under WRC-15. Agenda Item 1.7
957	Studies towards review of the definitions of *fixed service*, *fixed station* and *mobile station*	Delete after WRC-15

Recommendations:

Recommendation No.		***Action recommended***
7 *(Rev. WRC-97)*	Adoption of standard forms for ship station and ship earth station licences and aircraft station and aircraft earth station licences	No change
9	Relating to the measures to be taken to prevent the operation of broadcasting stations on board ships or aircraft outside national territories	No change
71	Relating to the standardization of the technical and operational characteristics of radio equipment	No change
75 *(WRC-03)*	Study on the boundary between the out-of-band and spurious domains of primary radars using magnetrons	No change
401	Relating to the efficient use of aeronautical mobile (R) worldwide frequencies	No change
608 *(Rev. WRC-07)*	Guidelines for consultation meetings established in Resolution **609 (WRC-03)**	No change

WRC-15 Agenda Item 8

Agenda Item Title:
To consider and take appropriate action on requests from administrations to delete their country footnotes or to have their country name deleted from footnotes, if no longer required, taking into account Resolution 26 (Rev. WRC-07).

Discussion:

Allocations to the aeronautical services are generally made for all ITU Regions and normally on an exclusive basis. These principles reflect the global process of standardization within ICAO for the promotion of safety and to support the global interoperability of radiocommunication and radionavigation equipment used in civil aircraft. In some instances, however, footnotes to the ITU Table of Frequency Allocations allocate spectrum in one or more countries to other radio services in addition or alternatively to the aeronautical service to which the same spectrum is allocated in the body of the table.

The use of country footnote allocations to non-aeronautical services in aeronautical bands is generally not recommended by ICAO, on safety grounds, as such use may result in harmful interference to safety services. Furthermore, this practice generally leads to an inefficient use of available spectrum to aeronautical services, particularly when the radio systems sharing the band have differing technical characteristics. It also may result in undesirable (sub-) regional variations with respect to the technical conditions under which the aeronautical allocations can be used. This can have a serious impact on the safety of aviation.

The following footnotes in aeronautical bands should be deleted for safety and efficiency reasons are discussed below:

a) In the frequency bands used for the ICAO instrument landing system (ILS), (marker beacons 74.8 – 75.2 MHz; localizer 108 – 112 MHz and glide path 328.6 – 335.4 MHz) and the VHF omni-directional radio range system (VOR); 108 – 117.975 MHz, Nos. **5.181**, **5.197** and **5.259** allow for the introduction of the mobile service on a secondary basis and subject to agreement obtained under No. **9.21** of the Radio Regulations when these bands are no longer required for the aeronautical radionavigation service. The use of both ILS and VOR is expected to continue. In addition, WRC-03, as amended by WRC-07, has introduced

No. **5.197A** stipulating that the band 108 – 117.975 MHz is also allocated on a primary basis to the aeronautical mobile (R) service (AM(R)S), limited to systems operating in accordance with recognized international aeronautical standards. Such use shall be in accordance with Resolution **413 (Rev. WRC-12)**. The use of the band 108 – 112 MHz by the AM(R)S shall be limited to systems composed of ground-based transmitters and associated receivers that provide navigational information in support of air navigation functions in accordance with recognized international aeronautical standards. As a result, access to these bands by the mobile service is not feasible, in particular since no acceptable sharing criteria that secure the protection of aeronautical systems have been established to date. Nos. **5.181**, **5.197** and **5.259** should now be deleted since they do not represent a realistic expectation for an introduction of the mobile service in these bands.

b) In the frequency band 1 215 – 1 300 MHz, which is used by civil aviation for the provision of radionavigation services through No. **5.331.** Footnote No. **5.330** allocates the band in a number of countries to the fixed and mobile service. Given the receiver sensitivity of aeronautical uses of the frequency band, ICAO does not support the continued inclusion of an additional service through country footnotes. ICAO would therefore urge administrations to remove their name from the No. **5.330**.

c) In the frequency bands 1 610.6 – 1 613.8 MHz and 1 613.8 – 1 626.5 MHz, which is assigned to the aeronautical radionavigation service, No. **5.355** allocates the band on a secondary basis to the fixed service in a number of countries. Given that this band is allocated to a safety of life service, ICAO does not support the continued inclusion of an additional service through country footnotes. ICAO would therefore urge administrations to remove their name from the No. **5.355.**

d) In the frequency band 1 559 – 1 610 MHz, which is used for elements of the ICAO global navigation satellite system (GNSS), Nos. **5.362B** and **5.362C** allow the operation of the fixed service in some countries on a primary basis until 1 January 2010 and on a secondary basis until 1 January 2015. This band is allocated, on a worldwide, primary basis, to the aeronautical radionavigation service (ARNS) and to the radionavigation-satellite service (RNSS). The band already supports operation of two prime elements of the global navigation satellite system (GNSS), i.e. global navigation satellite system (GLONASS) and global positioning system (GPS), the standards for which have been adopted into ICAO SARPs. SARPs for other RNSS systems, such as the European Galileo system, are under development. Studies undertaken in preparation for WRC-2000 indicate that a geographical separation distance exceeding line-of-sight (in the order of 400 km) between aircraft using GNSS and stations of the fixed service is required to ensure safe operation of GNSS. This is a very severe restriction, which can prohibit the safe use of GNSS over wide areas around any fixed service installation. Were a fixed service to be introduced into this band then harmful interference situations could arise leading to disruption to GNSS, affecting the safety of aircraft in flight. Thus, the WRC-2000 agreement to terminate all use by the fixed service in this band in 2015 still constitutes a severe and unacceptable constraint on the safe and effective use of GNSS in some areas of the world. It is, therefore, recommended that deletion of these allocations be effective from 2015.

e) In the frequency band 3 400 – 4 200 MHz, the existing allocation to the fixed satellite service (FSS) (space-Earth) is used to provide aeronautical VSAT service, see discussion under agenda items 1.1 and 9.1.5. No. **5.430A** allocates this band also to the mobile service in a number of States in Region 1, including States in Africa. African States are recommended to withdraw their names from this footnote.

f) In the frequency band 4 200 – 4 400 MHz, which is reserved for use by airborne radio altimeters, No. **5.439** allows the operation of the fixed service on a secondary basis in some countries. Radio altimeters are a critical element in aircraft automatic landing systems and serve as a sensor in ground proximity warning systems. Interference from the fixed service has the potential to affect the safety of all-weather operations. Deletion of this footnote is recommended.

ICAO Position:

To support deletion of Nos. **5.181, 5.197** and **5.259**, as access to the frequency bands 74.8 – 75.2, 108 – 112 and 328.6 –335.4 MHz by the mobile service is not feasible and could create the potential for harmful interference to important radionavigation systems used by aircraft at final approach and landing as well as systems operating in the aeronautical mobile service operating in the frequency band 108 – 112 MHz.

To support deletion of No. **5.330** as access to the frequency band 1 215 – 1 300 MHz by the fixed and mobile services could potentially cause harmful interference to services used to support aircraft operations.

To support deletion of No. **5.355** as access to the frequency bands 1 610.6 – 1 613.8 and 1 613.8 – 1 626.5 MHz by the fixed services could potentially jeopardize aeronautical use of these frequency bands.

To support the deletion of Nos. **5.362B** and **5.362C** as of 2015 in order to eliminate harmful interference that has been caused by the fixed service to essential aeronautical radionavigation satellite functions in the frequency band 1 559 –1 610 MHz and to permit the full utilization of GNSS services to aircraft on a global basis.

To support the removal of States in the African region from No. **5.430A** to ensure the protection of the safety operation of the aeronautical VSAT in the frequency band 3 400 – 4 200 MHz, where it is allocated on primary basis to the mobile service.

To support the deletion of No. **5.439** to ensure the protection of the safety critical operation of radio altimeters in the frequency band 4 200 – 4 400 MHz.

Note 1.— Administrations indicated in the footnotes mentioned in the ICAO Position above which are urged to remove their country names from these footnotes are as follows:

No. ***5.181*** *Egypt, Israel and Syrian Arab Republic*

No. ***5.197*** *Syrian Arab Republic*

No. ***5.259*** *Egypt, and Syrian Arab Republic*

No. ***5.330*** *Angola, Bahrain, Bangladesh, Cameroon, Chad, China, Djibouti, Egypt, Eritrea, Ethiopia, Guyana, India, Indonesia, Iran (Islamic Republic of), Iraq, Israel, Japan, Jordan, Kuwait, Nepal, Oman, Pakistan, the Philippines, Qatar, Saudi Arabia, Somalia, Sudan, South Sudan, the Syrian Arab Republic, Togo, the United Arab Emirates, and Yemen*

No. ***5.355*** *Bahrain, Bangladesh, Congo (Rep of the), Djibouti, Egypt, Eritrea, Iraq, Israel, Kuwait, Qatar, Syrian Arab Republic, Somalia, Sudan, South Sudan, Chad, Togo and Yemen*

No. ***5.362B*** *Algeria, Armenia, Azerbaijan, Belarus, Benin, Cameroon, Democratic People's Republic of Korea, Gabon, Georgia, Guinea, Guinea-Bissau, Jordan, Kazakhstan, Kyrgyzstan, Libya, Lithuania, Mali, Mauritania, Nigeria, Pakistan, Poland, Romania, Russian Federation, Saudi Arabia, Senegal, the Syrian Arab Republic, Tajikistan, Tanzania, Turkmenistan, Tunisia, Ukraine, and Uzbekistan*

No. ***5.362C*** *Chad, Congo (Rep of the), Eritrea, Iraq, Israel, Jordan, Qatar, Somalia, Sudan, South Sudan, the Syrian Arab Republic, Togo, and Yemen*

No. ***5.430A*** *Algeria, Saudi Arabia, Bahrain, Benin, Botswana, Burkina Faso, Cameroon, Congo (Rep. of the), Côte d'Ivoire, Egypt, French overseas departments and communities in Region 1, Gabon, Guinea, Israel, Jordan, Kuwait, Lesotho, Malawi, Mali, Morocco, Mauritania, Mozambique, Namibia, Niger, Oman, Qatar, the Syrian Arab Republic, the Dem. Rep. of the Congo, Senegal, Sierra Leone, South Africa, Swaziland, Chad, Togo, Tunisia, Zambia and Zimbabwe*

No. ***5.439*** *Iran (Islamic Republic of)*

WRC-15 Agenda Item 9.1

Agenda Item Title:
To consider and approve the Report of the Director of the Radiocommunication Bureau, in accordance with Article 7 of the Convention:

On the activities of the Radiocommunication Sector since WRC-12.

Note: The subdivision of Agenda item 9.1 into sub-items, such as 9.1.1, 9.1.2, etc. was made at the first session of the Conference Preparatory Meeting for WRC-15 (CPM15-1) and is summarized in the BR Administrative Circular CA/201 of 19 March 2012.

Sub-item 1 (9.1.1);
Resolution 205 – Protection of the systems operating in the mobile-satellite service in the band 406 –406.1 MHz

Discussion:

This resolution calls for studies into the protection requirements of the distress and safety system operating at 406 MHz from interference and that the Director of the Radiocommunication Bureau to report any regulatory action required to WRC-15.
Emergency Locating Transmitters (ELT's) are an element of the COSPAS-SARSAT system. Mandatory carriage of ELT's for aircraft is specified in Annex 6 to the ICAO Convention. SARPs for ELTs are contained in Annex 10 to the ICAO Convention. . The use of ELTs offers the possibility of dramatically shortening the time required to alert rescue forces to the distress and to assist in final "homing" by the rescue team. In the ITU, such beacons are named emergency position-indicating radio beacons (EPIRBs). ICAO supports the continued protection of this system through appropriate provisions in the Radio Regulations.

ICAO Position:

Support increased protection of COSPAS-SARSAT system in the frequency band 406 – 406.1 MHz.

Sub-item 5 (9.1.5);
Consideration of technical and regulatory actions in order to support existing and future operation of fixed-satellite service earth stations within the band 3 400 – 4 200 MHz, as an aid to the safe operation of aircraft and reliable distribution of meteorological information in some countries in Region 1 (Resolution 154 (WRC-12))

Discussion:

The efficient provision of air navigation services requires the implementation and operation of ground communications infrastructure with the availability, reliability and integrity in order to fulfill the performance requirements of ICAO and ITU.
In the Africa and Indian Ocean region, the difficulty of fulfilling these requirements, given the extent of the airspace and weakness in terrestrial communication infrastructure, led, in 1997, the ICAO AFI Planning and Implementation Regional Group to approve the use of fixed satellite technology (VSAT) to support terrestrial aeronautical communications services in the frequency band 3.4 – 4.2 GHz. In tropical regions, due to more pronounced rain attenuation at higher frequency bands, this frequency band remains the only viable option for satellite links with high availability.
Since the 90s, States and / or organizations in the AFI Region have developed and implemented networks of satellite-based VSAT systems in this fixed satellite service (FSS) band. These VSAT networks support all aeronautical communications services including the extension of VHF aeronautical mobile, navigation and surveillance systems.
Today, these VSAT systems constitute a real infrastructure spanning the entire African continent and beyond and the availability of the entire 3.4 – 4.2 GHz FSS band is crucial for the AFI Region to ensure the continued growth of traffic while maintaining the required level of safety in this region.
Recommendation **724**, adopted by the WRC-07, indicates that satellite communication systems operating in the fixed satellite service may be the only medium to support the requirements of the ICAO communication, navigation,

surveillance and air traffic management systems, where an adequate terrestrial communication infrastructure is not available.

WRC-07 allocated the frequency band 3.4 – 3.6 GHz to the mobile, except aeronautical mobile, service on a primary basis in some countries, including Region 1, subject to regulatory and technical restrictions (No. **5.430A**). The deployment of (non-aeronautical terrestrial) mobile service systems in vicinity of airports has led to an increased number of cases of interference into the FSS (VSAT) receivers. Consequently, some additional measures need to be adopted to improve the protection of the FSS links supporting aeronautical communications.

ICAO supports ITU-R studies on the appropriate regulatory and/or technical measures that Administrations in the AFI region should apply to facilitate protection of VSATs used for the transmission of aeronautical and meteorological information in the 3.4 – 4.2 GHz frequency band from other services operating in the band. This will ensure the continued growth of traffic while maintaining the required level of safety in this region.

Note: The problem can also occur in other regions. The 3.4 – 4.2 GHz frequency range is used by VSAT networks for aeronautical communications in tropical regions of Central/South America and the Asia Pacific as well as Africa. Hence there is a potential link to WRC-15 AI 1.1.

ICAO Position:

> To support possible technical and regulatory measures to ensure protection of VSATs used for the transmission of aeronautical and meteorological information in the frequency range 3.4 – 4.2 GHz from other services operating in the same or adjacent frequency range.

Sub-item 6 (9.1.6);
Resolution 957 – Studies towards review of the definitions of fixed service, fixed station and mobile station

Discussion:

These three definitions are indirectly related to aeronautical services and hence any change in the definitions could have an impact on the interpretation of the definition of aeronautical mobile services. This Resolution calls for studies into whether a change in the definition of these terms is required and for the Director of the Radiocommunication Bureau to report to WRC-15

ICAO Position:

Ensure that any change to the definitions as a result of a review of the studies referenced in Resolution **957** do not adversely impact aviation.

ATTACHMENT: AGENDA WRC-15

RESOLUTION 807 (WRC-12)

Agenda for the 2015 World Radiocommunication Conference

The World Radiocommunication Conference (Geneva, 2012),

considering

a) that, in accordance with No. 118 of the ITU Convention, the general scope of the agenda for a world radiocommunication conference should be established four to six years in advance and that a final agenda shall be established by the Council two years before the conference;

b) Article 13 of the ITU Constitution relating to the competence and scheduling of world radiocommunication conferences and Article 7 of the Convention relating to their agendas;

c) the relevant resolutions and recommendations of previous world administrative radio conferences (WARCs) and world radiocommunication conferences (WRCs),

recognizing

a) that WRC-12 has identified a number of urgent issues requiring further examination by WRC-15;

b) that, in preparing this agenda, some items proposed by administrations could not be included and have had to be deferred to future conference agendas,

resolves

to recommend to the Council that a world radiocommunication conference be held in 2015 for a maximum period of four weeks, with the following agenda:

1 on the basis of proposals from administrations, taking account of the results of WRC-12 and the Report of the Conference Preparatory Meeting, and with due regard to the requirements of existing and future services in the bands under consideration, to consider and take appropriate action in respect of the following items:

1.1 to consider additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for International Mobile Telecommunications (IMT) and related regulatory provisions, to facilitate the development of terrestrial mobile broadband applications, in accordance with Resolution **233 (WRC-12)**;

1.2 to examine the results of ITU-R studies, in accordance with Resolution **232 (WRC-12)**, on the use of the frequency band 694-790 MHz by the mobile, except aeronautical mobile, service in Region 1 and take the appropriate measures;

1.3 to review and revise Resolution **646 (Rev.WRC-12)** for broadband public protection and disaster relief (PPDR), in accordance with Resolution **648 (WRC-12)**;

1.4 to consider possible new allocation to the amateur service on a secondary basis within the band 5 250-5 450 kHz in accordance with Resolution **649 (WRC-12)**;

1.5 to consider the use of frequency bands allocated to the fixed-satellite service not subject to Appendices **30**, **30A** and **30B** for the control and non-payload communications of unmanned aircraft systems (UAS) in non-segregated airspaces, in accordance with Resolution **153 (WRC-12)**;

1.6 to consider possible additional primary allocations:

1.6.1 to the fixed-satellite service (Earth-to-space and space-to-Earth) of 250 MHz in the range between 10 GHz and 17 GHz in Region 1;

1.6.2 to the fixed-satellite service (Earth-to-space) of 250 MHz in Region 2 and 300 MHz in Region 3 within the range 13-17 GHz;

and review the regulatory provisions on the current allocations to the fixed-satellite service within each range, taking into account the results of ITU-R studies, in accordance with Resolutions **151 (WRC-12)** and **152 (WRC-12)**, respectively;

1.7 to review the use of the band 5 091-5 150 MHz by the fixed-satellite service (Earth-to-space) (limited to feeder links of the non-geostationary mobile-satellite systems in the mobile-satellite service) in accordance with Resolution **114 (Rev.WRC-12)**;

1.8 to review the provisions relating to earth stations located on board vessels (ESVs), based on studies conducted in accordance with Resolution **909 (WRC-12)**;

1.9 to consider, in accordance with Resolution **758 (WRC-12)**:

1.9.1 possible new allocations to the fixed-satellite service in the frequency bands 7 150-7 250 MHz (space-to-Earth) and 8 400-8 500 MHz (Earth-to-space), subject to appropriate sharing conditions;

1.9.2 the possibility of allocating the bands 7 375-7 750 MHz and 8 025-8 400 MHz to the maritime-mobile satellite service and additional regulatory measures, depending on the results of appropriate studies;

1.10 to consider spectrum requirements and possible additional spectrum allocations for the mobile-satellite service in the Earth-to-space and space-to-Earth directions, including the satellite component for broadband applications, including International Mobile Telecommunications (IMT), within the frequency range from 22 GHz to 26 GHz, in accordance with Resolution **234 (WRC-12)**;

1.11 to consider a primary allocation for the Earth exploration-satellite service (Earth-to-space) in the 7-8 GHz range, in accordance with Resolution **650 (WRC-12)**;

1.12 to consider an extension of the current worldwide allocation to the Earth exploration-satellite (active) service in the frequency band 9 300-9 900 MHz by up to 600 MHz within the frequency bands 8 700-9 300 MHz and/or 9 900-10 500 MHz, in accordance with Resolution **651 (WRC-12)**;

1.13 to review No. **5.268** with a view to examining the possibility for increasing the 5 km distance limitation and allowing space research service (space-to-space) use for proximity operations by space vehicles communicating with an orbiting manned space vehicle, in accordance with Resolution **652 (WRC-12)**;

1.14 to consider the feasibility of achieving a continuous reference time-scale, whether by the modification of coordinated universal time (UTC) or some other method, and take appropriate action, in accordance with Resolution **653 (WRC-12)**;

1.15 to consider spectrum demands for on-board communication stations in the maritime mobile service in accordance with Resolution **358 (WRC-12)**;

1.16 to consider regulatory provisions and spectrum allocations to enable possible new Automatic Identification System (AIS) technology applications and possible new applications to improve maritime radiocommunication in accordance with Resolution **360 (WRC-12)**;

1.17 to consider possible spectrum requirements and regulatory actions, including appropriate aeronautical allocations, to support wireless avionics intra-communications (WAIC), in accordance with Resolution **423 (WRC-12)**;

1.18 to consider a primary allocation to the radiolocation service for automotive applications in the 77.5-78.0 GHz frequency band in accordance with Resolution **654 (WRC-12)**;

2 to examine the revised ITU-R Recommendations incorporated by reference in the Radio Regulations communicated by the Radiocommunication Assembly, in accordance with Resolution **28 (Rev.WRC-03)**, and to decide whether or not to update the corresponding references in the Radio Regulations, in accordance with the principles contained in Annex 1 to Resolution **27 (Rev.WRC-12)**;

3 to consider such consequential changes and amendments to the Radio Regulations as may be necessitated by the decisions of the Conference;

4 in accordance with Resolution **95 (Rev.WRC-07)**, to review the resolutions and recommendations of previous conferences with a view to their possible revision, replacement or abrogation;

5 to review, and take appropriate action on, the Report from the Radiocommunication Assembly submitted in accordance with Nos. 135 and 136 of the Convention;

6 to identify those items requiring urgent action by the Radiocommunication Study Groups in preparation for the next world radiocommunication conference;

7 to consider possible changes, and other options, in response to Resolution 86 (Rev. Marrakesh, 2002) of the Plenipotentiary Conference, an advance publication, coordination, notification and recording procedures for frequency assignments pertaining to satellite networks, in accordance with Resolution **86 (Rev.WRC-07)** to facilitate rational, efficient, and economical use of radio

frequencies and any associated orbits, including the geostationary-satellite orbit;
8 to consider and take appropriate action on requests from administrations to delete their country footnotes or to have their country name deleted from footnotes, if no longer required, taking into account Resolution **26 (Rev.WRC-07)**;
9 to consider and approve the Report of the Director of the Radiocommunication Bureau, in accordance with Article 7 of the Convention:
9.1 on the activities of the Radiocommunication Sector since WRC-12;
9.2 on any difficulties or inconsistencies encountered in the application of the Radio Regulations; and
9.3 on action in response to Resolution **80 (Rev.WRC-07)**;
10 to recommend to the Council items for inclusion in the agenda for the next WRC, and to give its views on the preliminary agenda for the subsequent conference and on possible agenda items for future conferences, in accordance with Article 7 of the Convention,

resolves further

to activate the Conference Preparatory Meeting,

invites the Council

to finalize the agenda and arrange for the convening of WRC-15, and to initiate as soon as possible the necessary consultations with Member States,

instructs the Director of the Radiocommunication Bureau

to make the necessary arrangements to convene meetings of the Conference Preparatory Meeting and to prepare a report to WRC-15,

instructs the Secretary-General

to communicate this Resolution to international and regional organizations concerned.

Attachment G

Technical Information
and Frequency Sharing Criteria

1. INTRODUCTION

This attachment contains a repository of technical information for the various frequency bands relevant to aviation. This includes relevant references to other technical documentation, interference scenarios and frequency sharing criteria.

The following material was not included in the circulated version of the Handbook

Band: 130–535 kHz (selected bands)

Technical Information:

Service: Aeronautical radionavigation
Aviation use: Non-directional beacons, locator beacons
Annex 10:
SARPs: Annex 10, Volume I, Chapter 3, paragraphs 3.4 and 3.9
Frequency plan: Regional Plan
Channelization: 1 kHz spacing; in EUR Region 0.5 kHz spacing may also be used
Planning criteria:
Annex 10, Volume V, Chapter 3, paragraph 3.2
Annex 10, Volume I, Attachment C, paragraph 6
Annex 10, Volume V, Attachment B
Air Navigation Plan: European Frequency Management Manual (EUR Doc. 11), Part 3, Chapter 1 (download from http://www.paris.icao.int/documents_open/files.php?subcategory_id=96
Note.— Reference to planning criteria for other regions to be added.
RTCA: DO-179, MOPS for ADF equipment (1982)
Eurocae: ED-51, MPS for Airborne ADF Equipment (1983), Amendment #1 (1987)
ARINC characteristic: 712-7, Airborne ADF System (1992)
ITU Res./Rec.:
ITU-R: P.368: Ground wave propagation curves for frequencies between 10 kHz and 30 MHz
Other material:

- CCIR Report No. 910-1 — Sharing between the maritime mobile service and the aeronautical radionavigation service in the band 415–526.5 kHz.
  Note.— This report is published in Annex 3 to Volume VIII of the Report of the XVII Plenary Assembly of the International Radio Consultative Committee (CCIR) *(Düsseldorf, 1990).*
- *Final Acts of the Regional Administrative Conference for the Planning of the MF Maritime Mobile and Aeronautical Radionavigation Service (Region 1), Geneva 1985*

INTERFERENCE FROM NON-AERONAUTICAL SOURCES AND FREQUENCY SHARING BETWEEN NDB AND MARITIME MOBILE SERVICES IN BANDS BETWEEN 415 AND 435 kHz

The MF frequency bands allocated to aeronautical radionavigation service between 415 and 495 kHz are used for NDBs in all three ITU regions and shared with the maritime mobile service. In Region 1, in the band 415–435 kHz, the sharing is on a joint primary basis. In Regions 2 and 3, in the band 415–495 kHz (and in Region 1, in the band 435–495 kHz), the aeronautical radionavigation service is on a secondary basis although in some countries the aeronautical radionavigation service has a primary status (Footnotes 5.77 and 5.78). With careful planning and coordination, acceptable sharing arrangements can be achieved, facilitated by the geographically different areas of operation of the two services.

The protection of aeronautical beacons from transmissions of coast and ship stations of the maritime mobile service can be assured by the application of the criteria contained in Appendix 12 to the Radio Regulations. Additional guidance material is contained in Annex 10. Some ICAO regions, notably the European Region, have also agreed to apply supplementary criteria to NDB frequency assignments in their areas. An overview of the relevant provisions is given below.

ITU Radio Regulations

Appendix 12
Special Rules Applicable to Radiobeacons
Section 1 — Aeronautical Radiobeacons

1) The assignment of frequencies to aeronautical radiobeacons operating in the bands between 160 kHz and 535 kHz shall be based on a protection ratio against interference of at least 15 dB for each beacon throughout its service area.

2) The radiated power should be kept to the minimum value necessary to give the desired field strength at the service range.

3) The daylight service range of radiobeacons referred to in 1) above shall be based on the following field strengths:

4) *Regions 1 and 2*

   — 70 microvolts per metre for radiobeacons north of 30° N;

   — 120 microvolts per metre for radiobeacons between 30° N and 30° S;

— 70 microvolts per metre for radiobeacons south of 30° S.

5) *Region 3*

— 70 microvolts per metre for radiobeacons north of 40° N;

— 120 microvolts per metre for radiobeacons between 40° N and 50° S;

— 70 microvolts per metre for radiobeacons south of 50° S.

The above provisions have the status of Regulations through the linked reference at Article 28 (28.23 and 28.24), which specifies the above as special rules which must be complied with.

ICAO Annex 10

Frequency planning material relevant for NDB assignments is also contained in:

i) Annex 10, Volume I, 3.4 — Specification for non-directional radio beacon (NDB);

ii) Annex 10, Volume I, Attachment C — Information and material for guidance in the application of SARPs for ILS, VOR, PAR, 75 MHz marker beacons (en-route), NDB and DME; and

iii) Annex 10, Volume V, Attachment B — Considerations affecting the deployment of LF/MF frequencies and the avoidance of harmful interference.

The planning guidance in Attachment B of Annex 10, Volume V, is related to the RF-filtering characteristics of ADF receivers used in aircraft. These characteristics are used for developing adjacent channel NDB planning parameters for establishing the required separation distance in the case where the NDB and maritime service frequencies operate on adjacent channels.

Propagation model

Daytime propagation at low frequency (LF) and medium frequency (MF) are greatly affected by the conductivity and permittivity characteristics of the ground. Night-time transmissions from NDBs are prone to ionospheric reflection. This condition does not generally provide a reliable service and such use is not recommended. The appropriate ground wave transmission model used for frequency assignment planning is contained in ITU-R Recommendation P.368. This recommendation provides ground wave propagation data for frequencies from 10 kHz up to 30 MHz. In the frequency range of interest for NDB, there are separate curves for the frequencies of 200, 300, 400 and 500 kHz. Separate propagation curves are provided for sea and for eight different values of ground conductivity and permittivity, which must be ascertained from local knowledge to enable accurate application.

CCIR Report 910-1 — Sharing between the maritime mobile service and the aeronautical radionavigation service in the band 415–526.5 kHz

Parts of the frequency band 415–526.5 kHz are allocated to both the maritime mobile service and the aeronautical radionavigation service. As a result of differences in operational use, i.e. frequency planning characteristics, radiated power, etc., the coexistence of these two radio services in the same bands may present problems. Particular attention is required with respect to the problems which have their origin in the power levels used. In general, the coast stations of the maritime mobile service operate at power levels in the order of 20 to 30 dB higher than short- and medium-range NDBs. For example, coast station operation at e.r.p. of 10 to 50 Watts is typical as is ship station operation at 40 Watts e.r.p., whereas an NDB with a range of 50 NM would have an e.r.p. of less than 1 Watt (taking into account the relative antenna efficiencies which may be as low as 10 to 30 per cent).

This highly important report examines in detail some of the important parameters to be addressed in any analysis of these situations. The required protection to both maritime (NAVTEX services on 518 kHz) and NDB is examined for the full range of conditions of propagation. Two annexes provide detailed analysis for particular cases: Annex I for protection of NAVTEX services and Annex II for protection of NDB services.

Band: 2 850–22 000 kHz (selected bands)

Technical Information:

Service: AM(R)S
Aviation use: Air-ground communications (HF voice and data)
Annex 10:
SARPs: Annex 10, Volume III, Part II, Chapter 2, 2.4
Frequency plan: Appendix 27 (see ITU below)
Channelization: 3 kHz spacing SSB
Planning criteria: see ITU below
RTCA:
- DO-163, Minimum Performance Standards-Airborne HF Radio Communications Transmitting and Receiving Equipment Operating within the Radio-Frequency Range of 1.5 to 30 Megahertz (1976)
- DO-265, Minimum Operational Performance Standards for Aeronautical Mobile High Frequency Data Link (HFDL) (2000)
- DO-277, Minimum Aviation System Performance Standards (MASPS) for the High Frequency Data Link Operating in the Aeronautical Mobile (Route) Service (AM(R)S) (2002)

Eurocae:
ARINC characteristic:
622-4, ATS Data Link Applications Over ACARS Air-Ground Network
634, HF Data Link System Design Guidance Material
635-4, HF Data Link Protocols
714-6, Mark 3 Airborne SELCAL System
719-5, Airborne HF/SSB System
753-3, HF Data Link System
ITU Res./Rec.:
- Appendix 27 to Radio Regulations (Frequency Allotment Plan, Planning Criteria).
- Res. 207*.
- Res. 405*: Relating to the use of frequencies of the aeronautical mobile (R) service.
- Rec. 401*: Relating to the efficient use of aeronautical mobile (R) worldwide frequencies.
- Rec. 402: Relating to cooperation in the efficient use of worldwide frequencies in the aeronautical mobile (R) service.

ITU-R: ITU-R M.1458: Use of the frequency bands between 2.8 and 22 MHz by the AM(R)S for data transmission using class of emission J2D.

Other material:

- The reports of AMCP/3, AMCP/4, AMCP/5 and ADSP/3 contain ICAO material relevant to the development of SARPs for HF data link.
- DO-258A, Interoperability Requirements for ATS Applications Using ARINC 622 Data Communications (2005)

Bands: 3 023 kHz and 5 680 kHz

Technical Information:

Service: AM(R)S
Aviation use: Search and rescue frequencies in HF
Annex 10:
SARPs:
Frequency plan: Annex 10, Volume V, Chapter 2, 2.2
Channelization:
Planning criteria:
RTCA: DO-163, Minimum Performance Standards-Airborne HF Radio Communications Transmitting and Receiving Equipment Operating within the Radio-Frequency Range of 1.5 to 30 Megahertz (1976), Errata
Eurocae:
ARINC characteristic:
ITU Res./Rec.:

- Res. 405: Relating to the use of frequencies of the aeronautical mobile (R) service
- Rec. 401: Relating to the efficient use of aeronautical mobile (R) frequencies

ITU-R:
Other material:

- Radio Regulations, Chapter VII
- Radio Regulations, Appendix 27

Band: 74.8–75.2 MHz

Technical Information:

Service: Aeronautical radionavigation
Aviation use: Marker beacon
Annex 10:
SARPs: Annex 10, Volume I, Chapter 3, 3.1.7 and 3.6
Frequency plan: Fixed frequency of 75 MHz
Channelization:
Planning criteria: Annex 10, Volume I, Attachment C, Section 5
RTCA: DO-143, MOPS for Airborne Radio Marker Receiving Equipment Operating on 75 MHz (1970)
Eurocae: 1/WG7/70, MPS for 75 MHz marker beacon receiving equipment (1970)
ARINC characteristic:
ITU Res./Rec.:
ITU-R:
Other material:

Band: 108–117.975 MHz

Technical Information:

Service: Aeronautical radionavigation
Aviation use:
VOR (108–117.975 MHz)
ILS localizer (108–111.975 MHz)
GBAS (112.050–117.900 MHz)
Annex 10:
SARPs: Annex 10, Volume I, Chapter 3, 3.1 (ILS), 3.3 (VOR), 3.7 (GBAS) and Volume III, Chapter 6 (VDL Mode 4)
Frequency plan: Annex 10, Volume I, Chapter 3, 3.1.6 (ILS), 3.7.3.5.4.1 (GBAS)
Channelization: 100 kHz/50 kHz spacing for ILS, VOR and 25 kHz for GBAS
Planning criteria:
Annex 10, Volume V, Chapter 4, 4.2
Annex 10, Volume I, Attachment C, 2.6 (ILS)
Annex 10, Volume I, Attachment C, 3.5 (VOR/ILS)
Annex 10, Volume I, Appendix B, 3.6.8.2.2 and Attachment D, 7.2.1 (GBAS)
RTCA:
ILS:
- DO-195, MOPS for Airborne ILS Localizer Receiving Equipment Operating within the Radio Frequency Range of 108–112 MHz (1986)

VOR:
- DO-180A, MOPS for Airborne Area Navigation Equipment Using a Single Collocated VOR/DME Sensor Input (1990)
- DO-187, MOPS for Airborne Area Navigation Equipment Using Multi-Sensor Inputs (1984)
- DO-196, MOPS for Airborne VOR Receiving Equipment Operating within the Radio Frequency Range of 108–117.95 MHz (1986)

GBAS:
- DO-246C, GNSS Based Precision Approach Local Area Augmentation System (LAAS) — Signal-in-Space Interface Control Document (ICD) (2005)

Eurocae:
ILS:
- ED-46B, MOPS for Airborne Localizer Receiving Equipment
- ED-74, MOPS for Combined ILS and MLS Airborne Receiving Equipment, Amend. 1 (1997)
- ED-88, MOPS for MMR including ILS, MLS, and GPS used for Supplemental Means of Navigation

VOR:
- ED-22B, MPS for Airborne VOR Receiving Equipment (1988)

VOR:
- ED-27, MOPR for Airborne Area Navigation Systems Based on VOR and DME as Sensors (1979)
- ED-28, MPS for Airborne Area Navigation Computing Equipment Based on VOR and DME as Sensors
- ED-52, MPS for Conventional and Doppler VOR Ground Equipment (1984)

GBAS:
- ED-95, MASPS for GBAS to Support CAT 1 Operations (1999)
- ED-114, MOPS for GBAS Ground Facility to Support CAT 1 Approach and Landing (2003)

VDL Mode 4:
- ED-108, MOPS for VHF VDL Mode 4 Aircraft Transceiver for ADS-B (2001)

ARINC characteristic:

ILS: 578-4, Airborne ILS Receiver
ILS: 710-10, Mark 2 Airborne ILS Receiver
VOR: 579-2, Airborne VOR Receiver
VOR/ILS: 711-10, Airborne VOR ILS Receiver

ITU Res./Rec.: Res. 413 (Rev. WRC-07): Use of the band 108-117.975 MHz by the aeronautical mobile (R) service

ITU-R:
- ITU-R M44-1: Signal-to-interference ratios and minimum field strengths required in the aeronautical mobile (route) service above 30 MHz
- ITU-R.SM 1009-1: Compatibility between the Sound Broadcasting Service in the Band 87–108 MHz and the Aeronautical Services in the Band 108–137 MHz
- ITU-R M1841: Compatibility between FM sound-broadcasting in the band of about 87-108 MHz and the aeronautical ground-based augmentation system (GBAS) in the band about 108-117.975 MHz.

Other material:
- Receiver susceptibility to FM broadcast:
  - DO-176, FM Broadcast Interference related to Airborne ILS, VOR and VHF Communications (1981)
  - Annex 10, Volume I, Chapter 3, 3.1.4 (ILS)
  - Annex 10, Volume I, Attachment C, 2.2.10 (ILS)
  - Annex 10, Volume I, Chapter 3, 3.3.8 (VOR)
  - Annex 10, Volume I, Attachment C, 3.6.5 (VOR)
  - Annex 10, Volume I, Appendix B, 3.6.8.2.2 (GBAS)
  - Annex 10, Volume III, Part I, 6.3.5.4 (VDL)
- RTCA DO-117, Standard Adjustment Criteria for Airborne Localizer and Glide Slope Receivers (1963), Errata
- RTCA DO-217, MASPS for DGNSS Instrument Approach System: Special Category 1 (SCAT-1) (1993), Change 1 to DO-217 (1994), Change 2 to DO-217 (1996)

INTERFERENCE FROM NON-AERONAUTICAL SOURCES AND COMPATIBILITY BETWEEN ILS/VOR AND FM BROADCASTING

General

The ITU WARC in 1979 allocated the band at 100–108 MHz to broadcasting services in Region 1. This band was previously allocated in that way only in Regions 2 and 3. The band is adjacent to the VOR/ILS band at 108–117.975 MHz, and interference effects have been experienced due to transmissions of broadcast stations, particularly those operating on frequencies close to the band edge and in areas where there is a high density of both FM stations and ILS or VOR. In many countries, FM sound broadcasting services of both low and high power are operated in this band. In some countries, the broadcast services also include analogue television transmissions. Compatibility problems due to intermodulation products, generated by both FM transmitter stations and in ILS/VOR receivers, as well as overloading of the front end of aircraft ILS/VOR receivers, became apparent when broadcast stations commenced use of the frequencies in the band 100–108 MHz in the mid-seventies in Region 2. Studies on a suitable planning methodology initiated by the CCIR (now ITU-R) in a joint aeronautical/broadcasting group have documented a viable methodology for broadcast and aeronautical frequency assignment planning with a view to ensuring a safe situation for air operations.

Any resolution of this problem through planning and coordination automatically restricts both services. In high-density areas, such as Western Europe and North America, the full potential of the frequency band for either service cannot be realized. Both services tend to be at their greatest density in areas of high population, which places a severe constraint on the full utilization of the potential of the 40 channels available for use by ILS (see Annex 10, Volume I, 3.1.6). VOR services are also affected but not to the same critical degree. VHF communications, because of their greater frequency separation, are also affected, but to a lesser degree than ILS/VOR.

ITU-R studies

After many studies on the compatibility between ILS/VOR and FM broadcasting were initiated in ITU, ITU-R approved Recommendation SM.1009-1: “Compatibility between the Sound-Broadcasting Service in the Band of about 87-108 MHz and the Aeronautical Services in the Band 108-137 MHz” in 1995.

The three Annexes of Recommendation SM.1009 deal comprehensively with the subject and are:

Annex 1: Interference mechanism, system parameters and compatibility assessment criteria;
Annex 2: General assessment method; and
Annex 3: Detailed compatibility assessment and practical verification.

The report comprehensively covers the treatment of conflict situations for the four interference modes:

Type A: FM broadcasting-transmitter-generated interference products falling within the ILS/VOR bands. The two sub-types are:

Type A1: spurious or harmonic intermodulation products generated by one or more FM transmitters within the aeronautical band; and

Type A2: non-negligible components of the FM broadcasting signal, operating near the band edge 108 MHz, within the aeronautical band (affecting only aeronautical frequencies near the 108 MHz band edge).

Type B: ILS/VOR-receiver-generated interference caused by high-level broadcast signals operating outside the ILS/VOR band. The two sub-types are:

Type B1: interference that may be generated in the aeronautical receiver being driven into non-linearity due to high-power broadcasting signals outside the aeronautical band. The effect on the receiver resulting in the generation of intermodulation products in the receiver; and

Type B2: performance degradation due to high-power overload and desensitization without any frequency relationship.

This Recommendation, with its three detailed Annexes, provides the essential requirements for the identification and analysis of interference situations and for the coordination between broadcasting and aeronautical interests within a country or between countries. The criteria and methods have been developed and reviewed by a group of experts and represent the best available information on the subject. Furthermore, the Recommendation is recognized by aeronautical and telecommunication authorities as the definitive guidance for planning and coordination purposes.

SARPs on FM-immunity for ILS, VOR, GBAS, VDL and VHF communications

Since 1984, Annex 10 has incorporated provisions covering the FM-immunity performance of airborne receivers. These performance requirements are a considerable improvement compared to those of unmodified receivers. In many cases, compliance with these SARPs will require equipment replacement. These SARPs were incorporated to standardize the FM-immunity performance of ILS, VOR and VHF communication receivers to FM broadcast signals. While the SARPs were incorporated in the Annex with Amendment No. 65 in 1984, implementation was not required until 1998, allowing fourteen years for modification or refit. In some areas of the world, implementation is not necessary due to the lower level of implementation of both ILS/VOR and FM broadcasting stations. Implementation of these SARPs took place in Europe by 2001 and is foreseen in other regions.

The FM-immunity SARPs are contained in:

for ILS:	Annex 10, Volume I, 3.1.4, Interference immunity performance for ILS localizer receiving systems and Annex 10, Volume I, Attachment C, 2.2.9, providing guidance material;
for VOR:	Annex 10, Volume I, 3.3.8, Interference immunity performance for VOR receiving systems;
for GBAS:	Annex 10, Volume I, Appendix B, 3.6.8.2.2;
for VDL:	Annex 10, Volume III, Part I, 6.3.5.4 (VDL); and
for VHF Com:	Annex 10, Volume III, Part II, 2.3.3, Interference immunity performance and Annex 10, Volume III, Part II, Attachment, 1.3.

LEGBAC consultative arrangements

In Europe, the Limited European Group on Broadcasting Aeronautical Compatibility (LEGBAC) has developed a methodology, including software tools, to assess compatibility of assignments to FM broadcasting stations and ILS/VOR assignments. This methodology has been accepted as the European-wide assessment method. It is compliant with the provisions of the Final Acts of the 1984 ITU Broadcasting Conference, ITU-R Recommendation SM.1009 and the relevant

SARPs.

Band: 117.975–137 MHz

Technical Information:

Service: AM(R)S
Aviation use: Air-ground and air-air communication (VHF voice and data)
Annex 10:
SARPs: Annex 10, Volume III, Part II, Chapter 2, 2.1, 2.2 and 2.3
Frequency plan: Annex 10, Volume V, Chapter 4, 4.1
Channelization: 25 kHz/8.33 kHz
Planning criteria: Annex 10, Volume V, Attachment A
RTCA:
- DO-186A, MOPS for airborne radio communications equipment operating within the radio frequency range 117.975–137 MHz (1995), Change 1 (1998), Change 2 (2002)
- DO-207, MOPS for Devices that Prevent Blocked Channels Used in Two-Way Radio Communications Due to Unintentional Transmissions (1991)
- DO-209, MOPS for Devices that Prevent Blocked Channels Used in Two-Way Radio Communications Due to Simultaneous Transmissions (1992), Errata (1992)
- DO-219, MOPS for ATC Two-Way Data Link Communications (1993)
- DO-267A, MASPS for Flight Information Services Broadcast (FIS-B) Data Link (2004)
- DO-271B, Minimum Operational Performance Standards for Aircraft VDL Mode 3 Transceiver Operating in the Frequency Range 117.975–137.000 MHz (2003)
- DO-281, Minimum Operational Performance Standards for Aircraft VDL Mode 2 Physical, Link and Network Layer (2002)

Eurocae:
- ED-23B, MOPS for Airborne VHF Rx-Tx Operating in 117.975–136.975 (1995), Amendment #3 (1997)
- ED-67, MOPS for Devices That Prevent Unintentional or Continuous Transmissions
- ED-92A, MOPS for Airborne VDL Mode 2 Transceiver Operating in the Frequency Range 118–136.975 MHz (2003)

ARINC characteristic:
566A-9, Mark 3 VHF Communications Transceiver
622-4, ATS Data Link Applications Over ACARS Air-Ground Network
631-3, VHF Digital Link Implementation Provisions Functional Description
716-11, Airborne VHF Communications Transceiver
724-9, Mark 2 Aircraft Communications Addressing and Reporting System (ACARS)
750-4, VHF Data Radio

ITU Res./Rec.:

ITU-R: ITU-R SM.1009: Compatibility between the sound broadcasting service in the band 87–108 MHz and the aeronautical services in the band 108–137 MHz

Other material:

- RTCA DO-165, Initial Report on Civil Aviation Frequency Spectrum Requirements 1980-2000 (1976)
- RTCA DO-169, VHF Air-Ground Communication Technology and Spectrum Utilization (1979)
- RTCA DO-176, FM Broadcast Interference Related to Airborne ILS, VOR and VHF Communications (1981)
- RTCA DO-224B, Signal-in-space MASPS for Advanced VHF Digital Data Communications Including Compatibility with Digital Voice Techniques (2000), Change 1 (2001), Change 2 (2002)
- RTCA DO-225, VHF Air-Ground Communications System Improvements Alternatives Study and Selection of Proposals for Future Action (1994)
- RTCA DO-264, Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications (2000)
- RTCA DO-284, Next Generation Air/Ground Communication (NEXCOM) Safety and Performance Requirements (2003)
- RTCA DO-285, Next Generation Air/Ground Communication (NEXCOM) VDL Mode 3 Interoperability (2003)
- Eurocae ED-78A, Guidelines for the Approval of the Provision and Use of ATS Supported by Data Communications
- Eurocae ED-85A, Data Link Application System Document (DLASD) for the “Departure Clearance” Data Link Service
- Eurocae ED-89A, DLASD for the “ATIS” Data-link Service
- Eurocae ED-100A, Interoperability Requirements for ATS Applications Using ARINC 622 Data Communications
- Eurocae ED-106A, Data Link Application System Document for “Oceanic Clearance” (OCL) Datalink Service
- Eurocae ED-110A, Interoperability Requirements Standard for ATN Baseline 1 (Interop ATN B1)
- Eurocae ED-120, Safety and Performance Requirements Standard for Initial Air Traffic DLS in Continental Airspace

Frequency: 121.5 MHz, 123.1 MHz and 243 MHz

Technical Information:

Annex 10:
SARPs: Annex 10, Volume III, Part II, Chapter 5
Frequency plan: Annex 10, Volume V, Chapter 4
Channelization:
Planning criteria:

RTCA: DO-183, MOPS for Emergency Locator Transmitters-Automatic Fixed-ELT (AF), Automatic Portable-ELT (AP), Automatic Deployable-ELT (AD), Survival-ELT (S) Operating on 121.5 and 243.0 MHz (1983)

Eurocae: ED-62, MOPS for Aircraft Emergency Locator Transmitters (121.5/243 MHz and 406 MHz)

ARINC characteristic:

ITU Res./Rec.: Res. 18 (Mob-83) relating to the procedure for identifying and announcing the position of ships and aircraft of States not parties to an armed conflict

ITU-R: ITU-R M.690-1: Technical characteristics of emergency position-indicating radio beacons (EPIRBs) operating on the carrier frequencies of 121.5 MHz and 243 MHz (This ITU-R Recommendation is incorporated by reference in the Radio Regulations as per Appendix 15 (Table 15-2)

Other material:

- ITU Radio Regulations, Chapter VII
- RTCA DO-154, Recommended Basic Characteristics for Airborne Radio Homing and Alerting Equipment for Use with ELTs (1973)
- RTCA DO-182, ELT Equipment Installation and Performance (1982)

Band: 328.6–335.4 MHz

Technical Information:

Service: Aeronautical radionavigation
Aviation use: ILS glide path
Annex 10:
SARPs: Annex 10, Volume I, Chapter 3, 3.1.5
Frequency plan: Annex 10, Volume I, Chapter 3, 3.1.6
Channelization: 300 kHz or 150 kHz spacing
Planning criteria: as for ILS localizer
RTCA: DO-192, MOPS for Airborne ILS Glide Slope Receiving Equipment Operating within the Radio Frequency Range of 328.6–335.4 MHz (1986)
Eurocae: ED-47B, MOPS for Airborne Glide Path Receiving Equipment
ARINC characteristic: 551, Airborne Glide Slope Receiver — Mark 2
ITU Res./Rec.:
ITU-R:
Other material: RTCA DO-117, Standard Adjustment Criteria for Airborne Localizer and Glide Slope Receivers (1963), Errata

Band: 406–406.1 MHz

Technical Information:

Service: Mobile-satellite (Earth-to-space)
Aviation use: Search and rescue
Annex 10:
SARPs: Annex 6; Annex 10, Volume III, Part II, Chapter 5 and Appendix 1 to Chapter 5; and Annex 10, Volume V, Chapter 2.
RTCA: DO-204, MOPS for 406 MHz Emergency Locator Transmitters (ELT) (1989), Change 1 (1994), Change 2 (1997), Change 3 (2001)
Eurocae: ED-62, MOPS for Aircraft Emergency Locator Transmitters (121.5/ 243 MHz and 406 MHz)
ARINC characteristic:
ITU Res./Rec.: Res. 205 (Rev. Mob-87): Protection of the band 406–406.1 MHz allocated to the mobile-satellite service
ITU-R:

- ITU-R M.633 Transmission characteristics of a satellite position indicating radio beacon (satellite EPIRB) system operating through a low polar orbiting satellite system in the 406 MHz band
- ITU-R M.1478 Protection criteria for COSPAS/SARSAT search and rescue processors in the band 406–406.1 MHz.

Other material:

- COSPAS/SARSAT Doc. C/S T.001; Specifications for COSPAS/SARSAT 406 MHz distress beacons
- COSPAS/SARSAT Doc. C/S T.012; 406 MHz frequency management plan

Band: 960–1 215 MHz

Technical Information:

Service: Aeronautical radionavigation
Aviation use: DME
Annex 10:
SARPs: DME: Annex 10, Volume I, Chapter 3, 3.5
Frequency plan:
DME: Annex 10, Volume I, Chapter 3, Table A
DME: Annex 10, Volume V, Chapter 4, 4.3
Planning criteria:
DME, Annex 10, Volume I, Attachment C, Section 7
EUR ANP COM/3
RTCA:
- DO-152, Minimum Operational Characteristics-Vertical Guidance Equipment Used in Airborne Volumetric Navigational Systems (1972), Appendix D (1974)
- DO-180A, MOPS for Airborne Area Navigation Equipment Using a Single Collocated VOR/DME Sensor Input (1990)
- VOR: DO-187, MOPS for Airborne Area Navigation Equipment Using Multi-Sensor Inputs (1984)
- DO-189, MOPS for Airborne DME Operating within the Radio Frequency Range of 960–1 215 MHz (1985)

Eurocae:
- ED-27, MOPR for Airborne Area Navigation Systems Based on VOR and DME as Sensors (1979)
- ED-28, MPS for Airborne Area Navigation Computing Equipment Based on VOR and DME as Sensors
- ED-39, MOPR for Airborne Area Navigation Systems Based on Two DME as Sensors (1984)
- ED-40, MPS for Airborne Computing Equipment for Area Navigation Systems Using Two DME as Sensors (1984)
- ED-54, MPS for (DME/N and DME/P) Interrogators (airborne equipment) (1987)
- ED-57, MPS for distance measuring equipment (DME/N and DME/P) (ground equipment), (1986), Amendment #1 (1992)

ARINC characteristic: 709-8, Airborne DME Supplement 8, 709A-1, Precision Airborne DME
ITU Res./Rec.: Res. 605 (WRC-2000): Use of the frequency band 1 164–1 215 MHz by systems of the radionavigation-satellite service (space-to-Earth)

ITU-R:

- M.1639: Protection criterion for the aeronautical radionavigation service with respect to aggregate emissions from space stations in the radio-navigation-satellite service in the band 1 164–1 215 MHz
- M.1642: Methodology for assessing the maximum aggregate equivalent power flux-density at an aeronautical radionavigation service station from all radionavigation-satellite service systems operating in the 1 164–1 215 MHz band

Other material:

Band: 978 MHz

Technical Information (UAT):

Service: Aeronautical radionavigation
Aviation use: ADS-B, TIS-B, FIS-B, Universal Access Transceiver (UAT)
Annex 10:
SARPS: Annex 10, Volume III, Chapter 12
Frequency plan: Single frequency
Channelization: Single frequency
Planning criteria:
RTCA:
- DO-239, MOPS for Traffic Information Service (TIS) Data Link Communications (1997)
- DO-267A, MASPS for Flight Information Services Broadcast (FIS-B) Data Link (2004)
- DO-282A, MOPS for Universal Access Transceiver (UAT) Automated Dependent Surveillance-Broadcast (2004)
- DO-286A, MASPS for Traffic Information Services-Broadcast (TIS-B) (2005)

Eurocae:
ARINC characteristic:
ITU Res./Rec.:
ITU-R:
Other material: RTCA DO-232, Operations Concepts for Data Link Applications of Flight Information Services (1996)

Bands: 1 030 MHz and 1 090 MHz

Technical Information (SSR):

Service: Aeronautical radionavigation
Aviation use: SSR/ACAS
Annex 10:
SARPs: Annex 10, Volume IV, Chapters 3 and 4
Frequency plan: Two frequencies: 1 030 MHz for ground-to-air interrogations and 1 090 MHz for air-to-ground reply
Channelization: N/A
Planning criteria: Coordination of the pulse repetition frequency (PRF) on a national basis is required for overlapping coverage areas of SSR
RTCA:
- DO-144, Minimum Operational Characteristics-Airborne ATC Transponder Systems (1970), Change 1
- DO-181C, MOPS for ATCRBS/Mode S Airborne Equipment (2001), Change 1 (2002)
- DO-185A, Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II) Airborne Equipment (1997)
- DO-197A, Minimum Operational Performance Standards for an Active Traffic Alert and Collision Avoidance System I (Active TCAS I) (1994), Change 1 (1997)
- DO-218B, MOPS for the Mode S Airborne Data Link Processor (2001)

Eurocae:
Mode S:
- MOPS for the Airborne Data Links Processor
- ED-86, Equipment Characteristics for Mode S Transponders with Extended Interface Functions
- ED-101, MOPS for Mode S Specific Service Applications
- ED-117, MOPS for Mode S Multilateration Systems for Use in A-SMGCS (2003) [Rx or Tx/Rx]

SSR:
- 1/WG7/71, MPS for Airborne Secondary Surveillance Radar Transponder Apparatus
- ED-43, MOPR for SSR Transponder and Alticoder
- ED-73B, MOPS for SSR Mode S Transponders (2003)
- ED-115, MOPS for Light Aviation SSR Transponders (2002)

ARINC characteristic:
718-4, Mark 3 ATC Transponder (ATCRBS/Mode S)
718A-1, Mark 4 ATC Transponder (ATCRBS/Mode S)
735-2, TCAS; 735A-1 Mark 2 TCAS

ITU Res./Rec.: Res. 18 (Mob-83): Relating to the procedure for identifying and announcing the position of ships and aircraft of States not parties to an armed conflict

ITU-R:

Other material: RTCA DO-184, Traffic Alert and Collision Avoidance System (TCAS) I Functional Guidelines (1983)

Band: 1 090 MHz

Technical Information (1090ES):

Service: Aeronautical radionavigation
Aviation use: ADS-B, Mode S Extended Squitter
Annex 10:
SARPS:
Annex 10, Volume 3, Appendix to Chapter 5
Annex 10, Volume 4, Chapter 3
Frequency plan: Single frequency
Channelization: Single frequency
Planning criteria:
RTCA:
- DO-242A, Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B) (2002)
- DO-260A, MOPS for 1 090 MHz Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information Services (TIS-B) (2003)

Eurocae: ED-102, MOPS for 1 090 MHz ADS-B (2000)
ARINC characteristic: 745-2, Automatic Dependent Surveillance
ITU Res./Rec.:
ITU-R:
Other material:

Band: 1 215–1 400 MHz

Technical Information:

Service: Radiolocation/Aeronautical radionavigation/Radionavigation-satellite
Aviation use: Medium- and long-range surveillance radar
Annex 10:
SARPs:
Frequency plan: Nationally produced
Channelization: Nationally produced
Planning criteria: Nationally produced
RTCA: DO-206, MASPS for Radiodetermination Satellite Service (RDSS) (1990)
Eurocae:
ARINC characteristic:
ITU Res./Rec.:
ITU-R:

- ITU-R M.1463: Characteristics of and protection criteria for radars operating in the radiodetermination service in the frequency band 1 215–1 400 MHz
- M.1584 - Methodology for computation of separation distances between earth stations of the radionavigation-satellite service (Earth-to-space) and radars of the radiolocation service and the aeronautical radionavigation service in the frequency band 1 300-1 350 MHz

Other material:

Bands: 1 544–1 545 MHz and 1 645.5–1 646.5 MHz

Technical Information:

Service: Mobile-satellite
Aviation use: Distress and safety communications (satellite EPIRBs)
Annex 10:
SARPs:
Frequency plan:
Planning criteria:
RTCA:
Eurocae:
ARINC characteristic: 761-2, Second Generation Aviation Satellite Communications System, Aircraft Installation Provisions
ITU Res./Rec.: Radio Regulations: Article N38/Appendix 15
ITU-R:
Other material:

Bands: 1 545–1 555 MHz and 1 646.5–1 656.5 MHz

Technical Information:

Service: AMS(R)S
Aviation use: Satellite communications
Annex 10:
SARPs: Annex 10, Volume III, Part I, Chapter 4
Frequency plan: Prepared by space segment provider
Channelization:
Planning criteria:
RTCA:
- DO-215A, Guidance on Aeronautical Mobile Satellite Service (AMSS) End-to-End System Performance (1995), Change 1 (1998)
- DO-210D, MOPS for Geosynchronous Orbit Aeronautical Mobile Satellite Services (AMSS) Avionics (2000), Change 1 (2000), Change 2 (2001)
- DO-270, MASPS for the Aeronautical Mobile-Satellite (R) Service (AMS(R)S) as Used in Aeronautical Data Links (2001)

Eurocae:
ARINC characteristic:
741 P1, Aviation Satellite Communications System: Part 1 — Aircraft Installation Provisions;
741 P2, ASCS: Part 2 — System Design and Equipment Functional Description;
741 P4, ASCL: Part 4 — Specification and Description Language
ITU Res./Rec.:
- Res. 44 (Mob-87): Compatibility of equipment used in the mobile-satellite service
- Res. 222 (WRC-2000): Use of the bands 1 525–1 559 MHz and 1 626.5–1 660.5 MHz by the mobile-satellite service

ITU-R:
- ITU-R M.828-1: Definition of availability for communication circuits in the mobile-satellite service
- ITU-R M.1037: Bit error performance objectives for the AMS(R)S radio links
- ITU-R M.1089: Technical considerations for the coordination of mobile-satellite systems supporting the AMS(R)S
- ITU-R M.1180: Availability of communication circuits in the AMS(R)S
- ITU-R M.1233: Technical considerations for sharing satellite network resources between the MSS (other than AMS(R)S) and AMS(R)S
- ITU-R M.1234: Permissible level of interference in a digital channel of a geostationary satellite network in the AMS(R)S in the bands 1 545–1 555 MHz and 1 646.5–1 656.5 MHz and its associated feeder links caused by other networks of this service and the FSS

Other material:

- AMCP/5 Report
- RTCA DO-231, Design Guidelines and Recommended Standards for the Implementation and Use of AMS(R)S Voice Services in a Data Link Environment (1996)
- RTCA DO-262, MOPS for Avionics Supporting Next Generation Satellite Systems (NGSS) (2000), Change 1 (2001)

Band: 1 559–1 626.5 MHz

Technical Information:

Service: Radionavigation-satellite/Aeronautical radionavigation
Aviation use: GNSS
Annex 10:
SARPs: Annex 10, Volume I, Chapters 2 and 3
Frequency plan: GPS; GLONASS
Channelization:
Planning criteria:
RTCA:
- DO-208, MOPS for Airborne Supplemental Navigation Equipment using GPS (1991), Change 1 (1993) Errata (1995)
- DO-228, MOPS for GNSS Airborne Antenna Equipment (1999), Change 1 (2000)
- DO-229C, MOPS for Global Positioning System/Wide Area Augmentation System Airborne Equipment (2001), Errata (2002)

  Note.— DO-235A (not a Standard) is shown below under Other Material.
- DO-245A, Minimum Aviation System Performance Standards for Local Area Augmentation System (LAAS) (2004)
- DO-246C, GNSS Based Precision Approach Local Area Augmentation System (LAAS) — Signal-in-Space Interface Control Document (ICD) (2005)
- DO-253A, MOPS for GPS Local Area Augmentation System Airborne Equipment (2001)
- DO-261, NAVSTAR GPS L5 Signal Specification (2000)

Eurocae:
- ED-72A, MOPS for Airborne GPS Receiving Equipment Used for Supplemental Means of Navigation (1997)
- ED-88, MOPS for MMR including ILS, MLS, and GPS Used for Supplemental Means of Navigation
- ED-97, Interim Technical Performance Statement for EGNOS/WAAS Airborne Equipment (2000)

ARINC characteristic:
743, Airborne GPS Receiver, 743A, GNSS Sensor;
756-3, GNSS Navigation & Landing Unit
760-1, GNSS Navigation Unit (GNU)
ITU Res./Rec.:
- Res. 610 (WRC-03): Coordination and bilateral resolution of technical compatibility issues for radionavigation-satellite service networks and systems in the bands 1 164–1 300 MHz, 1 559–1 610 MHz and 5 010–5 030 MHz

- Res. 739 (Rev. WRC-07): Compatibility between the radio astronomy service and the active space services in certain adjacent and nearby frequency bands
- Res. 212 (Rev. WRC-07): Implementation of International Mobile Telecommunications in the bands 1 885–2 025 MHz and 2 110–2 200 MHz
- Res. 225 (Rev. WRC-07): Use of additional frequency bands for the satellite component of IMT

ITU-R:

- ITU-R M.823: Technical characteristics for differential transmissions for GNSS from maritime radio beacons in the frequency band 283.6–315 MHz in Region 1 and 285–325 MHz in Regions 2 and 3
- ITU-R M.1088: Considerations for sharing with systems of other services operating in the bands allocated to the radionavigation-satellite service
- ITU-R M.1317: Considerations for sharing between systems of other services operating in bands allocated to the radionavigation-satellite service and aeronautical radionavigation services and the global navigation satellite system GLONASS
- ITU-R M.1318: Interference protection evaluation model for the radionavigation-satellite service in the 1 559–1 610 MHz band
- ITU-R M.1343: Essential technical requirements of mobile earth stations for global non-geostationary mobile-satellite service systems in the band 1–3 GHz
- ITU-R M.1477: Technical and performance characteristics of current and planned radionavigation-satellite service (space-to-Earth) and aeronautical radionavigation service receivers to be considered in interference studies in the band 1 559–1 610 MHz
- ITU-R M.1480: Essential technical requirements of land mobile earth stations for global GSO MSS systems providing voice and/or data communications in the band 1–3 GHz

Other material:

- GNSS Panel Reports
- RTCA DO-235A, Assessment of Radio Frequency Interference Relevant to GNSS (2002)
- RTCA DO-292, Assessment of Radio Frequency Interference Relevant to the GNSS L5/E5A Frequency Band (2004)

PROTECTION OF GNSS IN BAND 1 559–1 610 MHz

The radionavigation-satellite band at 1 559–1 610 MHz supports the operation of the GNSS which is expected to become the future all-purpose radionavigation system for aviation operations. GPS and GLONASS, presently in operation, have been identified as the initial components of the systems that will be used, possibly with ground augmentation. Both systems are also available for all purposes where a position fixing facility is required. This includes all mobile navigation needs for land, sea or air, survey, mineral exploitation, search and rescue, etc.

Very stringent integrity and reliability standards, and other performance characteristics have been developed by the ICAO NSP (see SARPs for GNSS). Both GPS and GLONASS operate using multiple orbiting satellites (up to 24 in number) at around 20 000 km above the Earth's surface. Each satellite transmits exact orbital parameters (ephemeris data) with its corresponding highly accurate (atomic source) timing signal. Ground receivers solve four simultaneous equations for at least three sets of position data using the receivers' integral accurate time source to obtain a two-dimensional position. A minimum of four satellites is required to provide a three-dimensional position. The two systems use different methods of modulation and transmission, with GPS using pseudo-random coding transmitted on the same frequency and GLONASS using frequency division on discrete frequency for individual satellites.

Brief spectrum details of the occupation of the 1 559–1 610 MHz frequency band, present and expected, are shown in Figure 7-5. The details of the two systems presently in operation are:

> **GPS.** The centre frequency is 1 575.42 MHz. The occupied bandwidth is dependent on the type of receiver, and its tracking process coarse acquisition (C/A) code requires plus or minus 4 MHz and precision (P) code plus or minus 12 MHz.
>
> **GLONASS.** GLONASS operates on 12 frequencies spaced at 0.5625 MHz in the band between 1 598.0625 and 1 605.3750.
>
> **GNSS augmentation.** Proposals have been made for augmentation systems to improve GNSS integrity, which may operate in the lower end of the 1 559–1 610 MHz band. Protection requirements are tentative but early indications are that they would be similar to the systems already in use.

Aircraft receiving system protection

The performance requirements for the aircraft receiving system in regard to the projection from interference are contained in:

— Annex 10, Volume I

— RTCA DO-229C, *Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System (GPS/WAAS) Airborne Equipment* (2001), Errata (2002);

— RTCA DO-228, *Minimum Operational Performance Standards for Global Navigation Satellite Systems (GNSS) Airborne Antenna Equipment* (1999), Change 1 (2000).

The document RTCA DO-235A, *Assessment of Radio Frequency Interference Relevant to the GNSS* (2002), addresses the specifics of the interference situation. This document contains basic material for protection calculations.

The maximum tolerable aggregate interference power levels measured at the antenna port for aircraft receivers, as contained in Annex 10, Volume I, are:

	Tracking	**Acquisition**
GPS		
Narrow-band signals	–150.5 dBW	–156.5 dBW
Wide-band signals	–140.5 dBW per 1 MHz	–146.5 dBW per 1 MHz
GLONASS		
Narrow-band signals	–149 dBW	–155 dBW
Wide-band signals	–143 dBW per 0.5 MHz	–149 dBW per 0.5 MHz

Wide-band signals are 1 MHz and wider, and narrow-band are nominally less than 700 kHz.

Sharing and protection from other radio services

Fixed links

No published characteristics are available for the fixed links operated under Footnotes 5.362B and 5.362C by the countries included in the footnotes. Information from other work in connection with these fixed links indicates typical systems with characteristics as follows:

Frequency:	Anywhere in band 1 400–1 660 MHz at a bandwidth of 600 kHz
Output Power:	1.2 W
Antenna Gain:	up to 22 dB
Front/Back:	16 dB
Side Lobe Attenuation:	9 dB min

With these characteristics, unacceptable interference to GNSS services could exist at distances of 400 km and greater to an aircraft receiver in the main lobe of the fixed link transmitter. Ground station GNSS monitors used for augmentation may be affected within 80 km. The numbers, locations and operating frequencies of the equipment are only known to the licensing national administrations. National coordination with authorities in the countries concerned is necessary to establish the sharing possibilities on an individual site basis.

These links have the potential to inhibit GNSS operations over a wide area. The problem has been recognized internationally. ICAO Policy (Section 1 559–1 626.5 MHz of this handbook) supports the removal of the GNSS band at 1 559–1 610 MHz from both footnotes.

ICAO studies

The ICAO GNSS Panel has prepared material on the protection of GNSS to be used as ICAO input documentation to ITU-R and other discussions on this subject. This material contains the protection requirements for all GNSS and support systems that are expected to be utilized for aviation purposes.

The protection requirements for GNSS systems as stated by the NSP are:

- Minus 137 dBW/m^2/MHz (wide-band signals)
- Minus 148 dBW/m^2/MHz (narrow-band signals)

Protection of GNSS from the spurious emissions of mobile earth stations (MES)

Mobile-satellite terminals in the band 1–3 GHz

The band 1 610–1 626.5 MHz is allocated for use by mobile-satellite terminals for transmissions in the Earth-to-space direction to satellites in non-geostationary orbits (NGSO). The mobile terminals may either be fixed to a vehicle or other mobile unit, or be hand-held. The systems presently proposed may be either of CDMA (wide-band) or of FDMA (narrow-band) type. These systems generate unwanted emissions which

can interfere with GNSS services in the band 1 559–1 610 MHz.
GSO mobile-satellite systems operating in other bands between 1 and 3 GHz and particularly the Earth-to-space band at 1 660–1 660.5 MHz also have the potential to cause interference. The latter band is also used by AMS(R)S for transmissions from the aircraft (i.e. from an aeronautical earth station) to the satellite. For this situation, special measures have to be applied by aircraft systems designers to maintain the AMS(R)S signal level at the GNSS antenna below the agreed protection value.

Any of these mobile terminals may be used in the vicinity of airports, which creates the need for an international agreement to control the manufacture and use of, and the cross-border controls relating to, such terminals. The Global Mobile Personal Communications by Satellite MOU, developed jointly by ITU and the World Telecommunications Policy Forum 1996, has been raised for signature by all participating countries as an agreement addressing the import and control of mobile satellite equipment.

NGSO MES terminals

Protection of GNSS from NGSO MES is addressed by Recommendation ITU-R M.1343 (Essential technical requirements of mobile earth stations for global non-geostationary mobile-satellite systems in the band 1–3 GHz).

The purpose of this recommendation, approved in 1997, is to provide a common technical basis to:

1) establish type approval requirements for MES terminals;
2) facilitate the licensing of MES terminal operations;
3) facilitate the development of mutual recognition arrangements of type approvals of MES terminals; and
4) facilitate the development of mutual recognition arrangements to facilitate the circulation and the use of MES terminals.

GSO MES terminals

Protection of GNSS from GSO MES is addressed by Recommendation ITU-R M.1480 (Essential technical requirements of land mobile earth stations for global GSO MSS systems providing voice and/or data communications in the band 1–3 GHz).

This recommendation has been developed from a European initiative which was approved by the ITU-Radiocommunication Sector.

The data for the “carrier-on” condition only have been extracted. For the “carrier-off” condition and all other relevant data, reference should be made to the

Recommendation. The subject is complex and the information presented here is for general guidance only.

The limits relate to the level of unwanted emissions at the output of the MES in the frequency bands quoted. The first column is for terminals with antenna gain less than 8 dBi and e.i.r.p. less than 15 dBW. The measurement bandwidth is 1 MHz unless indicated otherwise.

Frequency range	**e.i.r.p. limit**	**e.i.r.p. limit**
(MHz)	(dBW)	(dBW)
1 559–1 600	–70	–70
1 600–1 605	–70	–70
1 605–1 612.5	–70 to –58.5 (1)	(2)

Notes.—

1. *Linear interpolation in dBW versus frequency.*
2. *Linearly interpreted from –70 dBW in 1 MHz at 1 605 MHz to –46 dBW at 1 610 MHz. Special conditions are applicable to GLONASS protection (see Recommendation)***.**

Band: 2 700–3 300 MHz

Technical Information:

Service: Aeronautical radionavigation/Radionavigation
Aviation use: Primary surveillance radar, surveillance radar element of precision approach radar (PAR) medium-range systems, ground-based weather radar.
Annex 10:
SARPs: Annex 10, Volume I, paragraph 3.2.4
Frequency plan:
Planning criteria:
RTCA:
Eurocae:
ARINC characteristic:
ITU Res./Rec.:
ITU-R:

- ITU-R M.629: Use for the RN service of the frequency bands 2 900–3 100 MHz, 5 470–5 650 MHz, 9 200–9 300 MHz, 9 300– 9 500 MHz and 9 500–9 800 MHz
- ITU-R M.1460: Technical and operational characteristics and protection criteria of radiodetermination and meteorological radars in the 2 900–3 100 MHz band
- ITU-R M.1461: Procedures for determining the potential for interference between radars operating in the radiodetermination service and systems in other services
- ITU-R M.1464: Characteristics of and protection criteria for radionavigation and meteorological radars operating in the frequency band 2 700–2 900 MHz
- ITU-R M.1465: Characteristics of and protection criteria for radars operating in the radiodetermination service in the frequency band 3 100–3 700 MHz

Other material:

Band: 4 200–4 400 MHz

Technical Information:

Service: Aeronautical radionavigation
Aviation use: Radio altimeters
Annex 10
SARPs:
Frequency plan:
Planning criteria:
RTCA:
- DO-155, Minimum Performance Standards — Airborne Low-range Radar Altimeters (1974)
- DO-161A, Minimum Performance Standards — Airborne Ground Proximity Warning Equipment (1976)

Eurocae:
- ED-30, MPS for Airborne Low-Range Radio (Radar) Altimeter Equipment (1980), Amend. 1 (1980)
- ED-83, Recommendations on Ground Collision Avoidance Systems

ARINC characteristic:
594-4, Ground Proximity Warning System (GPWS)
723-3, Ground Proximity Warning System
707-6, Radar Altimeter (RALT) Supplement 6
ITU Res./Rec.: Rec. No. 606 (Mob-87): The possibility of reducing the band 4 200–4 400 MHz used by radio altimeters in the aeronautical radionavigation service
ITU-R:
- Report [BL/8] (Düsseldorf 1990)
- Question 94/8: Bandwidth required for radio altimeter

Other material:

PROTECTION ASPECTS OF RADIO ALTIMETERS IN BAND 4 200-4 400 MHz

General

The frequency band at 4 200–4 400 MHz has been allocated to the aeronautical radionavigation service (ARNS) and is reserved exclusively for radio altimeters by Footnote 5.438. The radio altimeter, in one of its main applications, performs the highly important task of providing flare guidance in the last stages of automated approach to land. Equally critical is its use as an input to ground proximity warning systems (GPWS) in aircraft, which give a "pull up" warning at a predetermined altitude and closure rate.

For these applications, a good interference rejection performance is essential. Integrity standards of the order of one failure in 10^{19} operations are not uncommon. The use of a wide frequency band is an essential feature in effective designs to achieve high orders of interference rejection and freedom from disruptive effects due to the high levels of pollution of the radio environment which exist in densely populated areas.

Studies have determined the necessity for the retention of the existing 200 MHz of spectrum to meet the exacting requirements of high accuracy with good all-round performance.

ITU-R studies

CCIR Report 1186 discusses the technical background to meeting the operational performance required for modern conditions. It concludes that:

"The whole of the band 4 200 to 4 400 MHz currently allocated is required up to at least the year 2015."

In coming to this conclusion, Report 1186 reviews the accuracy requirements and the design features to meet those requirements as laid down in MOPS and MASPS. The relationship between frequency excursion and accuracy is particularly noted. Typical performance requirements are contained in ARINC Doc 707-1, Section 3.7 as follows:

- Accuracy: Within 1.5 ft., or 2 per cent if greater, in the range 20 to 2 500 ft.
- Output noise: 0.25 ft.
- Output Resolution: 0.125 ft.

Band: 5 000–5 250 MHz

Technical Information:

Service: Aeronautical radionavigation
Aviation use: MLS
Annex 10:
SARPs: Annex 10, Volume I, Chapter 3, 3.11
Frequency plan: Annex 10, Volume I, Table A
Planning criteria:
Annex 10, Volume V, Chapter 4, 4.4
Annex 10, Volume I, Attachment G, Section 9
RTCA: DO-177, MOPS for MLS airborne receiving equipment (1981), Change 1 & 2 (1986)
Eurocae:
- ED-36, MOPS for MLS Airborne Receiving Equipment
- ED-53A, MOPS for MLS Ground Based Equipment
- ED-74, MOPS for Combined ILS and MLS Airborne Receiving Equipment, Amend. 1 (1997)
- ED-88, MOPS for MMR including ILS, MLS, and GPS used for Supplemental Means of Navigation

ARINC characteristic: 727-1, Airborne Microwave Landing System
ITU Res./Rec.: Rec. 607 (Mob-87): Future requirements of the band 5 000–5 250 MHz for the aeronautical radionavigation service
ITU-R:
- ITU-R S.1342: Method for determining coordination distances, in the 5 GHz band, between the international standard microwave landing System (MLS) in the aeronautical radionavigation service (ARNS) and non-geostationary mobile-satellite service stations providing feeder uplink services
- M.1582: Method for determining coordination distances, in the 5 GHz band, between the international standard microwave landing system stations operating in the aeronautical radionavigation service and stations of the radionavigation-satellite service (Earth-to-space)

Other material: RTCA DO-226, Guidance Material for Evolving Airborne Precision Area Navigation Equipment with Emphasis on MLS (1995)

MLS COORDINATION WITH FSS IN BAND 5 090–5 150 MHz

Protection requirements for MLS (coordination with FSS earth stations)

The band 5 000–5 250 MHz is allocated to the aeronautical radionavigation service (ARNS). Footnote 5.444 gives precedence in the band 5 030–5 150 MHz to the international standard system (microwave landing system) for precision approach and landing. Footnote 5.444A allocates on a joint primary basis the band 5 091–5 150 MHz to the FSS (for mobile-satellite feeder links) in the Earth-to-space direction until the year 2010. This allocation was made by ITU WRC-95. Resolution No. 114, calling for studies of the compatibility between these two services, was approved.

The compatibility studies under Resolution 114 were carried out by ITU-R WP4A, which primarily deals with fixed-satellite systems, and it was found appropriate for the results of the work obtained in WP4A to be examined by the ICAO AWOP/16 held in 1997. AWOP/16 proposed numerous amendments, most of which were later adopted at the ITU Radiocommunication Assembly in 1997.

ITU-R Recommendations

The method for the determination of coordination distances between earth stations in the mobile-satellite service (feeder links) in the band 5 091–5 150 MHz and MLS in the band 5 030–5 090 MHz which was agreed in ITU-R is contained in ITU-R Rec. S.1342 (Method for determining coordination distances, in the 5 GHz band, between the international standard microwave landing system (MLS) in the aeronautical radionavigation service (ARNS) and non-geostationary mobile-satellite service stations providing feeder uplink services).

This Recommendation addresses only the protection of MLS in the band 5 030–5 090 MHz. This band is displayed at Table A of Annex 10, Volume I, which specifies 200 channels for MLS installations. The Recommendation recognizes that the sharing between MLS in the band 5 091–5 150 MHz and the FSS in the band 5 091–5 250 MHz, and other new ARNS in the band 5 030–5 250 MHz and FSS in the band 5 091–5 250 MHz remains to be studied. (It should also be noted that AWOP/16 concluded that co-frequency sharing between the FSS and MLS is not feasible.) The band 5 091–5 150 MHz is required to satisfy future long-term requirements.

Band: 5 350–5 470 MHz

Technical Information:

Service: Aeronautical radionavigation
Aviation use: Airborne weather radar
Annex 10:
SARPs: Annex 6, Part 1, Chapter 6, 6.11
Frequency plan:
Channelization:
Planning criteria:
RTCA:
- DO-173, Minimum Operational Performance Standards for Airborne Weather and Ground Mapping Pulsed Radars (1980), Corrigendum/Errata/Change 1
- DO-220, Minimum Operational Performance Standards for Airborne Weather Radar with Forward-Looking Windshear Detection Capability (1993), Change 1 (1995)

Eurocae:
ARINC characteristic: No. 708A-3, Airborne Weather Radar with Forward Looking Windshear Detection Capability
ITU Res./Rec.:
ITU-R:
Other material:

Band: 8 750–8 850 MHz

Technical Information:

Service: Aeronautical radionavigation/radiolocation
Aviation use: Airborne Doppler radar
Annex 10:
SARPs:
Frequency plan:
Channelization:
Planning criteria:
RTCA:
- DO-158, Minimum Performance Standards-Airborne Doppler Radar Navigation Equipment (1975)
- DO-173, Minimum Operational Performance Standards for Airborne Weather and Ground Mapping Pulsed Radars (1980), Corrigendum/Errata/Change 1
- DO-220, Minimum Operational Performance Standards (MOPS) for Airborne Weather Radar with Forward-Looking Windshear Detection Capability (1993)

Eurocae:
ARINC characteristic:
ITU Res./Rec.:
ITU-R:
Other material:

Band: 9 000–9 500 MHz

Technical Information:

Service: Aeronautical radionavigation/radionavigation
Aviation use: Primary radar 3 cm short-range applications including precision approach. Airport surface detection equipment (ASDE)
Annex 10:
SARPs: Annex 10, Volume I, Chapter 3, 3.2
Frequency plan:
Channelization:
Planning criteria:
RTCA: DO-173, Minimum Operational Performance Standards for Airborne Weather and Ground Mapping Pulsed Radars (1980), Corrigendum/ Errata/Change 1
Eurocae: ED-116, MOPS for Surface Movement Radar Sensor Systems for Use in A-SMGCS
ARINC characteristic: 708A-3, Airborne Weather Radar with Forward Looking Windshear Detection Capability
ITU Res./Rec.:
ITU-R: ITU-R M.629: Use for the radionavigation service of the radio frequency bands 2 900–3 100 MHz, 5 470–5 650 MHz, 9 200–9 300 MHz, 9 300–9 500 MHz and 9 500–9 800 MHz
Other material:

Band: 13.25–13.4 GHz

Technical Information:

Service: Aeronautical radionavigation
Aviation use: Airborne Doppler radar
Annex 10:
SARPs:
Frequency plan:
Channelization:
Planning criteria:
RTCA:
- DO-158, Minimum Performance Standards-Airborne Doppler Radar Navigation Equipment (1975)
- DO-173, Minimum Operational Performance Standards for Airborne Weather and Ground Mapping Pulsed Radars (1980), Corrigendum/Errata/Change 1
- DO-220, Minimum Operational Performance Standards (MOPS) for Airborne Weather Radar with Forward-Looking Windshear Detection Capability (1993), Change 1 (1995)

Eurocae:
ARINC characteristic:
ITU Res./Rec.:
ITU-R: ITU-R M.496.3: Limits of power flux-density of radionavigation transmitters to protect space station receivers in the fixed-satellite service in the 14 GHz band
Other material:

Band: 15.4–15.7 GHz

Technical Information:

Service: Aeronautical radionavigation/radiolocation
Aviation use: Primary radar particularly airport surface detection equipment (ASDE)
Annex 10:
SARPs:
Frequency plan:
Channelization:
Planning criteria:
RTCA: DO-173, Minimum Operational Performance Standards for Airborne Weather and Ground Mapping Pulsed Radars (1980), Corrigendum/Errata/Change 1
Eurocae: ED-116, MOPS for Surface Movement Radar Sensor Systems for use in A-SMGCS (2004)
ARINC characteristic:
ITU Res./Rec.:
ITU-R:

- ITU-R S.1340: Sharing between feeder links for the mobile-satellite service and the aeronautical radionavigation service in the Earth-to-space direction in the band 15.4–15.7 GHz
- ITU-R S.1341: Sharing between feeder links for the mobile-satellite service and the aeronautical radionavigation service in the space-to-Earth direction in the band 15.4–15.7 GHz and the protection of the radio astronomy service in the band 15.35–15.4 GHz

SHARING IN THE BAND 15.4–15.7 GHz

General

The part of the band at 15.43–15.63 GHz of the aeronautical radionavigation band 15.4–15.7 GHz is shared with the fixed-satellite service (FSS), an allocation which was made by WRC-95 and later amended by WRC-97 (Footnote 5.511A). The FSS use is restricted to feeder links for non-geostationary satellites in the mobile-satellite service. The conditions of use are covered by Footnotes 5.511A and 5.511C, which place restrictions on both services as part of the protection requirements.

ITU-R studies

Aeronautical utilization of band

The band is utilized by the ARNS for a variety of systems:

- Airport surface detection equipment (ASDE): radar systems used at civil airports for the control of surface movement;
- Radar sensing and measurement system (RSMS): sensing systems used in small aircraft and helicopters for height and other low-range measurement;
- Aircraft landing system(s) (ALS): a transportable landing system used for temporary airfields;
- Multi-purpose radar (MPR): an airborne surveillance radar.

Descriptions of these systems are given in Annex A of the ITU-R Recommendations S.1340 and S.1341 (see below).

ITU-R Recommendations

(i) Rec. ITU-R S.1340: Sharing between the ARNS and MSS Feeder Links in the Earth-to-space direction.

This recommendation contains the following limitations:

— Limits the emissions from ALS and MPR at low angles (paragraph 2.1);
— Limits horizontal emission by earth stations to 54 dB (W/MHz);
— Restricts RSMS to band 15.43 to 15.63 GHz;
— Establishes coordination distances for the protection of ALS and MPR;
— Urges the limit of 42 dBW on all ARNS stations.

(ii) Rec. ITU-R S.1341: Sharing between Feeder Links for MSS and the ARNS and the RAS in the space-to-Earth direction.

This recommendation contains the following limitations:

— Limits the power flux-density of the FSS at the Earth's surface for various angles of arrival (paragraph 2.1);
— Establishes coordination distances for ALS and MPR (paragraph 5);
— Limits earth stations to operate above 5 degrees;
— Makes provision for the protection of the radio astronomy service in the band 15.35–15.4 GHz.

Band: 24.25–24.65 GHz

Technical Information:

Service: Radionavigation
Aviation use: Primary radar: airport surface detection equipment (ASDE)
Annex 10:
SARPs:
Frequency plan:
Channelization:
Planning criteria:
RTCA:
Eurocae:
ARINC characteristic:
ITU Res./Rec.:
ITU-R:
Other material:

Band: 31.8–33.4 GHz

Technical Information:

Service: Radionavigation
Aviation use: Airport surface detection equipment (ASDE)
Annex 10:
SARPs:
Frequency plan:
Channelization:
Planning criteria:
RTCA:
Eurocae:
ARINC characteristic:
ITU Res./Rec.: Rec. No. 707 (WARC-79): Relating to the use of the frequency band 32–33 GHz shared between the inter-satellite service and the radionavigation service.
ITU-R:
Other material:

Attachment H

ITU RESOLUTIONS AND RECOMMENDATIONS
(as contained in the Radio Regulations)

1. INTRODUCTION

The ITU Resolutions and Recommendations contained in the Radio Regulations and referenced below are relevant to specific frequency bands used by aviation, specific aviation safety systems or certain WRC agenda items referenced in the ICAO Position.

Resolution	Footnotes/ WRC-15 agenda item	Band Description
18 (Rev. WRC-12)	—	
67 (WRC-12)	**WRC-15 AI 9**	Re-arrangement of the Radio Regulations
75 (Rev. WRC-12)	5.547	31.8–32.3 and 37-38 GHz
114 (Rev. WRC-12)	5.444; 5.444A **WRC-15 AI 1.7**	5 091–5 150 MHz
151 (WRC-12)	**WRC-15 AI 1.6**	10-17 GHz Region 1, Fixed satellite service
152 (WRC-12)	**WRC-15 AI 1.6**	13-17 GHz Region 2&3, Fixed satellite service
153 (WRC-12)	**WRC-15 AI 1.5**	Use of non-safety, un-protected fixed satellite spectrum for unmanned aircraft
154 (WRC-12)	**WRC-15 AI 9.1**	3400-4200 MHz; VSAT
205 (Rev. WRC-12)	—	406–406.1 MHz
207 (Rev. WRC-03)	—	Aeronautical HF bands
215 (Rev. WRC-12)		L-band mobile satellite/AMS(R)S spectrum
221 (Rev. WRC-07)	5.444	5 030–5 150 MHz
222 (Rev. WRC-07)	5.353A; 5.357A	L-band mobile satellite/AMS(R)S spectrum
233 (WRC-12)	**WRC-15 AI 1.1**	Mobile broadband below 6 GHz

Resolution	Footnotes/ WRC-15 agenda item	Band Description
225 (Rev. WRC-12)	5.351A	L band mobile satellite; GNSS, 2700-2900 MHz
229 (WRC-12)	5.446A	5 150–5 350 MHz
405	—	Aeronautical HF bands
413 (Rev. WRC-12)	5.197A	108–117.975 MHz; AM(R)S
417 (Rev. WRC-12)	5.327A	960–1 164 MHz; AM(R)S
418 (Rev. WRC-12)	5.444B	5 091–5 150 MHz (AMS)
422 (WRC-12)		L-band mobile satellite/AMS(R)S spectrum
423 (WRC-12)	**WRC-15 AI 1.17**	WAIC
608 (WRC-03)	5.329	1 215–1 300 MHz
609 (Rev. WRC-07)	5.328A	1 164–1 215 MHz
610 (WRC-03)	5.328B	1 164–1 300 MHz; 1 559–1 610 MHz; 5 010–5 030 MHz
651 (WRC-12)	**WRC-15 AI 1.12**	9000-9200 MHz Earth exploration satellite service
739 (Rev. WRC-07)	5.208B	1 525–1 559 MHz; 1 559–1 610 MHz
748 (Rev. WRC-12)	5.444B	5 091–5 150 MHz (AMS, FSS)
750(Rev. WRC-12)	5.338A	1350–1400 MHz
804 (Rev. WRC-12)		Establishment of WRC Agendas
807 (WRC-12)		Agenda for WRC-15
808 (WRC-12)		Agenda for WRC-18
957		Definition of mobile and fixed services
Recommendation	**Footnotes**	**Band**
401	—	Aeronautical HF bands
608 (Rev. WRC-07)	—	1 164–1 215 MHz
707	5.548	31.8–33 GHz
724 (WRC-07)	—	Use of VSAT stations
201 (WRC12)		Mob. Sat and ground components

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