

International Standards
and Recommended Practices



Annex 10
to the Convention on
International Civil Aviation

Aeronautical Telecommunications

Volume V
Aeronautical Radio Frequency
Spectrum Utilization

This edition incorporates all amendments adopted by the Council prior to 13 March 2001 and supersedes, on 1 November 2001, all previous editions of Annex 10, Volume V.

For information regarding the applicability of the Standards and Recommended Practices, see Foreword.

Second Edition
July 2001

International Civil Aviation Organization

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**Annex 10
to the Convention on
International Civil Aviation**

Aeronautical Telecommunications

**Volume V
Aeronautical Radio Frequency
Spectrum Utilization**

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For information regarding the applicability of the Standards and Recommended Practices, see Foreword.

Second Edition
July 2001

International Civil Aviation Organization

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.

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FOREWORD

Historical background

Standards and Recommended Practices for Aeronautical Telecommunications were first adopted by the Council on 30 May 1949 pursuant to the provisions of Article 37 of the Convention on International Civil Aviation (Chicago 1944) and designated as Annex 10 to the Convention. They became effective on 1 March 1950. The Standards and Recommended Practices were based on recommendations of the Communications Division at its Third Session in January 1949.

Up to and including the Seventh Edition, Annex 10 was published in one volume containing four parts together with associated attachments: Part I — Equipment and Systems, Part II — Radio Frequencies, Part III — Procedures, and Part IV — Codes and Abbreviations.

By Amendment 42, Part IV was deleted from the Annex; the codes and abbreviations contained in that part were transferred to a new document, Doc 8400.

As a result of the adoption of Amendment 44 on 31 May 1965, the Seventh Edition of Annex 10 was replaced by two volumes: Volume I (First Edition) containing Part I — Equipment and Systems, and Part II — Radio Frequencies, and Volume II (First Edition) containing Communication Procedures.

As a result of the adoption of Amendment 70 on 20 March 1995, Annex 10 was restructured to include five volumes: Volume I — *Radio Navigation Aids*; Volume II — *Communication Procedures*; Volume III — *Communication Systems*; Volume IV — *Surveillance Radar and Collision Avoidance Systems*; and Volume V — *Aeronautical Radio Frequency Spectrum Utilization*. By Amendment 70, Volumes III and IV were published in 1995 and Volume V was published in 1996 with Amendment 71.

Table A shows the origin of amendments to Annex 10, Volume V subsequent to Amendment 71, together with a summary of the principal subjects involved and the dates on which the Annex and the amendments were adopted by Council, when they became effective and when they became applicable.

Action by Contracting States

Notification of differences. The attention of Contracting States is drawn to the obligation imposed by Article 38 of the

Convention by which Contracting States are required to notify the Organization of any differences between their national regulations and practices and the International Standards contained in this Annex and any amendments thereto. Contracting States are invited to extend such notification to any differences from the Recommended Practices contained in this Annex and any amendments thereto, when the notification of such differences is important for the safety of air navigation. Further, Contracting States are invited to keep the Organization currently informed of any differences which may subsequently occur, or of the withdrawal of any differences previously notified. A specific request for notification of differences will be sent to Contracting States immediately after the adoption of each amendment to this Annex.

The attention of States is also drawn to the provisions of Annex 15 related to the publication of differences between their national regulations and practices and the related ICAO Standards and Recommended Practices through the Aeronautical Information Service, in addition to the obligation of States under Article 38 of the Convention.

Promulgation of information. The establishment and withdrawal of and changes to facilities, services and procedures affecting aircraft operations provided in accordance with the Standards, Recommended Practices and Procedures specified in Annex 10 should be notified and take effect in accordance with the provisions of Annex 15.

Use of the text of the Annex in national regulations. The Council, on 13 April 1948, adopted a resolution inviting the attention of Contracting States to the desirability of using in their own national regulations, as far as practicable, the precise language of those ICAO Standards that are of a regulatory character and also of indicating departures from the Standards, including any additional national regulations that were important for the safety or regularity of air navigation. Wherever possible, the provisions of this Annex have been deliberately written in such a way as would facilitate incorporation, without major textual changes, into national legislation.

Status of Annex components

An Annex is made up of the following component parts, not all of which, however, are necessarily found in every Annex; they have the status indicated:

1.— *Material comprising the Annex proper:*

- a) *Standards and Recommended Practices* adopted by the Council under the provisions of the Convention. They are defined as follows:

Standard: Any specification for physical characteristics, configuration, matériel, performance, personnel or procedure, the uniform application of which is recognized as necessary for the safety or regularity of international air navigation and to which Contracting States will conform in accordance with the Convention; in the event of impossibility of compliance, notification to the Council is compulsory under Article 38.

Recommended Practice: Any specification for physical characteristics, configuration, matériel, performance, personnel or procedure, the uniform application of which is recognized as desirable in the interest of safety, regularity or efficiency of international air navigation, and to which Contracting States will endeavour to conform in accordance with the Convention.

- b) *Appendices* comprising material grouped separately for convenience but forming part of the Standards and Recommended Practices adopted by the Council.
- c) *Definitions* of terms used in the Standards and Recommended Practices which are not self-explanatory in that they do not have accepted dictionary meanings. A definition does not have independent status but is an essential part of each Standard and Recommended Practice in which the term is used, since a change in the meaning of the term would affect the specification.
- d) *Tables and Figures* which add to or illustrate a Standard or Recommended Practice and which are referred to therein, form part of the associated Standard or Recommended Practice and have the same status.

2.— *Material approved by the Council for publication in association with the Standards and Recommended Practices:*

- a) *Forewords* comprising historical and explanatory material based on the action of the Council and including an explanation of the obligations of States with regard to the application of the Standards and Recommended Practices ensuing from the Convention and the Resolution of Adoption;
- b) *Introductions* comprising explanatory material introduced at the beginning of parts, chapters or sections of the Annex to assist in the understanding of the application of the text;
- c) *Notes* included in the text, where appropriate, to give factual information or references bearing on the

Standards or Recommended Practices in question, but not constituting part of the Standards or Recommended Practices;

- d) *Attachments* comprising material supplementary to the Standards and Recommended Practices, or included as a guide to their application.

Disclaimer regarding patents

Attention is drawn to the possibility that certain elements of Standards and Recommended Practices in this Annex may be the subject of patents or other intellectual property rights. ICAO shall not be responsible or liable for not identifying any or all such rights. ICAO takes no position regarding the existence, validity, scope or applicability of any claimed patents or other intellectual property rights, and accepts no responsibility or liability therefore or relating thereto.

Selection of language

This Annex has been adopted in four languages — English, French, Russian and Spanish. Each Contracting State is requested to select one of those texts for the purpose of national implementation and for other effects provided for in the Convention, either through direct use or through translation into its own national language, and to notify the Organization accordingly.

Editorial practices

The following practice has been adhered to in order to indicate at a glance the status of each statement: *Standards* have been printed in light face roman; *Recommended Practices* have been printed in light face italics, the status being indicated by the prefix **Recommendation**; *Notes* have been printed in light face italics, the status being indicated by the prefix *Note*.

The following editorial practice has been followed in the writing of specifications: for Standards the operative verb “shall” is used, and for Recommended Practices the operative verb “should” is used.

The units of measurement used in this document are in accordance with the International System of Units (SI) as specified in Annex 5 to the Convention on International Civil Aviation. Where Annex 5 permits the use of non-SI alternative units these are shown in parentheses following the basic units. Where two sets of units are quoted it must not be assumed that the pairs of values are equal and interchangeable. It may, however, be inferred that an equivalent level of safety is achieved when either set of units is used exclusively.

Any reference to a portion of this document, which is identified by a number and/or title, includes all subdivisions of that portion.

Table A. Amendments to Annex 10, Volume V

| <i>Amendment</i> | <i>Source(s)</i> | <i>Subject(s)</i> | <i>Adopted Effective Applicable</i> |
|---------------------|---|---|--|
| 71 | Air Navigation Commission; SP COM/OPS/95 Divisional Meeting; third meeting of the Aeronautical Mobile Communications Panel (AMCP) | Introduction of new Volume V consisting of existing Annex material and addition of material relating to the introduction of 8.33 kHz channel spacing and changes to material related to the protection of air-ground communications in the VHF band. | 12 March 1996 15 July 1996 7 November 1996 |
| 72 | Air Navigation Commission; fourth meeting of the Aeronautical Mobile Communications Panel (AMCP) | Definition for VHF digital link; amendment to Table 4-1 (<i>bis</i>). | 12 March 1997 21 July 1997 6 November 1997 |
| 73 | — | No change. | — |
| 74 | Air Navigation Commission | Introduction of: a) an inter-pilot air-to-air channel; and b) changes to specifications on emergency locator transmitters. | 18 March 1999 19 July 1999 4 November 1999 |
| 75 | Air Navigation Commission; sixth meeting of the Aeronautical Mobile Communications Panel (AMCP) | Clarification of guidance material on VDL interference immunity performance. | 13 March 2000 17 July 2000 2 November 2000 |
| 76 (2nd Edition) | Seventh meeting of the Aeronautical Mobile Communications Panel (AMCP) | Integrated voice and data link system (VDL Mode 3); data link satisfying surveillance applications (VDL Mode 4); update of references to the ITU Radio Regulations. | 12 March 2001 16 July 2001 1 November 2001 |
| 77 | Secretariat | Consequential changes resulting from GNSS SARPs which provide for GBAS data broadcast in the band 108 – 117.975 MHz. | 27 February 2002 15 July 2002 28 November 2002 |
| 78 | — | No change. | — |
| 79 | — | No change. | — |
| 80 | — | No change. | — |
| 81 | — | No change. | — |
| 82 | — | No change. | — |
| 83 | — | No change. | — |
| 84 | — | No change. | — |
| 85 | — | No change. | — |
| 86 | — | No change. | — |
| 87 | — | No change. | — |

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

CHAPTER 1. DEFINITIONS

Note.— All references to “Radio Regulations” are to the Radio Regulations published by the International Telecommunication Union (ITU). Radio Regulations are amended from time to time by the decisions embodied in the Final Acts of World Radiocommunication Conferences held normally every two to three years. Further information on the ITU processes as they relate to aeronautical radio system frequency use is contained in the Handbook on Radio Frequency Spectrum Requirements for Civil Aviation including statement of approved ICAO policies (Doc 9718).

When the following terms are used in this volume of the Annex, they have the following meanings:

Alternative means of communication. A means of communication provided with equal status, and in addition to the primary means.

Double channel simplex. Simplex using two frequency channels, one in each direction.

Note.— This method was sometimes referred to as cross-band.

Duplex. A method in which telecommunication between two stations can take place in both directions simultaneously.

Frequency channel. A continuous portion of the frequency spectrum appropriate for a transmission utilizing a specified class of emission.

Note.— The classification of emissions and information relevant to the portion of the frequency spectrum appropriate for a given type of transmission (bandwidths) are specified in the Radio Regulations, Article S2 and Appendix S1.

Offset frequency simplex. A variation of single channel simplex wherein telecommunication between two stations is effected by using in each direction frequencies that are

intentionally slightly different but contained within a portion of the spectrum allotted for the operation.

Operational control communications. Communications required for the exercise of authority over the initiation, continuation, diversion or termination of a flight in the interest of the safety of the aircraft and the regularity and efficiency of a flight.

Note.— Such communications are normally required for the exchange of messages between aircraft and aircraft operating agencies.

Primary means of communication. The means of communication to be adopted normally by aircraft and ground stations as a first choice where alternative means of communication exist.

Simplex. A method in which telecommunication between two stations takes place in one direction at a time.

Note.— In application to the aeronautical mobile service, this method may be subdivided as follows:

- a) single channel simplex;
- b) double channel simplex;
- c) offset frequency simplex.

Single channel simplex. Simplex using the same frequency channel in each direction.

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

CHAPTER 2. DISTRESS FREQUENCIES

Introduction

Note.— ITU Radio Regulations Article S30 provides general conditions for distress and safety communications for all mobile services. Appendix S13 designates the frequencies to be used for these situations. The aeronautical mobile service is also permitted under Appendix S13, Part A1, Section 1 to conform to special arrangements between governments where these have been agreed. ICAO Annexes constitute such agreements.

The Standards and Recommended Practices relating to radio frequencies for distress communications take into account certain procedures that have been adopted by ICAO and also certain provisions made by the ITU in its Radio Regulations.

Annex 10, Volume II requires that an aircraft in distress when it is airborne should use the frequency in use for normal communications with aeronautical stations at the time. However, it is recognized that, after an aircraft has crashed or ditched, there is a need for designating a particular frequency or frequencies to be used in order that uniformity may be attained on a worldwide basis, and so that a guard may be maintained or set up by as many stations as possible including direction-finding stations, and stations of the maritime mobile service.

The frequency 2 182 kHz also offers possibilities for communication between aircraft and stations of the maritime mobile service. The ITU Radio Regulations specify in Appendix S13, Part A2 that the frequency 2 182 kHz is the international distress frequency for radiotelephony to be used for that purpose by ship, aircraft and survival craft stations using frequencies in the authorized bands between 1 605 kHz and 4 000 kHz when requesting assistance from the maritime service.

With respect to emergency locator transmitters (ELTs) designed to be detected and located by satellite, the Radio Regulations authorize the use of these devices, which are referenced in ITU as satellite emergency position indicating radio beacons (EPIRBs). Radio Regulations Appendix S13, Part A2 specifies that the band 406 – 406.1 MHz is used exclusively by satellite emergency position indicating radio beacons in the earth-to-space direction.

The frequency 4 125 kHz is also authorized by the ITU to enable communications between stations in the maritime mobile service and aircraft stations in distress. The current ITU Radio Regulations (RR S5.130 and Appendix S13) state that the carrier frequency 4 125 kHz may be used by aircraft stations to communicate with stations of the maritime mobile

service for distress and safety purposes. The aeronautical mobile (R) service frequencies 3 023 kHz and 5 680 kHz may be employed for coordinated search and rescue operations with the maritime mobile service under RR S5.115.

Similarly, the frequency 500 kHz (RR S5.83) is the international distress frequency for Morse radiotelegraphy to be used for that purpose by ship, aircraft and survival craft stations using frequencies in the bands between 415 kHz and 535 kHz when requesting assistance from the maritime service (RR Appendix S13, Part A2).

With respect to survival craft stations, the Radio Regulations provide for the use of the frequency(ies) 500 kHz, 8 364 kHz, 2 182 kHz, 121.5 MHz and 243 MHz, if the survival craft is capable of operating in the bands 415 – 535 kHz, 4 000 – 27 500 kHz, 1 605 – 2 850 kHz, 117.975 – 137 MHz and 235 – 328.6 MHz respectively (RR Appendix S13, Part A2).

2.1 Frequencies for emergency locator transmitters (ELTs) for search and rescue

2.1.1 Until 1 January 2005 emergency locator transmitters carried in compliance with Standards of Annex 6, Parts I, II and III shall operate either on both 406 MHz and 121.5 MHz or on 121.5 MHz.

2.1.2 All emergency locator transmitters installed on or after 1 January 2002 and carried in compliance with Standards of Annex 6, Parts I, II and III shall operate on both 406 MHz and 121.5 MHz.

2.1.3 From 1 January 2005, emergency locator transmitters carried in compliance with Standards of Annex 6, Parts I, II and III shall operate on both 406 MHz and 121.5 MHz.

Note 1.— ITU Radio Regulations (S5.256 and Appendix S13) provide for the use of 243 MHz in addition to the above frequencies.

Note 2.— Specifications for ELTs are found in Annex 10, Volume III, Part II, Chapter 5.

2.2 Search and rescue frequencies

2.2.1 Where there is a requirement for the use of high frequencies for search and rescue scene of action coordination

purposes, the frequencies 3 023 kHz and 5 680 kHz shall be employed.

2.2.2 Recommendation.— *Where specific frequencies are required for communication between rescue coordination centres and aircraft engaged in search and rescue operations, they should be selected regionally from the appropriate aeronautical mobile frequency bands in light of the nature of*

the provisions made for the establishment of search and rescue aircraft.

Note.— *Where civil commercial aircraft take part in search and rescue operations, they will normally communicate on the appropriate en-route channels with the flight information centre associated with the rescue coordination centre concerned.*

CHAPTER 3. UTILIZATION OF FREQUENCIES BELOW 30 MHz

Introduction

High frequency bands allocated to the aeronautical mobile (R) service

The frequency bands between 2.8 MHz and 22 MHz allocated to the aeronautical mobile (R) service are given in Article S5 of the ITU Radio Regulations. The utilization of these bands must be in accordance with the relevant provisions of the Radio Regulations. Prior to 1 September 1979, the provisions are contained in the Final Acts of the ITU Extraordinary Administrative Radio Conference (Geneva 1966). On 1 September 1979, revised provisions came into force, details of which are contained in the Final Acts of the World Administrative Radio Conference for the Aeronautical Mobile (R) Service (Geneva 1978) and Appendix 27 Aer2 to the Radio Regulations, except the Frequency Allotment Plan which entered into force at 0001 hours UTC, 1 February 1983. In the Radio Regulations, 1998 version, based on the World Administrative Radio Conference for the Mobile Services (1987), Appendix S27 now incorporates editorial amendments to Appendix 27 Aer2. In the utilization of these bands, States' attention is drawn to the possibility of harmful radio interference from non-aeronautical sources of radio frequency energy and the need to take appropriate measures to minimize its effects.

3.1 Method of operations

3.1.1 In the aeronautical mobile service, single channel simplex shall be used in radiotelephone communications utilizing radio frequencies below 30 MHz in the bands allocated exclusively to the aeronautical mobile (R) service.

3.1.2 Assignment of single sideband channels

3.1.2.1 Single sideband channels shall be assigned in accordance with Volume III, Part II, Chapter 2, 2.4.

3.1.2.2 For the operational use of the channels concerned administrations shall take into account the provisions of S27/19 of Appendix S27 of the ITU Radio Regulations.

3.1.2.3 **Recommendation.**— *The use of aeronautical mobile (R) frequencies below 30 MHz for international operations should be coordinated as specified in Appendix S27 of the ITU Radio Regulations as follows:*

S27/19 The International Civil Aviation Organization (ICAO) co-ordinates radiocommunications of the aeronautical mobile (R) service with international aeronautical operations and this Organization should be consulted in all appropriate cases in the operational use of the frequencies in the Plan.

3.1.2.4 **Recommendation.**— *Where international operating requirements for HF communications cannot be satisfied by the Frequency Allotment Plan at Part 2 of Appendix S27 to the Radio Regulations, an appropriate frequency may be assigned as specified in Appendix S27 by the application of the following provisions:*

S27/20 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.

Note.— Part I, Section II B of Appendix S27 relates to Interference Range Contours, and application of the procedure results in a protection ratio of 15 dB.

S27/21 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.

S27/22 The co-ordination described in No. S27/21 shall be effected where appropriate and desirable for the efficient utilization of the frequencies in question, and especially when the procedures of No. S27/19 are unsatisfactory.

3.1.2.5 The use of classes of emission J7B and J9B shall be subject to the following provisions of Appendix S27:

S27/12 For radiotelephone emissions the audio frequencies will be limited to between 300 and 2 700 Hz and the occupied bandwidth of other authorized emissions

will not exceed the upper limit of J3E emissions. In specifying these limits, however, no restriction in their extension is implied in so far as emissions other than J3E are concerned, provided that the limits of unwanted emissions are met (see Nos. S27/73 and S27/74).

S27/14 On account of the possibility of interference, a given channel should not be used in the same allotment area for radiotelephony and data transmissions.

S27/15 The use of channels derived from the frequencies indicated in S27/18 for the various classes of emissions other than J3E and H2B will be subject to special arrangements by the administrations concerned and affected in order to avoid harmful interference which may result from the simultaneous use of the same channel for several classes of emission.

3.1.3 Assignment of frequencies for aeronautical operational control communications

3.1.3.1 Worldwide frequencies for aeronautical operational control communications are required to enable aircraft operating agencies to meet the obligations prescribed in Annex 6, Part I. Assignment of these frequencies shall be in accordance with the following provisions of Appendix S27:

S27/9 A world-wide allotment area is one in which frequencies are allotted to provide long distance communications between an aeronautical station within that allotment area and aircraft operating anywhere in the world.*

S27/217 The world-wide frequency allotments appearing in the tables at No. S27/213 and Nos. S27/218 to S27/231, 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.

* The type of communications referred to in S27/9 may be regulated by administrations.

Note 1.— Tables S27/213 and S27/218 to S27/231 appearing in Appendix S27 to the ITU Radio Regulations refer to, respectively, the Frequency Allotment Plan, listing frequencies by areas, and the Frequency Allotment Plan, listing frequencies in numerical order.

Note 2.— Guidance material on the assignment of worldwide frequencies is contained in Attachment C.

3.2 NDB frequency management

3.2.1 **Recommendation.**— *NDB frequency management should take into account the following:*

- a) the interference protection required at the edge of the rated coverage;*
- b) the application of the figures shown for typical ADF equipment;*
- c) the geographical spacings and the respective rated coverages;*
- d) the possibility of interference from spurious radiation generated by non-aeronautical sources (e.g. electric power services, power line communication systems, industrial radiation, etc.).*

Note 1.— Guidance material to assist in determining the application of the foregoing is given in Attachment B.

Note 2.— Attention is drawn to the fact that some portions of the bands available for aeronautical beacons are shared with other services.

3.2.2 **Recommendation.**— *To alleviate frequency congestion problems at locations where two separate ILS facilities serve opposite ends of a single runway, the assignment of a common frequency to both of the outer locators should be permitted, and the assignment of a common frequency to both of the inner locators should be permitted, provided that:*

- a) the operational circumstances permit;*
- b) each locator is assigned a different identification signal; and*
- c) arrangements are made whereby locators using the same frequency cannot radiate simultaneously.*

Note.— The Standard in Volume I, 3.4.4.4, specifies the equipment arrangements to be made.

CHAPTER 4. UTILIZATION OF FREQUENCIES ABOVE 30 MHz

4.1 Utilization in the band 117.975 – 137 MHz

Introduction

The band 118 – 132 MHz was allocated in 1947 by the Atlantic City ITU Radio Conference, and again in 1959 by the Geneva Conference, but with extension downwards to 117.975 MHz, for the exclusive use by the aeronautical mobile (R) service.

ITU Radio Conferences subsequent to 1947 also made provisions for the use of the band 132 – 136 MHz for the aeronautical mobile (R) service under conditions which vary for the different ITU Regions, countries or combination of countries. The utilization of this band has been included in the Allotment Table in this chapter. The ITU World Administrative Radio Conference (1979) made provisions for the use of the band 136 – 137 MHz by the aeronautical mobile (R) service, subject to conditions of Nos. S5.203, S5.203A and S5.203B of the Radio Regulations. The use of frequencies in the 136 – 137 MHz part of the band must take account of the conditions contained in these notes. In the utilization of these bands, States' attention is drawn to the possibility of harmful radio interference from non-aeronautical sources of radio frequency energy and the need to take appropriate measures to minimize its effects.

This chapter deals with Standards and Recommended Practices relating to this band and includes matters pertaining to the selection of particular frequencies for various aeronautical purposes. These Standards are introduced by the following preface, which sets out the principles upon which the utilization of VHF on a worldwide basis with due regard to economy has been planned.

Preface

The utilization of VHF on a worldwide basis with due regard to economy and practicability requires a plan that will take into account:

- a) the need for an orderly evolution towards improved operation and the required degree of worldwide standardization;
- b) the desirability of providing for an economic transition from present utilization to optimum utilization of

the frequencies available, taking into account the maximum possible utilization of existing equipment;

- c) *the need to provide for coordination between international and national utilization so as to ensure mutual protection from interference;*
- d) *the need for providing a framework for the integrated development of Regional Plans;*
- e) *the desirability of incorporating in any group of frequencies to be used those now in use for international air services;*
- f) *the need for keeping the total number of frequencies and their grouping in appropriate relation to the airborne equipment known to be widely used by international air services;*
- g) *a requirement for the provision of a single frequency that may be used for emergency purposes on a world-wide basis and, also, in certain regions, for another frequency that may be used as a common frequency for special purposes; and*
- h) *the need for providing sufficient flexibility to allow for the differences in application necessitated by regional conditions.*

4.1.1 General allotment of frequency band 117.975 – 137 MHz

Note.— The plan includes a general Allotment Table that subdivides the complete band 117.975 – 137 MHz, the chief subdivisions being the bands of frequencies allocated to both national and international services, and the bands allocated to national services. Observance of this general subdivision should keep to a minimum the problem of coordinating national and international application.

4.1.1.1 The block allotment of the frequency band 117.975 – 137 MHz shall be as shown in Table 4-1.

4.1.1.2 **Recommendation.**— *In the case of the band 136 – 137 MHz, international applications have not yet been agreed, and these frequencies should be brought into use on a regional basis where and in the manner required.*

4.1.2 Frequency separation and limits of assignable frequencies

Note.— In the following text the channel spacing for 8.33 kHz channel assignments is defined as 25 kHz divided by 3 which is 8.333 ... kHz.

4.1.2.1 The minimum separation between assignable frequencies in the aeronautical mobile (R) service shall be 8.33 kHz.

Note.— It is recognized that in some regions or areas, 100 kHz, 50 kHz or 25 kHz channel spacing provides an adequate number of frequencies suitably related to international and national air services and that equipment

designed specifically for 100 kHz, 50 kHz or 25 kHz channel spacing will remain adequate for services operating within such regions or areas. It is further recognized that assignments based on 25 kHz channel spacing as well as 8.33 kHz channel spacing may continue to co-exist within one region or area.

4.1.2.2 Until at least 1 January 2005, DSB-AM equipment specifically designed for 25 kHz channel spacing shall be safeguarded with respect to its suitability for the aeronautical mobile (R) service (AM(R)S) except in those regions or areas where regional agreement permits the use of equipment specifically designed for 8.33 kHz channel spacing or for VDL Mode 3 when used for air-ground voice communications.

Table 4-1. Allotment table

| <i>Block allotment of frequencies (MHz)</i> | <i>Worldwide utilization</i> | <i>Remarks</i> |
|---|---|---|
| a) 118 – 121.4 inclusive | International and National Aeronautical Mobile Services | Specific international allotments will be determined in the light of regional agreement. National assignments are covered by the provisions in 4.1.5.9. |
| b) 121.5 | Emergency frequency | In order to provide a guard band for the protection of the aeronautical emergency frequency, the nearest assignable frequencies on either side of 121.5 MHz are 121.4 MHz and 121.6 MHz, except that by regional agreement it may be decided that the nearest assignable frequencies are 121.3 MHz and 121.7 MHz. |
| c) 121.6 – 121.9917 inclusive | International and National Aerodrome Surface Communications | Reserved for ground movement, pre-flight checking, air traffic services clearances, and associated operations. |
| d) 122 – 123.05 inclusive | National Aeronautical Mobile Services | Reserved for national allotments. |
| e) 123.1 | Auxiliary frequency SAR | See 4.1.4.1. |
| f) 123.15 – 123.6917 inclusive | National Aeronautical Mobile Services | Reserved for national allotments, with the exception of 123.45 MHz which is also used as the worldwide air-to-air communications channel (see g)). |
| g) 123.45 | Air-to-air communications | Designated for use as provided for in 4.1.3.2.1. |
| h) 123.7 – 129.6917 inclusive | International and National Aeronautical Mobile Services | Specific international allotments will be determined in light of regional agreement. National assignments are covered by the provisions in 4.1.5.9. |
| i) 129.7 – 130.8917 inclusive | National Aeronautical Mobile Services | Reserved for national allotments but may be used in whole or in part, subject to regional agreement, to meet the requirements mentioned in 4.1.8.1.3. |
| j) 130.9 – 136.875 inclusive | International and National Aeronautical Mobile Services | Specific international allotments will be determined in light of regional agreement. National assignments are covered by the provisions in 4.1.5.9. (See the Introduction to 4.1 regarding the band 132 – 137 MHz.) |
| k) 136.9 – 136.975 inclusive | International and National Aeronautical Mobile Services | Reserved for VHF air-ground data link communications. |

4.1.2.2.1 Requirements for mandatory carriage of equipment specifically designed for 8.33 kHz channel spacing shall be made on the basis of regional air navigation agreements which specify the airspace of operation and the implementation timescales for the carriage of equipment, including the appropriate lead time.

Note.— No changes will be required to aircraft systems or ground systems operating solely in regions not using 8.33 kHz channel spacing.

4.1.2.2.2 Until at least 1 January 2005, equipment specifically designed for 8.33 kHz channel spacing shall be safeguarded with respect to its suitability for the AM(R)S.

4.1.2.2.3 Requirements for mandatory carriage of equipment specifically designed for VDL Mode 3 and VDL Mode 4 shall be made on the basis of regional air navigation agreements which specify the airspace of operation and the implementation timescales for the carriage of equipment, including the appropriate lead time.

4.1.2.2.3.1 The agreement indicated in 4.1.2.2.3 shall provide at least two years' notice of mandatory carriage of airborne systems.

4.1.2.2.4 Until at least 1 January 2010, equipment specifically designed to the VDL Mode 3 and VDL Mode 4 SARPs shall be safeguarded with respect to its suitability for the AM(R)S.

4.1.2.3 In the band 117.975 – 137 MHz, the lowest assignable frequency shall be 118 MHz and the highest 136.975 MHz.

4.1.2.4 In regions where 25 kHz channel spacing (DSB-AM and VHF digital link (VDL)) and 8.33 kHz DSB-AM channel spacing are in operation, the publication of the assigned frequency or channel of operation shall conform to the channel contained in Table 4-1 (*bis*).

Note.— Table 4-1 (bis) provides the frequency channel pairing plan which retains the numerical designator of the 25 kHz DSB-AM environment and allows unique identification of a 25 kHz VDL and 8.33 kHz channel.

4.1.3 Frequencies used for particular functions

4.1.3.1 Emergency channel

4.1.3.1.1 The emergency channel (121.5 MHz) shall be used only for genuine emergency purposes, as broadly outlined in the following:

- a) to provide a clear channel between aircraft in distress or emergency and a ground station when the normal channels are being utilized for other aircraft;

Table 4-1 (*bis*). Channelling/frequency pairing

| Frequency (MHz) | Time slot* | Channel spacing (kHz) | Channel |
|-----------------|------------|-----------------------|---------|
| 118.0000 | | 25 | 118.000 |
| 118.0000 | A | 25 | 118.001 |
| 118.0000 | B | 25 | 118.002 |
| 118.0000 | C | 25 | 118.003 |
| 118.0000 | D | 25 | 118.004 |
| 118.0000 | | 8.33 | 118.005 |
| 118.0083 | | 8.33 | 118.010 |
| 118.0167 | | 8.33 | 118.015 |
| 118.0250 | A | 25 | 118.021 |
| 118.0250 | B | 25 | 118.022 |
| 118.0250 | C | 25 | 118.023 |
| 118.0250 | D | 25 | 118.024 |
| 118.0250 | | 25 | 118.025 |
| 118.0250 | | 8.33 | 118.030 |
| 118.0333 | | 8.33 | 118.035 |
| 118.0417 | | 8.33 | 118.040 |
| 118.0500 | | 25 | 118.050 |
| 118.0500 | A | 25 | 118.051 |
| 118.0500 | B | 25 | 118.052 |
| 118.0500 | C | 25 | 118.053 |
| 118.0500 | D | 25 | 118.054 |
| 118.0500 | | 8.33 | 118.055 |
| 118.0583 | | 8.33 | 118.060 |
| 118.0667 | | 8.33 | 118.065 |
| 118.0750 | A | 25 | 118.071 |
| 118.0750 | B | 25 | 118.072 |
| 118.0750 | C | 25 | 118.073 |
| 118.0750 | D | 25 | 118.074 |
| 118.0750 | | 25 | 118.075 |
| 118.0750 | | 8.33 | 118.080 |
| 118.0833 | | 8.33 | 118.085 |
| 118.0917 | | 8.33 | 118.090 |
| 118.1000 | | 25 | 118.100 |
| | | | etc. |

* Time slot indication is for VDL Mode 3 channels. (Ref. Annex 10, Volume III, Part I, Chapter 6 for characteristics of VDL Mode 3 operation)

- b) to provide a VHF communication channel between aircraft and aerodromes, not normally used by international air services, in case of an emergency condition arising;

- c) to provide a common VHF communication channel between aircraft, either civil or military, and between such aircraft, and surface services, involved in common search and rescue operations, prior to changing when necessary to the appropriate frequency;
- d) to provide air-ground communication with aircraft when airborne equipment failure prevents the use of the regular channels;
- e) to provide a channel for the operation of emergency locator transmitters (ELTs), and for communication between survival craft and aircraft engaged in search and rescue operations;
- f) to provide a common VHF channel for communication between civil aircraft and intercepting aircraft or intercept control units and between civil or intercepting aircraft and air traffic services units in the event of interception of the civil aircraft.

Note 1.— The use of the frequency 121.5 MHz for the purpose outlined in c) is to be avoided if it interferes in any way with the efficient handling of distress traffic.

Note 2.— The current Radio Regulations make provisions that the aeronautical emergency frequency 121.5 MHz may also be used by mobile stations of the maritime mobile service, using A3E emission to communicate on this frequency for safety purposes with stations of the aeronautical mobile service (RR S5.200 and Appendix S13, Part A2).

4.1.3.1.2 The frequency 121.5 MHz shall be provided at:

- a) all area control centres and flight information centres;
- b) aerodrome control towers and approach control offices serving international aerodromes and international alternate aerodromes; and
- c) any additional location designated by the appropriate ATS authority,

where the provision of that frequency is considered necessary to ensure immediate reception of distress calls or to serve the purposes specified in 4.1.3.1.1.

Note.— Where two or more of the above facilities are collocated, provision of 121.5 MHz at one would meet the requirement.

4.1.3.1.3 The frequency 121.5 MHz shall be available to intercept control units where considered necessary for the purpose specified in 4.1.3.1.1 f).

4.1.3.1.4 The emergency channel shall be guarded continuously during the hours of service of the units at which it is installed.

4.1.3.1.5 The emergency channel shall be guarded on a single channel simplex operation basis.

4.1.3.1.6 The emergency channel (121.5 MHz) shall be available only with the characteristics as contained in Annex 10, Volume III, Part II, Chapter 2.

4.1.3.2 *Air-to-air communications channel*

4.1.3.2.1 An air-to-air VHF communications channel on the frequency of 123.45 MHz shall be designated to enable aircraft engaged in flights over remote and oceanic areas out of range of VHF ground stations to exchange necessary operational information and to facilitate the resolution of operational problems.

Note.— Use of the air-to-air channel can cause interference to and from aircraft using the same frequency for air-ground communications.

4.1.3.2.2 In remote and oceanic areas out of range of VHF ground stations, the air-to-air VHF communications channel on the frequency 123.45 MHz shall be available only with the characteristics as contained in Annex 10, Volume III, Part II, Chapter 2.

4.1.3.3 *Common signalling channel.* The frequency 136.975 MHz is reserved on a worldwide basis to provide a common signalling channel (CSC) to the VHF digital link (VDL). This CSC uses the Mode 2 VDL modulation scheme and carrier sense multiple access (CSMA).

4.1.4 Auxiliary frequencies for search and rescue operations

4.1.4.1 Where a requirement is established for the use of a frequency auxiliary to 121.5 MHz, as described in 4.1.3.1.1 c), the frequency 123.1 MHz shall be used.

4.1.4.2 The auxiliary search and rescue channel (123.1 MHz) shall be available only with the characteristics as contained in Annex 10, Volume III, Part II, Chapter 2.

4.1.5 Provisions concerning the deployment of VHF frequencies and the avoidance of harmful interference

4.1.5.1 In the case of those VHF facilities providing service up to the radio horizon, the geographical separation between facilities working on the same frequency shall, except where there is an operational requirement for the use of common frequencies for groups of facilities, be such that points at the protection heights and at the limit of the functional service range of each facility are separated by distances not less than that required to provide a desired to undesired signal ratio of 14 dB. This provision shall be

implemented on the basis of a regional air navigation agreement. For areas where frequency assignment congestion is not severe or is not anticipated to become severe, a 20 dB (10 to 1 distance ratio) separation criteria or radio line-of-sight (RLOS) separation criteria (whichever is smaller) may be used.

Note.— Guidance material relating to the establishment of the minimum separation distance based on the desired to undesired signal protection ratio of 14 dB is contained in Attachment A.

4.1.5.2 In the case of those VHF facilities providing service beyond the radio horizon, except where there is an operational requirement for the use of common frequencies for groups of facilities, planning for co-channel operations shall be such that points at the protection heights and at the limits of the functional service area of each facility are separated by distances not less than the sum of distances from each point to its associated radio horizon.

Note 1.— The distance to the radio horizon from a station in an aircraft is normally given by the formula:

$$D = K \sqrt{h}$$

where D = distance in nautical miles;
 h = height of the aircraft station above earth;
 K = (corresponding to an effective earth's radius of 4/3 of the actual radius);
 = 2.22 when h is expressed in metres; and
 = 1.23 when h is expressed in feet.

Note 2.— In calculating the radio line-of-sight distance between a ground station and an aircraft station, the distance from the radio horizon of the aircraft station computed from Note 1 must be added to the distance from the radio horizon of the ground station. In calculating the latter the same formula is employed, taking for h the height of the ground station transmitting antenna.

Note 3.— The criterion contained in 4.1.5.2 is applicable in establishing minimum geographical separation between VHF facilities, with the object of avoiding co-channel air-to-air interference. Guidance material relating to the establishment of separation distances between ground stations and between aircraft and ground stations for co-channel operations is contained in Section 3 of Attachment A. Guidance material relating to adjacent channel frequency deployment is contained in Section 2 of Attachment A.

Note 4.— Guidance material on the interpretation of 4.1.5.1 and 4.1.5.2 is contained in Attachment A.

4.1.5.3 The geographical separation between facilities working on adjacent channels shall be such that points at the protection heights and at the limit of the functional service range of each facility are separated by a distance sufficient to ensure operations free from harmful interference.

Note.— Guidance material covering separation distances and related system characteristics is contained in Attachment A.

4.1.5.4 The protection height shall be a height above a specified datum associated with a particular facility, such that below it harmful interference is improbable.

4.1.5.5 The protection height to be applied to functions or to specific facilities shall be determined regionally, taking into consideration the following factors:

- a) the nature of the service to be provided;
- b) the air traffic pattern involved;
- c) the distribution of communication traffic;
- d) the availability of frequency channels in airborne equipment;
- e) probable future developments.

4.1.5.6 **Recommendation.**— *Where the protection heights determined are less than those operationally desirable, separation between facilities operating on the same frequency should not be less than that necessary to ensure that an aircraft at the limit of the functional service range and the operationally desirable protection height of one facility does not come above the radio horizon with respect to adjacent facilities.*

Note.— The effect of this recommendation is to establish a geographical separation distance below which harmful interference is probable.

4.1.5.7 The geographical separation between VHF VOLMET stations shall be determined regionally and, generally, shall be such that operations free from harmful interference are secured at the highest altitude flown by aircraft in the area concerned.

Note.— Guidance material on the interpretation of 4.1.5.7 is contained in Attachment A.

4.1.5.8 Frequencies in the aeronautical mobile VHF band used for national services, unless worldwide or regionally allotted to this specific purpose, shall be so deployed that minimum interference is caused to facilities for the international air services in this band.

4.1.5.9 **Recommendation.**— *The problem of inter-State interference on frequencies allotted worldwide or on a regional basis to national services, should be resolved by consultation between the administrations concerned.*

4.1.5.10 The communication coverage provided by a VHF ground transmitter shall, in order to avoid harmful interference to other stations, be kept to the minimum consistent with the operational requirement for the function.

4.1.5.11 **Recommendation.**— *For ground VHF facilities which provide service beyond the radio horizon, any spurious or harmonic radiation outside the band ± 250 kHz from the assigned carrier frequency should not exceed an effective radiated power of 1 mW in any azimuth.*

4.1.6 Equipment requirements

Note 1.— *Frequency tolerances to which stations operating in the aeronautical mobile band (117.975 – 137 MHz) must conform are contained in Appendix 3 to the Radio Regulations. Tolerances for transmitters used for aeronautical services are not mentioned in this Annex, except in those cases where tighter tolerances than those contained in the Radio Regulations are required (e.g. the equipment specifications in Volume III contain several such instances).*

Note 2.— *The frequency tolerance applicable to individual components of a multi-carrier or similar system will be determined by the characteristics of the specific system.*

4.1.6.1 **Recommendation.**— *The antenna gain of an extended range VHF facility should preferably be such as to ensure that, beyond the limits of $\pm 2^\circ$ about the centre line of the angular width Φ of the area to be served, it does not exceed 3 dB above that of a dipole. But, in any case, it should be such as to ensure freedom from harmful interference with other radio services.*

Note 1.— *The actual azimuth, the angular width of the service area, and the effective radiated power would have to be taken into account in each individual case.*

Note 2.— *Guidance material on the interpretation of 4.1.6.1 is contained in Attachment A.*

4.1.7 Method of operation

4.1.7.1 Single channel simplex operation shall be used in the VHF band 117.975 – 137 MHz at all stations providing for aircraft engaged in international air navigation.

4.1.7.2 In addition to the above, the ground-to-air voice channel associated with an ICAO standard radio navigational aid may be used, subject to regional agreement, for broadcast or communication purposes or both.

4.1.8 Plan of assignable VHF radio frequencies for use in the international aeronautical mobile service

Introduction

This plan designates the list of frequencies available for assignment, together with provision for the use by the

aeronautical mobile (R) service of all frequencies with a channel spacing of 25 kHz, and of all frequencies with a channel width and spacing of 8.33 kHz, with the frequencies in Group A continuing to be used wherever they provide a sufficient number to meet the operational requirements.

The plan provides that the total number of frequencies required in any region would be determined regionally. The effect of this will be that frequencies assignable in any particular region may be restricted to a limited number of the frequencies in the list, the actual number being selected as outlined herein.

In order that the assignable frequencies may be coordinated between regions as far as practicable, the plan requires that, whenever the number of frequencies contained in Group A of 4.1.8.1.2 is sufficient to meet the requirements of a region, the frequencies of this Group be used in a sequence commencing with 118 MHz. This ensures that all regions will have in common the frequencies used in the region requiring the least number of frequencies and, in respect to any two regions, the region with the greater number will have in use all the frequencies used by the other.

Group A provides for frequency planning based on 100 kHz channel spacing.

Group B of the list at 4.1.8.1.2 contains the frequencies in the band 117.975 – 132 MHz ending in 50 kHz. Together with the frequencies in Group A, they provide for frequency planning based on 50 kHz channel spacing. In Group C are listed the frequency channels in the band 132 – 137 MHz based upon 50 kHz channel spacing. Group D contains the frequency channels in the band 132 – 137 MHz ending in 25 kHz, and Group E similarly lists the frequency channels in the band 117.975 – 132 MHz. The utilization of channels in Groups B, C, D and E is explained below.

Group F of the list at 4.1.8.1.2 contains the frequencies in the band 117.975 – 137 MHz when 8.33 kHz channel width is used. The utilization of the channels in this Group is explained below.

Whenever the number of frequencies required in a particular region exceeds the number in Group A, frequencies may be selected from the other Groups taking into account the provisions of 4.1.8.1 with respect to the use of channels based on 25 kHz channel spacing and, with regard to the band 132 – 137 MHz, the provisions of the Radio Regulations (see Introduction to 4.1). Although for Groups B, C, D and E a preferred order of selection is not indicated, regional planning may require a particular selection of frequencies from these Groups in order to cater for specific regional circumstances. This may apply particularly to the utilization of frequencies from the band 132 – 137 MHz for reasons of available airborne equipment and/or availability of particular frequency channels for the aeronautical mobile (R) service. It may also be found that, in a particular region, it is desirable to select frequencies from Group B first, before selecting frequencies from Groups C, D or E.

Where all the channels of Groups A, B, C, D and E of the list at 4.1.8.1.2 are insufficient to meet the requirements of a region, a part or parts of the band may be designated as containing 8.33 kHz width channels or designated as supporting VDL Mode 3. For parts of the band containing 8.33 kHz width channels, the appropriate frequencies from Group F should be used in accordance with 4.1.8.1.1 and 4.1.8.1.2. It should be noted that the designation of frequencies in Group F differs from that of the corresponding frequencies in Groups A to E to emphasize the difference in channel width. For part of the bands supporting VDL Mode 3, frequencies from Groups A, B, C, D and E are utilized on a time-division basis. A single frequency supports multiple channels, each utilizing the frequency in periodic time frames or time slots. Specific time slots for VDL Mode 3 are identified using the numeric designators of Table 4-1 (bis).

Although for Group F a preferred order of selection is not indicated, regional planning may require a particular selection of frequencies from this group in order to cater for specific regional circumstances.

In many regions particular frequencies have already been assigned for particular functions as, for instance, aerodrome or approach control. The plan does not make such assignments (except in respect to the emergency channel and ground service frequencies), such action being taken regionally if considered desirable.

4.1.8.1 The frequencies in the band 117.975 – 137 MHz for use in the aeronautical mobile (R) service shall be selected from the list in 4.1.8.1.2.

4.1.8.1.1 When the number of frequencies required in a particular region does not exceed the number of frequencies contained in Group A of 4.1.8.1.2, the frequencies to be used shall be selected in sequence, in so far as practicable, from those in Group A of 4.1.8.1.2.

4.1.8.1.1.1 When the number of frequencies required in a particular region exceeds those available in Groups A to E of 4.1.8.1.2, parts of the band shall be designated as containing 8.33 kHz width channels (voice) or as containing VDL Mode 3. Appropriate frequencies shall be selected from Group F of 4.1.8.1.2 for 8.33 kHz channel assignments or from Groups A to E in accordance with the time-slot assignments in accordance with Table 4-1 (bis) for VDL Mode 3. The remainder of the band shall continue to be used for 25 kHz width channels selected from the appropriate parts of Groups A to E.

Note 1.— The frequencies 121.425 – 121.575 MHz inclusive, 123.075 – 123.125 MHz inclusive and 136.500 – 136.975 MHz inclusive are not available for assignment to channels of less than 25 kHz width.

Note 2.— Services that continue operation using 25 kHz assignments will be protected in regions implementing 8.33 kHz channel spacing.

4.1.8.1.2 List of assignable frequencies

The list of assignable frequencies is shown in the Appendix to this chapter.

4.1.8.1.3 **Recommendation.**— *Frequencies for operational control communications may be required to enable aircraft operating agencies to meet the obligations prescribed in Annex 6, Part I, in which case they should be selected from the bands 128.825 – 132.025 MHz. These frequencies should be chosen, in so far as practicable, from the upper end of the band and in sequential order.*

Note.— It is recognized that the assignment of such frequencies and the licensing of the operation of the related facilities are matters for national determination. However, in regions where a problem exists with respect to the provision of frequencies for operational control purposes, it may be advantageous if States endeavour to coordinate the requirements of aircraft operating agencies for such channels prior to regional meetings.

4.1.8.2 The frequencies that may be allotted for use in the aeronautical mobile (R) service in a particular region shall be limited to the number determined as being necessary for operational needs in the region.

Note.— The number of frequencies required in a particular region is normally determined by the Council on the recommendations of Regional Air Navigation Meetings. The capabilities of VHF airborne equipment known to be widely used in the region will be taken into account in this determination.

4.2 Utilization in the band 108 – 117.975 MHz

4.2.1 The block allotment of the frequency band 108 – 117.975 MHz shall be as follows:

— *Band 108 – 111.975 MHz:*

- a) ILS in accordance with 4.2.2 and Annex 10, Volume I, 3.1.3;
- b) VOR provided that:
 - 1) no harmful adjacent channel interference is caused to ILS;
 - 2) only frequencies ending in either *even tenths* or *even tenths plus a twentieth* of a megahertz are used.
- c) GNSS ground-based augmentation system (GBAS) in accordance with Annex 10, Volume I, 3.7.3.5, provided that no harmful interference is caused to ILS and VOR.

Note.— ILS/GBAS geographical separation criteria and geographical separation criteria for GBAS and VHF

communication services operating in the 118 – 137 MHz band are under development. Until these criteria are defined and included in the SARPs, it is intended that frequencies in the band 112.050 – 117.900 MHz will be used for GBAS assignments.

— Band 111.975 – 117.975 MHz:

- a) VOR;
- b) GNSS ground-based augmentation system (GBAS) in accordance with Annex 10, Volume I, 3.7.3.5, provided that no harmful interference is caused to VOR.

Note 1.— Guidance material relating to the distance separation required to prevent harmful interference between ILS and VOR when using the band 108 – 111.975 MHz is found in Section 3 of Attachment C to Annex 10, Volume I.

Note 2.— Guidance material relating to the distance separation required to prevent harmful interference between VOR and GBAS when using the band 112.050 – 117.900 MHz is found in Section 7.2.1 of Attachment D to Annex 10, Volume I.

4.2.2 For regional assignment planning, the frequencies for ILS facilities shall be selected in the following order:

- a) localizer channels ending in *odd tenths* of a megahertz and their associated glide path channels;
- b) localizer channels ending in *odd tenths plus a twentieth* of a megahertz and their associated glide path channels.

4.2.2.1 ILS channels identified by localizer frequencies ending in an *odd tenth plus one twentieth* of a megahertz in the band 108 – 111.975 MHz shall be permitted to be utilized on the basis of regional agreement when they become applicable in accordance with the following:

- a) for restricted use commencing 1 January 1973;
- b) for general use on or after 1 January 1976.

Note.— See Note to 4.2.3.1.

4.2.3 For regional assignment planning, the frequencies for VOR facilities shall be selected in the following order:

- a) frequencies ending in *odd tenths* of a megahertz in the band 111.975 – 117.975 MHz;
- b) frequencies ending in *even tenths* of a megahertz in the band 111.975 – 117.975 MHz;
- c) frequencies ending in *even tenths* of a megahertz in the band 108 – 111.975 MHz;
- d) frequencies ending in *50 kHz* in the band 111.975 – 117.975 MHz, except as provided in 4.2.3.1;

- e) frequencies ending in *even tenths plus a twentieth* of a megahertz in the band 108 – 111.975 MHz except as provided in 4.2.3.1.

4.2.3.1 Frequencies for VOR facilities ending in *even tenths plus a twentieth* of a megahertz in the band 108 – 111.975 MHz and all frequencies ending in *50 kHz* in the band 111.975 – 117.975 MHz shall be permitted to be utilized on the basis of a regional agreement when they have become applicable in accordance with the following:

- a) in the band 111.975 – 117.975 MHz for restricted use;
- b) for general use in the band 111.975 – 117.975 MHz at a date fixed by the Council but at least one year after the approval of the regional agreement concerned;
- c) for general use in the band 108 – 111.975 MHz at a date fixed by the Council but giving a period of two years or more after the approval of the regional agreement concerned.

Note.— “Restricted use”, where mentioned in 4.2.2.1 a) and 4.2.3.1 a), is intended to refer to the limited use of the frequencies by only suitably equipped aircraft and in such a manner that:

- a) *the performance of ILS or VOR equipment not capable of operating on these frequencies will be protected from harmful interference;*
- b) *a general requirement for the carriage of ILS or VOR airborne equipment capable of operation on these frequencies will not be imposed; and*
- c) *operational service provided to international operators using 100 kHz airborne equipment is not derogated.*

4.2.4 To protect the operation of airborne equipment during the initial stages of deploying VORs utilizing 50 kHz channel spacing in an area where the existing facilities may not fully conform with the Standards in Annex 10, Volume I, Chapter 3, all existing VORs within interference range of a facility utilizing 50 kHz channel spacing shall be modified to comply with the provisions of Annex 10, Volume I, 3.3.5.7.

4.2.5 *Frequency deployment.* The geographical separation between facilities operating on the same and adjacent frequencies shall be determined regionally and shall be based on the following criteria:

- a) the required functional service radii of the facilities;
- b) the maximum flight altitude of the aircraft using the facilities;
- c) the desirability of keeping the minimum IFR altitude as low as the terrain will permit.

Table 4-2

| Group | DME channels | Associated paired VHF channels | Remarks | Assignment procedure |
|-------|---------------------|---|--|--------------------------------|
| 1 | EVEN 18X to 56X | ILS 100 kHz spacings | Would normally be used if a single DME is paired with ILS and is part of MLS | for general use (see 4.3.1) |
| 2 | EVEN 18Y to 56Y | ILS 50 kHz spacings | | |
| 3 | EVEN 80Y to 118Y | VOR 50 kHz spacings Odd tenths of a MHz | | |
| 4 | ODD 17Y to 55Y | VOR 50 kHz spacings | | |
| 5 | ODD 81Y to 119Y | VOR 50 kHz spacings Even tenths of a MHz | | |
| 6 | EVEN 18W to 56W | No associated paired VHF channel | | for later use (see 4.3.2) |
| 7 | EVEN 18Z to 56Z | No associated paired VHF channel | | |
| 8 | EVEN 80Z to 118Z | No associated paired VHF channel | | |
| 9 | ODD 17Z to 55Z | No associated paired VHF channel | | |
| 10 | ODD 81Z to 119Z | No associated paired VHF channel | | |

Note.— DME channels in Groups 1 and 2 may be used in association with ILS and/or MLS. DME channels in Groups 3, 4 and 5 may be used in association with VOR or MLS.

Note.— Guidance material on this subject is contained in the Attachments to this Annex.

4.2.6 Recommendation.— To alleviate frequency congestion problems at locations where two separate ILS facilities serve opposite ends of the same runway or different runways at the same airport, the assignment of identical ILS localizer and glide path paired frequencies should be permitted provided that:

- a) the operational circumstances permit;
- b) each localizer is assigned a different identification signal; and
- c) arrangements are made whereby the localizer and glide path not in operational use cannot radiate.

Note.— The Standards in Annex 10, Volume I, 3.1.2.7.2 and 3.1.3.9, specify the equipment arrangements to be made.

4.3 Utilization in the band 960 – 1 215 MHz for DME

Note.— Guidance on the frequency planning of channels for DME systems is given in Annex 10, Volume I, Attachment C, Section 7.

4.3.1 DME operating channels bearing the suffix “X” or “Y” in Table A, Chapter 3 of Annex 10, Volume I shall be chosen on a general basis without restriction.

Note.— The channel pairing plan provides for the use of certain Y channels with either VOR or MLS. The guidance material in Annex 10, Volume I, Attachment C, Section 7, includes specific provisions relating to situations where the same, or adjacent channel, is used in the same area for both systems.

4.3.2 DME channels bearing the suffix “W” or “Z” in Table A, Chapter 3 of Annex 10, Volume I, shall be chosen on the basis of regional agreement when they become applicable in accordance with the following:

a) for restricted regional use on or after, whichever is the later:

- 1) 1 January 1989; or
- 2) a date prescribed by the Council giving a period of two years or more following approval of the regional agreement concerned;

b) for general use on or after, whichever is the later:

- 1) 1 January 1995; or
- 2) a date prescribed by the Council giving a period of two years or more following approval of the regional agreement concerned.

Note.— “Restricted use” is intended to refer to the limited use of the channel by only suitably equipped aircraft and in such a manner that:

- a) the performance of existing DME equipment not capable of operating on these multiplexed channels will be protected from harmful interference;
- b) a general requirement for the carriage of DME airborne equipment capable of operating on these multiplexed channels will not be imposed; and
- c) operational service provided to international operators using existing DME equipment without the multiplexed channel capability is not derogated.

4.3.3 For regional assignment planning, the channels for DME associated with MLS shall be selected from Table 4-2.

4.3.3.1 *Groups 1 to 5.* These DME channels shall be permitted to be used generally. In selecting channels for assignment purposes the following rules are applicable:

- a) when an MLS/DME is intended to operate on a runway in association with an ILS, the DME channel, if possible, shall be selected from Group 1 or 2 and paired

with the ILS frequency as indicated in the DME channelling and pairing table in Table A of Annex 10, Volume I, Chapter 3. In cases where the composite frequency protection cannot be satisfied for all three components, the MLS channel may be selected from Group 3, 4 or 5;

- b) when an MLS/DME is intended to operate on a runway without the coexistence of an ILS, the DME channel to be used shall preferably be selected from Group 3, 4 or 5.

4.3.3.2 *Groups 6 to 10.* These DME channels shall be permitted to be used on the basis of a regional agreement when they have become applicable in accordance with the conditions specified at 4.3.2.

4.3.4 **Recommendation.**— *Coordination of regional DME channel assignments should be effected through ICAO.*

4.4 Utilization in the band 5 030.4 – 5 150.0 MHz

Note 1.— *Guidance material on the frequency protection planning of MLS facilities is contained in Attachment G to Annex 10, Volume I.*

Note 2.— *Guidance on determining coordination distances between MLS facilities and ground stations providing feeder links to non-geostationary mobile satellites is contained in ITU-R Recommendation S.1342.*

4.4.1 The MLS channels shall be selected from Table A, Chapter 3 of Annex 10, Volume I.

4.4.2 For regional planning purposes MLS channels shall be selected in accordance with the conditions specified in 4.3.3 for the associated DME facility.

4.4.3 Channel assignments in addition to those specified in 4.4.1 shall be made within the 5 030.4 – 5 150.0 MHz sub-band as necessary to satisfy future air navigation requirements.

APPENDIX TO CHAPTER 4. LIST OF ASSIGNABLE FREQUENCIES

| Frequency (MHz) | Annotations | Frequency (MHz) | Annotations |
|--------------------|--|--------------------|--|
| 121.5 | Emergency frequency | 121.95 | Reserved for aerodrome surface communications [see Table 4-1, Item c)] |
| 123.1 | Auxiliary frequency SAR | 121.625 | |
| 121.60 | Reserved for aerodrome surface communications [see Table 4-1, Item c)] | 121.675 | |
| 121.65 | | 121.725 | |
| 121.70 | | 121.775 | |
| 121.75 | | 121.825 | |
| 121.80 | | 121.875 | |
| 121.85 | | 121.925 | |
| 121.90 | | 121.975 | |

GROUP A Frequencies (MHz)

| | | | | | | | | | | | |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 118.00 | 118.90 | 119.80 | 120.70 | 123.80 | 124.70 | 125.60 | 126.50 | 127.40 | 128.30 | 129.20 | 131.20 |
| 118.10 | 119.00 | 119.90 | 120.80 | 123.90 | 124.80 | 125.70 | 126.60 | 127.50 | 128.40 | 129.30 | 131.30 |
| 118.20 | 119.10 | 120.00 | 120.90 | 124.00 | 124.90 | 125.80 | 126.70 | 127.60 | 128.50 | 129.40 | 131.40 |
| 118.30 | 119.20 | 120.10 | 121.00 | 124.10 | 125.00 | 125.90 | 126.80 | 127.70 | 128.60 | 129.50 | 131.50 |
| 118.40 | 119.30 | 120.20 | 121.10 | 124.20 | 125.10 | 126.00 | 126.90 | 127.80 | 128.70 | 129.60 | 131.60 |
| 118.50 | 119.40 | 120.30 | 121.20 | 124.30 | 125.20 | 126.10 | 127.00 | 127.90 | 128.80 | 130.90 | 131.70 |
| 118.60 | 119.50 | 120.40 | 121.30 | 124.40 | 125.30 | 126.20 | 127.10 | 128.00 | 128.90 | 131.00 | 131.80 |
| 118.70 | 119.60 | 120.50 | 121.40 | 124.50 | 125.40 | 126.30 | 127.20 | 128.10 | 129.00 | 131.10 | 131.90 |
| 118.80 | 119.70 | 120.60 | 123.70 | 124.60 | 125.50 | 126.40 | 127.30 | 128.20 | 129.10 | | |

GROUP B Frequencies (MHz)

| | | | | | | | | | | | |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 118.05 | 118.95 | 119.85 | 120.75 | 123.95 | 124.85 | 125.75 | 126.65 | 127.55 | 128.45 | 129.25 | 131.25 |
| 118.15 | 119.05 | 119.95 | 120.85 | 124.05 | 124.95 | 125.85 | 126.75 | 127.65 | 128.55 | 129.35 | 131.35 |
| 118.25 | 119.15 | 120.05 | 120.95 | 124.15 | 125.05 | 125.95 | 126.85 | 127.75 | 128.65 | 129.45 | 131.45 |
| 118.35 | 119.25 | 120.15 | 121.05 | 124.25 | 125.15 | 126.05 | 126.95 | 127.85 | 128.75 | 129.55 | 131.55 |
| 118.45 | 119.35 | 120.25 | 121.15 | 124.35 | 125.25 | 126.15 | 127.05 | 127.95 | 128.85 | 129.65 | 131.65 |
| 118.55 | 119.45 | 120.35 | 121.25 | 124.45 | 125.35 | 126.25 | 127.15 | 128.05 | 128.95 | 130.95 | 131.75 |
| 118.65 | 119.55 | 120.45 | 121.35 | 124.55 | 125.45 | 126.35 | 127.25 | 128.15 | 129.05 | 131.05 | 131.85 |
| 118.75 | 119.65 | 120.55 | 123.75 | 124.65 | 125.55 | 126.45 | 127.35 | 128.25 | 129.15 | 131.15 | 131.95 |
| 118.85 | 119.75 | 120.65 | 123.85 | 124.75 | 125.65 | 126.55 | 127.45 | 128.35 | | | |

GROUP C Frequencies (MHz)

| | | | | | | | | | | | |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 132.00 | 132.35 | 132.70 | 133.05 | 133.40 | 133.75 | 134.10 | 134.45 | 134.80 | 135.10 | 135.40 | 135.70 |
| 132.05 | 132.40 | 132.75 | 133.10 | 133.45 | 133.80 | 134.15 | 134.50 | 134.85 | 135.15 | 135.45 | 135.75 |
| 132.10 | 132.45 | 132.80 | 133.15 | 133.50 | 133.85 | 134.20 | 134.55 | 134.90 | 135.20 | 135.50 | 135.80 |
| 132.15 | 132.50 | 132.85 | 133.20 | 133.55 | 133.90 | 134.25 | 134.60 | 134.95 | 135.25 | 135.55 | 135.85 |
| 132.20 | 132.55 | 132.90 | 133.25 | 133.60 | 133.95 | 134.30 | 134.65 | 135.00 | 135.30 | 135.60 | 135.90 |
| 132.25 | 132.60 | 132.95 | 133.30 | 133.65 | 134.00 | 134.35 | 134.70 | 135.05 | 135.35 | 135.65 | 135.95 |
| 132.30 | 132.65 | 133.00 | 133.35 | 133.70 | 134.05 | 134.40 | 134.75 | | | | |

GROUP D Frequencies (MHz)

| | | | | | | | | | | | |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 132.025 | 132.525 | 133.025 | 133.525 | 134.025 | 134.525 | 135.025 | 135.525 | 136.000 | 136.250 | 136.500 | 136.750 |
| 132.075 | 132.575 | 133.075 | 133.575 | 134.075 | 134.575 | 135.075 | 135.575 | 136.025 | 136.275 | 136.525 | 136.775 |
| 132.125 | 132.625 | 133.125 | 133.625 | 134.125 | 134.625 | 135.125 | 135.625 | 136.050 | 136.300 | 136.550 | 136.800 |
| 132.175 | 132.675 | 133.175 | 133.675 | 134.175 | 134.675 | 135.175 | 135.675 | 136.075 | 136.325 | 136.575 | 136.825 |
| 132.225 | 132.725 | 133.225 | 133.725 | 134.225 | 134.725 | 135.225 | 135.725 | 136.100 | 136.350 | 136.600 | 136.850 |
| 132.275 | 132.775 | 133.275 | 133.775 | 134.275 | 134.775 | 135.275 | 135.775 | 136.125 | 136.375 | 136.625 | 136.875 |
| 132.325 | 132.825 | 133.325 | 133.825 | 134.325 | 134.825 | 135.325 | 135.825 | 136.150 | 136.400 | 136.650 | 136.900 |
| 132.375 | 132.875 | 133.375 | 133.875 | 134.375 | 134.875 | 135.375 | 135.875 | 136.175 | 136.425 | 136.675 | 136.925 |
| 132.425 | 132.925 | 133.425 | 133.925 | 134.425 | 134.925 | 135.425 | 135.925 | 136.200 | 136.450 | 136.700 | 136.950 |
| 132.475 | 132.975 | 133.475 | 133.975 | 134.475 | 134.975 | 135.475 | 135.975 | 136.225 | 136.475 | 136.725 | 136.975 |

GROUP E
Frequencies (MHz)

| | | | | | | | | | | | |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 118.025 | 118.925 | 119.825 | 120.725 | 123.925 | 124.825 | 125.725 | 126.575 | 127.425 | 128.275 | 129.125 | 131.175 |
| 118.075 | 118.975 | 119.875 | 120.775 | 123.975 | 124.875 | 125.775 | 126.625 | 127.475 | 128.325 | 129.175 | 131.225 |
| 118.125 | 119.025 | 119.925 | 120.825 | 124.025 | 124.925 | 125.825 | 126.675 | 127.525 | 128.375 | 129.225 | 131.275 |
| 118.175 | 119.075 | 119.975 | 120.875 | 124.075 | 124.975 | 125.875 | 126.725 | 127.575 | 128.425 | 129.275 | 131.325 |
| 118.225 | 119.125 | 120.025 | 120.925 | 124.125 | 125.025 | 125.925 | 126.775 | 127.625 | 128.475 | 129.325 | 131.375 |
| 118.275 | 119.175 | 120.075 | 120.975 | 124.175 | 125.075 | 125.975 | 126.825 | 127.675 | 128.525 | 129.375 | 131.425 |
| 118.325 | 119.225 | 120.125 | 121.025 | 124.225 | 125.125 | 126.025 | 126.875 | 127.725 | 128.575 | 129.425 | 131.475 |
| 118.375 | 119.275 | 120.175 | 121.075 | 124.275 | 125.175 | 126.075 | 126.925 | 127.775 | 128.625 | 129.475 | 131.525 |
| 118.425 | 119.325 | 120.225 | 121.125 | 124.325 | 125.225 | 126.125 | 126.975 | 127.825 | 128.675 | 129.525 | 131.575 |
| 118.475 | 119.375 | 120.275 | 121.175 | 124.375 | 125.275 | 126.175 | 127.025 | 127.875 | 128.725 | 129.575 | 131.625 |
| 118.525 | 119.425 | 120.325 | 121.225 | 124.425 | 125.325 | 126.225 | 127.075 | 127.925 | 128.775 | 129.625 | 131.675 |
| 118.575 | 119.475 | 120.375 | 121.275 | 124.475 | 125.375 | 126.275 | 127.125 | 127.975 | 128.825 | 129.675 | 131.725 |
| 118.625 | 119.525 | 120.425 | 121.325 | 124.525 | 125.425 | 126.325 | 127.175 | 128.025 | 128.875 | 130.925 | 131.775 |
| 118.675 | 119.575 | 120.475 | 121.375 | 124.575 | 125.475 | 126.375 | 127.225 | 128.075 | 128.925 | 130.975 | 131.825 |
| 118.725 | 119.625 | 120.525 | 123.725 | 124.625 | 125.525 | 126.425 | 127.275 | 128.125 | 128.975 | 131.025 | 131.875 |
| 118.775 | 119.675 | 120.575 | 123.775 | 124.675 | 125.575 | 126.475 | 127.325 | 128.175 | 129.025 | 131.075 | 131.925 |
| 118.825 | 119.725 | 120.625 | 123.825 | 124.725 | 125.625 | 126.525 | 127.375 | 128.225 | 129.075 | 131.125 | 131.975 |
| 118.875 | 119.775 | 120.675 | 123.875 | 124.775 | 125.675 | | | | | | |

GROUP F
(see also Table 4-1 (*bis*))

118.000 – 121.400 in 8.33 kHz steps

121.600 – 123.050 in 8.33 kHz steps

123.150 – 136.475 in 8.33 kHz steps

ATTACHMENT A. CONSIDERATIONS AFFECTING THE DEPLOYMENT OF VHF COMMUNICATION FREQUENCIES

Introduction

Paragraphs 4.1.5.2 and 4.1.5.3 specify the geographical separation required for co-channel operation of VHF facilities in the aeronautical mobile service. In Figure A-1 the distance AB indicates the separation required between facilities in order that aircraft a and b operating at the protection heights and at the limits of the functional service range of stations A and B respectively, will not experience harmful interference.

Paragraph 4.1.6.1 recommends the maximum antenna gain outside the main beam of facilities which provide service beyond the radio horizon. Figure A-2 illustrates the azimuthal angle to be protected and the method of derivation. Smaller beamwidths than 30 degrees are not considered practical at present.

Note.— The term “main beam” includes all azimuths where antenna gain exceeds 3 dB above that of a dipole.

1. Criteria employed in establishing geographical separation between ground stations for co-channel operation of VHF facilities that have a service area up to the radio horizon

1.1 To provide co-channel interference protection of 14 dB (5 to 1 distance ratio, as shown below) desired signal to undesired signal (D/U), the free-space loss (FSL) formula is used to calculate both the free-space loss of the desired signal (FSL_D) and the free-space loss of the undesired signal (FSL_U):

$$FSL \text{ (in dB)} = 32.4 + 20 \log f + 20 \log d$$

where f = frequency in MHz
 d = distance in km.

In comparing the FSL_D versus the FSL_U , the subtraction of the formula results in:

$$FSL_U - FSL_D = 20 \log dU - 20 \log dD$$
$$= 20 \log dU/dD$$

If $FSL_U - FSL_D = 14$ dB,
then $\log dU/dD = 14/20 = 0.7$;
then $dU/dD = 5.01$.

Note.— It is necessary to take into account that the effective radiated powers of transmitting stations may not be equal.

1.2 The desired distance (dD) is the distance between the desired ground facility and the limit of the functional service range of that ground facility (see Figure A-3).

Note.— When making assignments using a 14 dB D/U signal ratio, the potential effects of interference caused by mute lifts due to high communications loading on co-channel assignments should be considered.

1.3 The undesired distance (dU) is the distance between the limit of the functional service ranges of the desired facility and that of the undesired facility (i.e. the distance between the aircraft at the edges of the respective service ranges). See Figure A-1.

1.4 The required geographical separation between the desired and the undesired facility is therefore dD + dU plus the service range of the undesired facility (see Figure A-1).

1.5 If the calculated dU exceeds the RLOS between the aircraft, then a distance as small as the RLOS can be used as the distance between the edges of the service volumes.

2. Criteria employed in establishing adjacent channel frequency deployment with respect to receiver rejection and other system characteristics

2.1 For aircraft receivers designed for operation in a 50 kHz channel spacing environment and a ground station frequency tolerance of 50 parts in 10^6 (± 0.005 per cent), an effective adjacent channel rejection characteristic of 60 dB or better is assumed. This assumption will result in a geographical separation distance between the nearest limits of the functional service ranges of the two facilities of at least 5.6 km (3 NM).

2.2 For aircraft receivers designed for operation in a 25 kHz channel spacing environment and a ground station frequency tolerance of ± 0.002 per cent, and for aircraft receivers designed for operation in a 8.33 kHz spacing environment, and a ground station frequency tolerance of ± 0.001 per cent, an effective adjacent channel rejection

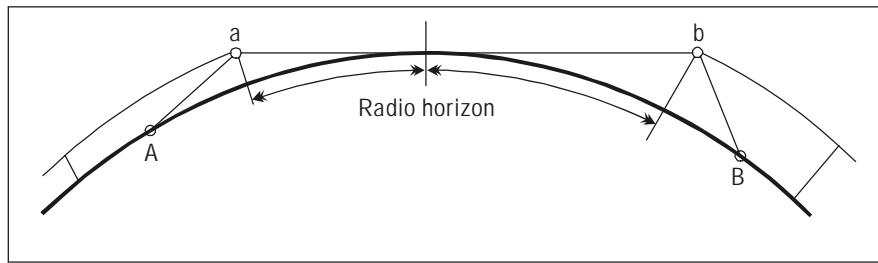


Figure A-1. Geographical separation required for co-channel operation of VHF facilities

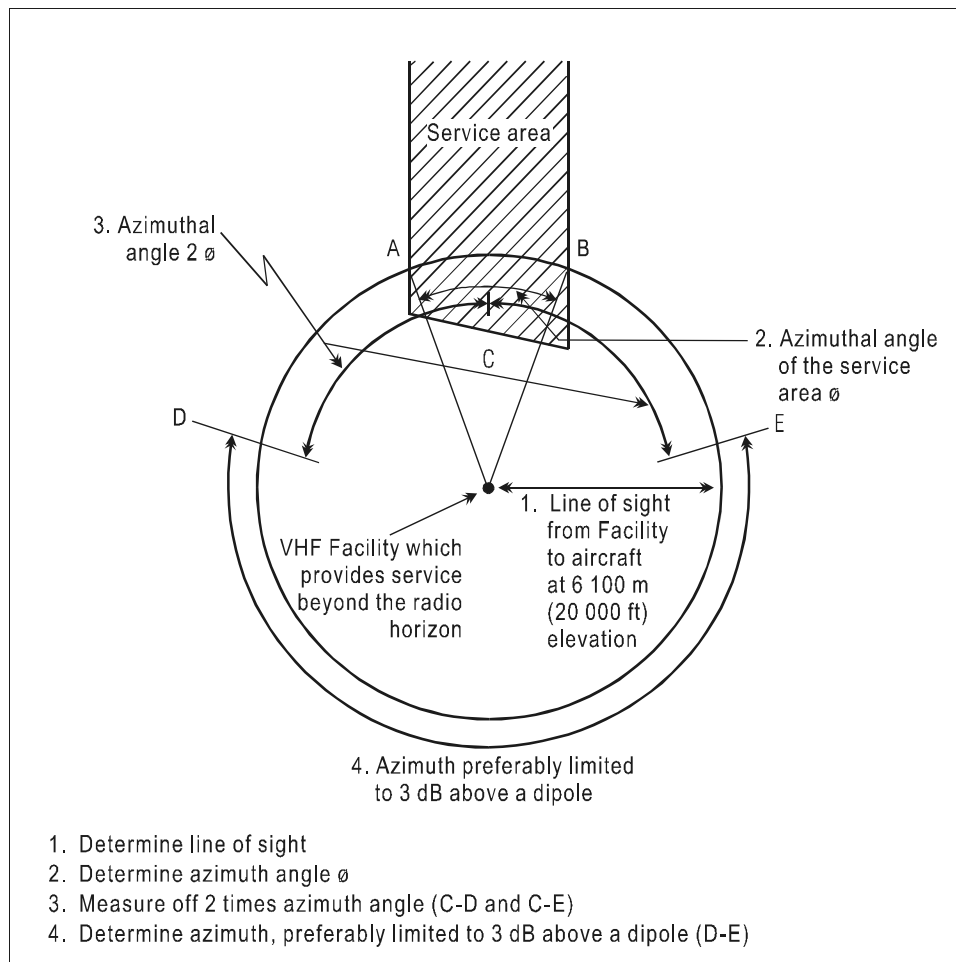


Figure A-2. Limit of azimuth protection for VHF facilities which provide a service beyond the radio horizon

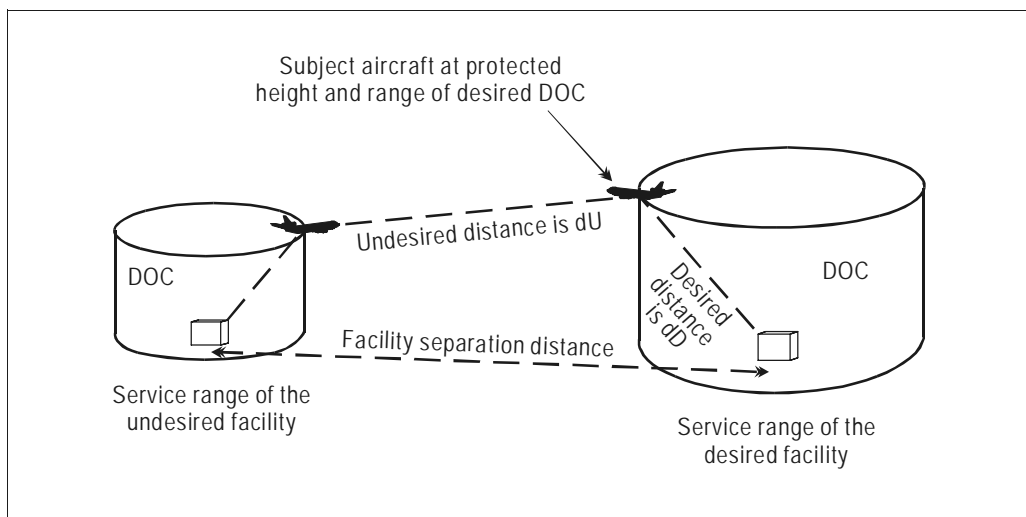


Figure A-3. Co-channel configuration for undesired/desired distance ratio

characteristic of 60 dB or better is assumed. This assumption will result in a geographical separation distance between the nearest limits of the functional service ranges between two facilities using 25 kHz spacing or between two facilities using 8.33 kHz spacing of at least 5.6 km (3 NM).

2.3 The above criteria are based on the concept of protection by receiver muting, except in the case of area control and FIR channels where a minimum field strength is specified in order to secure the desired wanted-to-unwanted signal ratio.

2.4 The following additional assumptions were made in establishing the criteria:

- 1) *Propagation*: free space propagation between aircraft. The ITU-R curves for 100 MHz vertical polarization over land in conjunction with an assumed ground antenna height of 20 m (65 ft) were used in computing ground-air field strengths.
- 2) *Minimum field strength at limit of functional service range*: 45 dB above 1 microvolt per metre at 3 000 m (10 000 ft) in the case of area control and FIR channels.

Note.— To meet this requirement, a station radiating 100 W from an antenna 20 m (65 ft) high should be not more than 185 km (100 NM) from the limit of its functional service range.

- 3) *Effective radiated power (ERP)*: a maximum ERP of 20 W from ground and airborne stations with the exception that, in case of ground stations providing flight information or area control service communications, it was necessary to assume a minimum ERP of 100 W.
- 4) *Airborne antenna polar patterns*: total variations not exceeding 10 dB. Since a maximum ERP was assumed (and therefore all variations are downwards from this figure), no allowance was necessary in respect of airborne transmitter polar diagrams.
- 5) *Wanted-to-unwanted signal ratio*: 20 dB at the receiver output.
- 6) *Receiver muting characteristics*: a muting threshold corresponding to a received field strength of 5 microvolts per metre.

2.5 The following criteria were based on all relevant assumptions made in 2.4. Two cases related to adjacent channel interference are considered separately:

- a) receiver mute lift; and
- b) desired-to-undesired signal ratio.

These cases might cause different planning criteria to be observed.

2.5.1 Where it is necessary to take account on a regional basis of receivers not specifically designed for an 8.33 kHz environment, the following characteristics should be assumed:

- a) an 8.33 kHz channel, which is assigned 8.33 kHz away from the assigned frequency of a 25 kHz channel, is assumed to be co-channel with that 25 kHz channel;
- b) an 8.33 kHz channel, spaced ± 16.67 kHz from the assigned frequency of a 25 kHz channel is assumed under all operating conditions (including all instabilities and doppler shifts), to have an adjacent channel rejection ratio of:
 - i) 23 dB aircraft against ground offset carrier systems;
 - ii) 30 dB aircraft against ground non-offset carrier systems; and
 - iii) 27 dB aircraft against aircraft systems.

Worst case conditions for planning purposes are used here for a mixed environment of 8.33 kHz and 25 kHz systems.

- c) an 8.33 kHz channel which is assigned 25 kHz away from the assigned frequency of a 25 kHz channel is assumed to have an effective adjacent channel characteristic of at least 60 dB.

2.5.2 Where it is necessary to take account of the implementation of VHF stations which use 8.33 kHz channel spacing, in a region where 25 kHz assignments occur, the assumptions of 2.5.1 a) to c) result in the following:

- a) where 8.33 kHz services are spaced ± 8.33 kHz away from the assigned frequency of a 25 kHz channel, the regionally agreed planning criteria for co-channel assignments should be used, applying either the radio horizon method (assumed to give at least 20 dB D/U) or a desired-to-undesired signal ratio of 14 dB;
- b) where 8.33 kHz services are spaced ± 16.67 kHz away from the assigned frequency of a 25 kHz channel, the following criteria should be applied:
 - i) Receiver mute lift criteria.

The minimum separation distance required for the prevention of receiver mute lifts is:

187 NM aircraft against ground offset carrier systems;

84 NM aircraft against ground non-offset carrier systems; and

118 NM aircraft against aircraft systems.

- ii) Desired-to-undesired signal ratio.

The minimum distance required to provide sufficient adjacent channel protection based upon a D/U ratio (assuming equal ERP from the wanted and unwanted signals) can be calculated given the maximum service range of the wanted signal by:

$$D_{adj} = \text{service range} / (10 (ACR - D/U) / 20)$$

D_{adj} = distance required between the edges of the two service ranges operating on adjacent channels

ACR = adjacent channel rejection

D_{adj} and service range expressed in the same units.

The D/U ratio used will depend on regionally agreed planning criteria.

Note.— The application of the 14 dB planning criteria assumes that it is highly unlikely that two aircraft will be at the maximum edge of their respective service volumes and at the closest point between these two volumes.

- c) 8.33 kHz channels spaced 25 kHz away from an assigned frequency of a 25 kHz channel should be planned in accordance with 2.2.

3. Criteria to be employed in establishing adjacent channel frequency deployment of VHF facilities that have a service range beyond the radio horizon

For the most economical use of frequencies and to ensure freedom from interference, planning must be based on an accurate knowledge of equipment used. When the equipment characteristics and field strength (or attenuation) curves are on hand for the troposcatter regions, it is relatively easy to determine the required geographical separation. When these are not known, the maximum permitted antenna gain stipulated in 4.1.6.1 will be assumed. There are several conditions that must be calculated and compared to determine the appropriate separation to be used. The conditions to be compared are:

- 1) ground facility-to-aircraft;
- 2) aircraft-to-ground facility;

- 3) aircraft-to-aircraft; and
- 4) ground facility-to-ground facility.

Case 1.— For the case of protection of aircraft A from a ground facility (see Figure A-4):

- A. Determine the signal level S (dB rel. $1 \mu\text{V/m}$) received from the desired station at the limit of the service radius at the protection altitude.
- B. Assign the desired protection ratio P (dB) required at the aircraft receiver.
- C. Let receiver adjacent channel rejection be represented by A (dB). Then the level L (dB rel. $1 \mu\text{V/m}$) that can be tolerated at the receiver antenna can be determined by:

$$L = S - P + A$$

- D. Distance d (km) from protection point to undesired facility to provide protection established by "C", is found by application of L to the appropriate curves.

Note 1.— Figures A-8 to A-15 are field strength curves appropriate for the average temperate climate over land or sea, which may be used to determine geographical separation

for situations where these field strengths will not normally be exceeded more than 5 per cent of the time. These curves were established by the Institute for Telecommunications Sciences and Aeronomy of the Environmental Science Services Administration of the United States.

Note 2.— For power levels other than 1 kW the necessary corrections under "C" would have to be made. For example, 5 kW ERP requires a minus 7 dB correction.

- E. The facility-to-facility separation D is d (km) plus service radius (km).

Case 2.— Aircraft (A)-to-ground facility (see Figure A-4):

- A. Determine signal level S_g at the ground facility receiving antenna for proper system operation.

- B. Proceed as in Case 1, where

$$L = S_g - P + A$$

- C. Ground facility-to-ground facility separation will also be determined as in Case 1 ($D = d + \text{service radius (km)}$).

Note.— Where ground facility receivers have sensitivities of less than 1 microvolt across 50 ohms, Case 2 is most likely to yield the separation to be used.

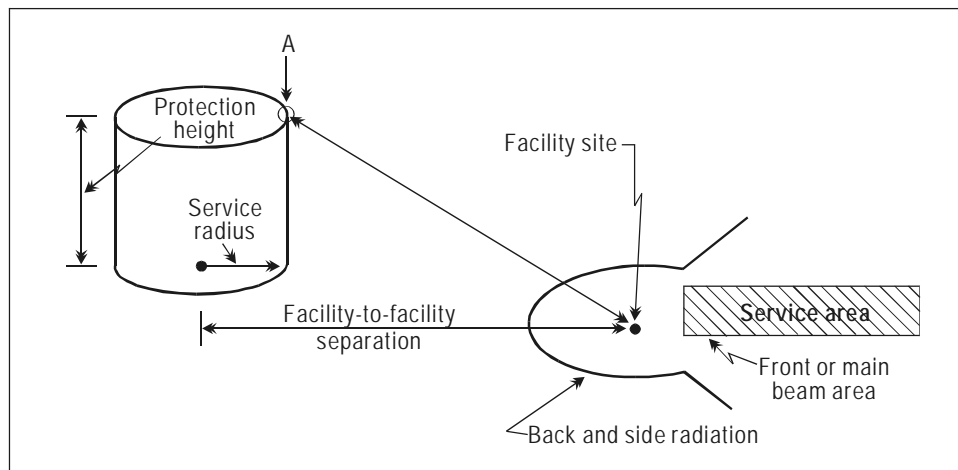


Figure A-4. Air-to-ground (facility from A) and ground-to-air (A from facility)

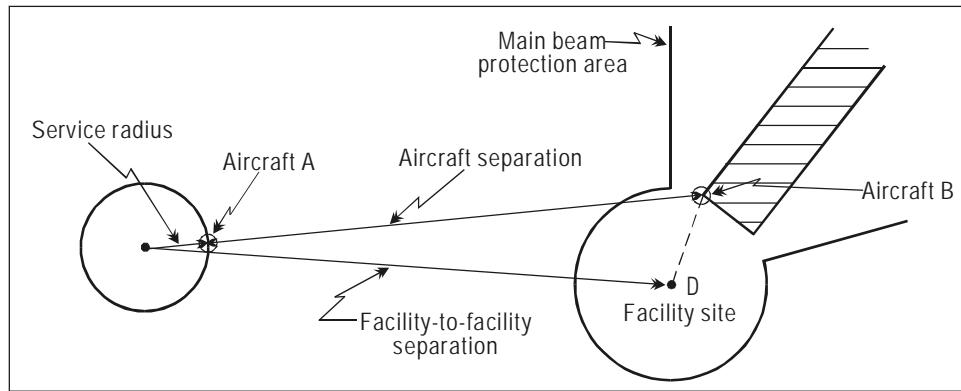


Figure A-5. Facility-to-facility separation based on air-to-air (A from B) and ground-to-ground (C and D)

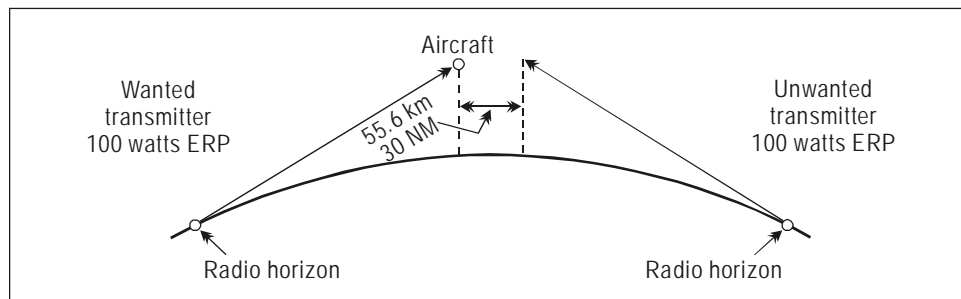


Figure A-6. VOLMET planning (illustrating co-channel protection)

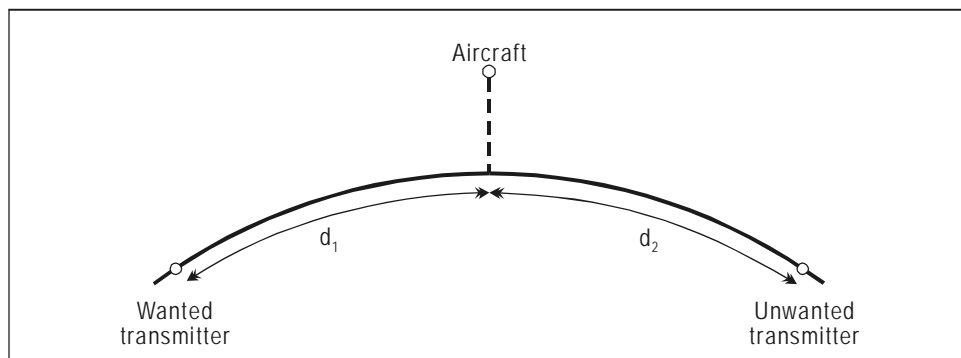


Figure A-7. VOLMET planning (illustrating adjacent channel protection)

Case 3.— Aircraft (A)-to-aircraft (B) (see Figure A-5):

- A. Establish service radius and protection altitude for facility to be protected (see aircraft A in Figure A-5).
- B. Determine closest point to aircraft A that aircraft B will be transmitting to the ground facility site and the altitude where this will take place.
- C. Proceed as in Case 1, using the aircraft (B) contacting ground facilities as the undesired signal.
- D. Then $L = S - P + A$
- E. The distance d to aircraft B (undesired) obtained from the curves, plus the service radius of the facility to be protected, will determine the separation between aircraft B and the ground facility protected.
- F. Facility-to-facility separation may then be determined graphically or by trigonometric means.

Case 4.— Ground facility-to-ground facility (see Figure A-5).

- A. Determine signal level that can be tolerated at the receiver antenna at one facility by $L = S_g - P + A$ (see Case 1).
- B. Then facility-to-facility separation for these conditions is read directly from the curves (after correcting for transmitter power of other facilities if different from 1 kW).
- C. Should equipment at the two facilities have different characteristics, repeat procedure in “A” and “B” for the other combinations of equipment.
- D. Of the two distances derived, use the greater to compare with other cases (see below).

Note.— In most instances, it will be found that the facility-to-facility consideration will not be the controlling factor in determining geographical separation.

Facility separation will then be the greatest distance derived for Cases 1 to 4.

4. Criteria to be employed in establishing geographical separation between ground stations and between aircraft and ground stations for co-channel operation of VHF facilities that have a service area beyond the radio horizon

Geographical separation of co-channel facilities can be calculated by using the method given in 2 above except that

the adjacent channel rejection A is omitted from consideration.

5. Criteria employed in establishing co-channel frequency deployment of VHF VOLMET facilities

In the case of VHF VOLMET services, the geographical separation between co-channel stations should be 55.6 km (30 NM) plus twice the distance to the radio horizon from an aircraft at the highest altitude flown by aircraft in the area concerned. (See Figure A-6.)

Note.— At 27.8 km (15 NM) beyond the radio horizon, the field strength at 13 500 m (45 000 ft), from a transmitter of 100 W ERP, will be approximately at the receiver muting level of 5 microvolts per metre.

6. Criteria employed in establishing adjacent channel frequency deployment of VHF VOLMET facilities

6.1 For aircraft receivers designed for operation in a 25 kHz channel spacing environment, an effective adjacent channel rejection characteristic of 60 dB or better is assumed. This assumption will result in a geographical separation distance D between VHF VOLMET ground transmitters derived as follows (nautical miles may be substituted for kilometres):

$$D = (d_1 + d_2) \text{ km}$$

where

$$\begin{aligned} d_1 &= \text{distance between aircraft and wanted ground station} \\ &= \text{radio horizon} + 27.8 \text{ km (15 NM)} \end{aligned}$$

and

$$\begin{aligned} d_2 &= \text{distance between aircraft and unwanted ground station} \\ &= 24.1 \text{ km (13 NM)}. \end{aligned}$$

(See Figure A-7.)

6.2 Where it is necessary to take account, on a regional basis, of receivers not specifically designed for 25 kHz channel spacing and used in a 25 kHz channel spacing environment, an effective adjacent channel rejection characteristic of the receiver of the order of 40 dB is assumed. This assumption will result in a minimum geographical separation distance D between VHF VOLMET ground transmitters derived as follows:

$$D = (d_1 + d_2) \text{ km}$$

where

d_1 = distance between aircraft and wanted ground station
 = radio horizon + 27.8 km (15 NM)

d_2 = distance between aircraft and unwanted ground station
 = 240.9 km (130 NM).

6.3 Application of the above criteria in the case of aircraft altitudes of 13 500 m (45 000 ft) and 20 000 m (66 000 ft) results in the following separation distances:

| Altitude | Receiver rejection characteristic | d_1 km (NM) | d_2 km (NM) | D km (NM) |
|----------------------|-----------------------------------|---------------|---------------|-------------|
| 13 500 m (45 000 ft) | 60 dB | 491 (265) | 24.1 (13) | 515 (278) |
| 13 500 m (45 000 ft) | 40 dB | 491 (265) | 241 (130) | 732 (395) |
| 20 000 m (66 000 ft) | 60 dB | 619 (334) | 24.1 (13) | 643 (347) |
| 20 000 m (66 000 ft) | 40 dB | 619 (334) | 241 (130) | 860 (464) |

6.4 The above criteria are based on the following additional assumptions:

1) *Effective radiated power*: an ERP of 100 W for the ground stations.

Note.— If an ERP of 20 W is assumed, this would result in separation distances for 13 500 m (45 000 ft) of 472 km (255 NM) for 60 dB receiver adjacent channel rejection and 572 km (309 NM) for 40 dB receiver adjacent channel rejection.

2) *Interfering signal strength*: if the received signal strength is in excess of the free space propagation value, then the maximum value will not exceed the free space value by more than 5 dB over average earth. This condition is satisfied when transmitters of 20 W ERP or more are used in conjunction with a receiver adjacent channel rejection of not less than 35 dB. Thus, the minimum distance for d_2 can be derived from a consideration of receiver muting level, receiver adjacent channel rejection and transmitter ERP.

7. RF — Characteristics for digital VHF systems, interference immunity performance

7.1 *Receiving function — interference immunity performance*. The standard measurement technique for digital systems provides that the desired signal field strength be doubled, and that the undesired signal be applied in increasing levels until the channel performance, that is the specified error rate, degrades to a value equal to the value found at the specified receiver sensitivity.

For the VDL, the effect of the measurement technique is that the desired signal strength is increased from 20 microvolts per metre to 40 microvolts per metre. Then the undesired signal on the adjacent or any other assignable channel is raised to the specified level higher than the desired signal until the specified error rate is exceeded.

Care should be taken to ensure that on-channel noise power is not included in the measurement of the undesired signal.

7.2 *Assignment criteria*. Assignment of frequencies for VHF digital link should take into account the VDL RF system characteristics in order to avoid harmful interference to or from co-channel and adjacent channel assignments, in keeping with regionally and nationally agreed spectrum management policies.

Figures A-8 to A-15. Propagation curves for standard atmosphere (301) for frequency of 127 MHz

ESSA/I.T.S.A.—1966 Propagation Model

These curves labelled “5 per cent time availability” represent only a statistically expected value; i.e., a probability of 0.05 that a particular situation will result in the specified field strength or greater during 5 per cent of the time.

The parameters used to develop these curves include:

- 1) frequency of 127 MHz;
- 2) horizontal or vertical polarization;
- 3) smooth earth with land or sea surface;
- 4) reflection coefficient of unity magnitude;
- 5) standard atmosphere with a 301 surface refractivity;
- 6) continental temperate climate;
- 7) Nakagami-Rice statistics for within-the-horizon fading;
- 8) an effective radiated power (ERP) corresponding to 1 kilowatt input power into a lossless half-wave dipole.

1/11/01

ATT A-10

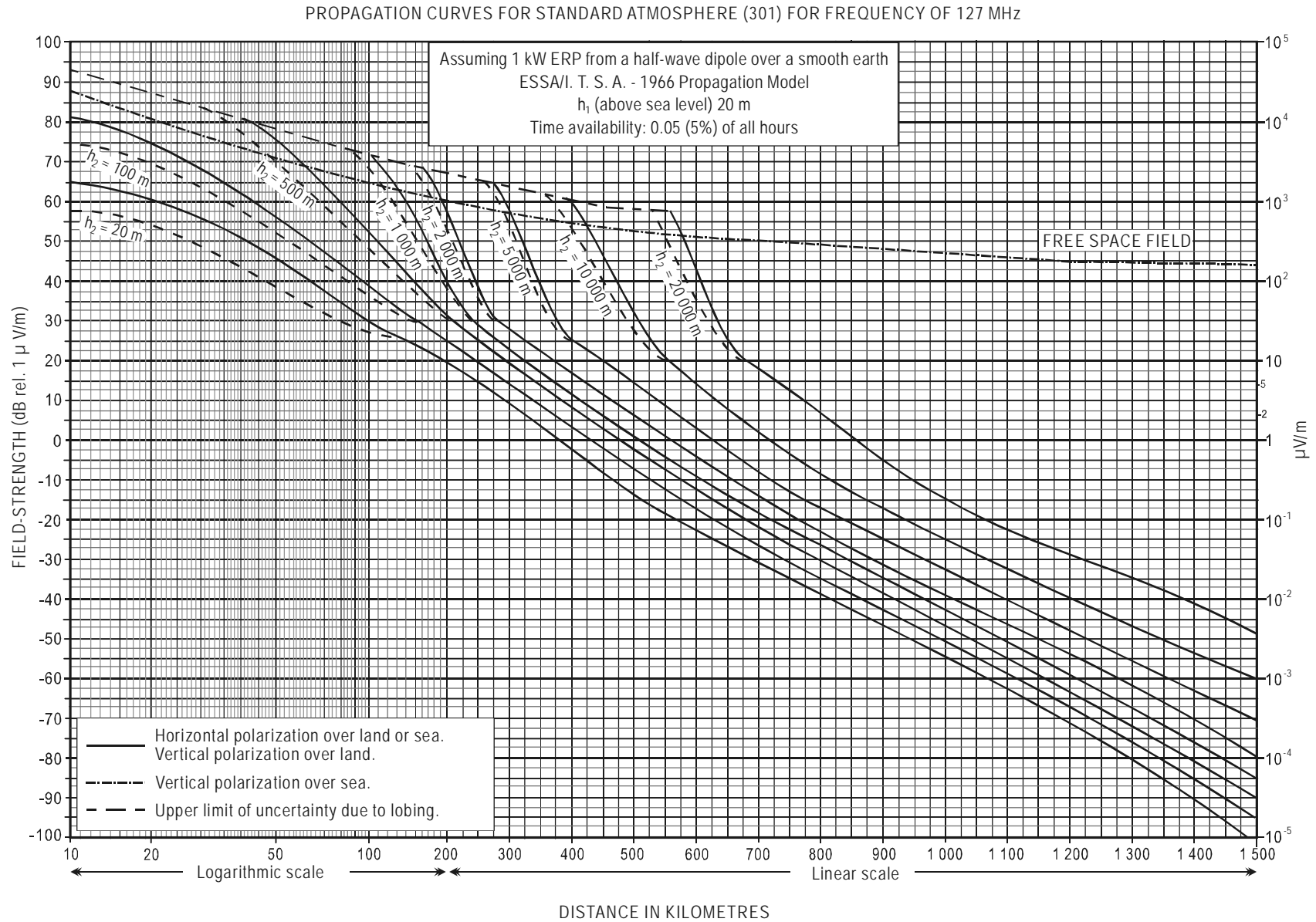
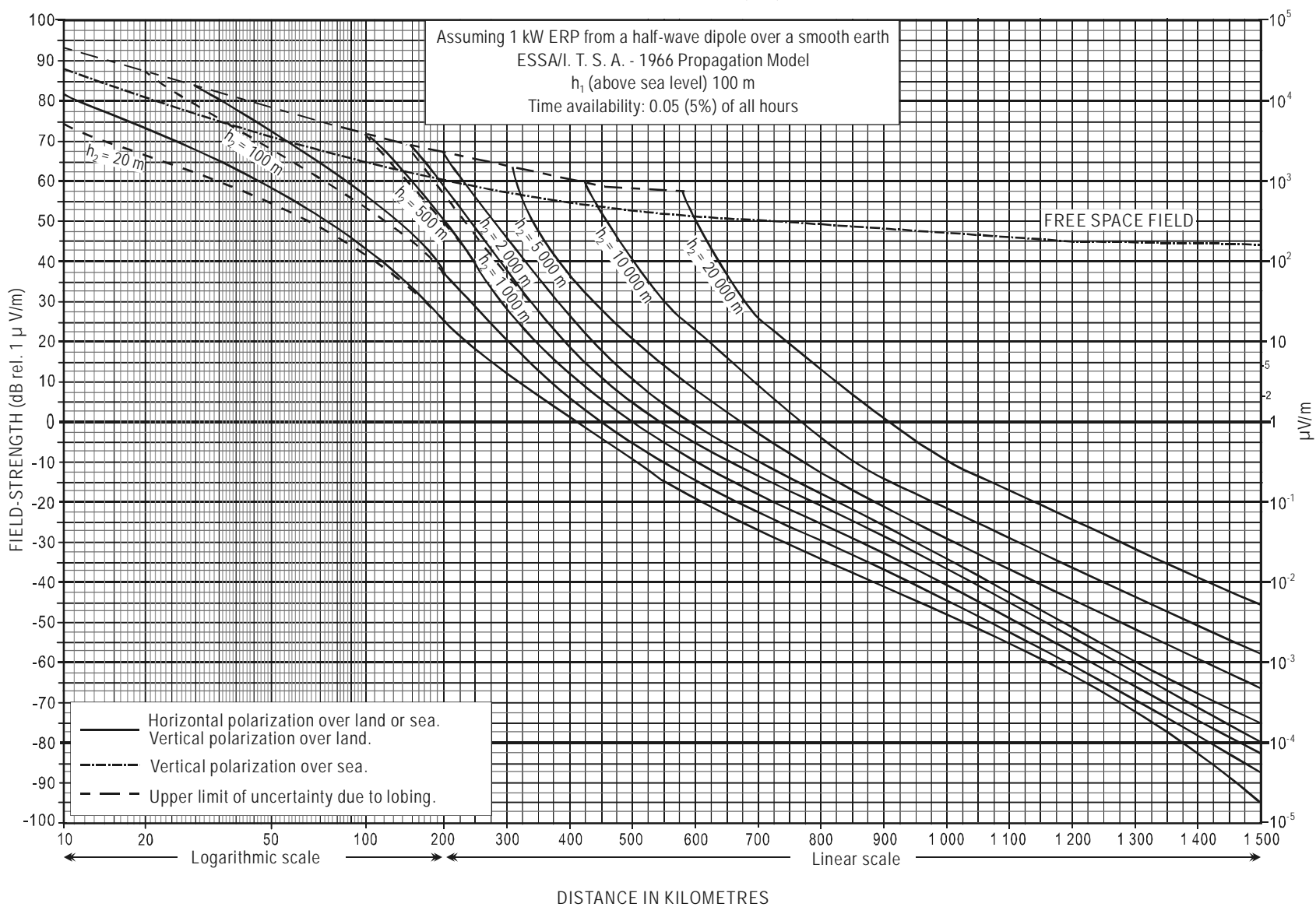


Figure A-8

PROPAGATION CURVES FOR STANDARD ATMOSPHERE (301) FOR FREQUENCY OF 127 MHz



ATT A-11

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Figure A-9

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ATT A-12

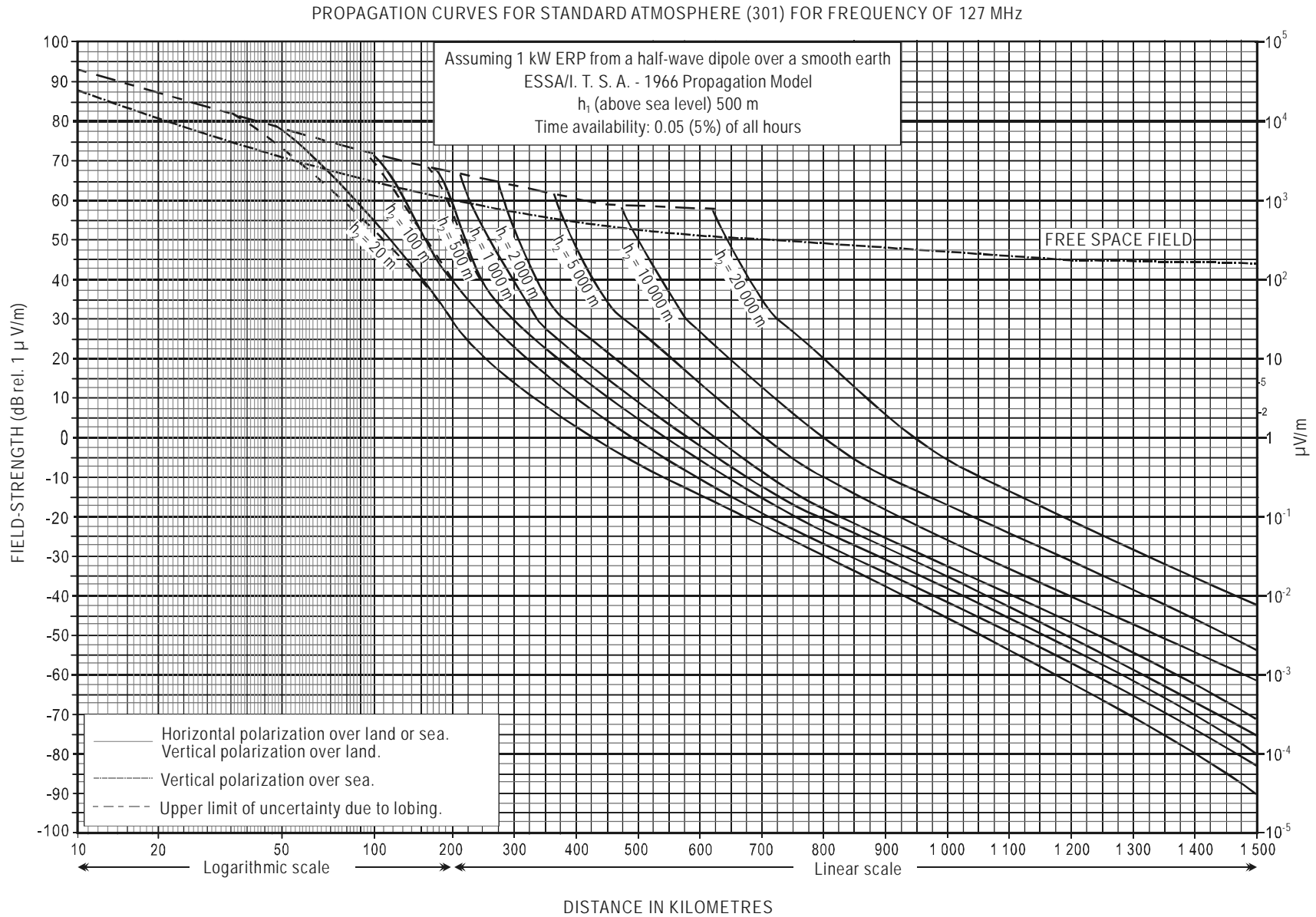
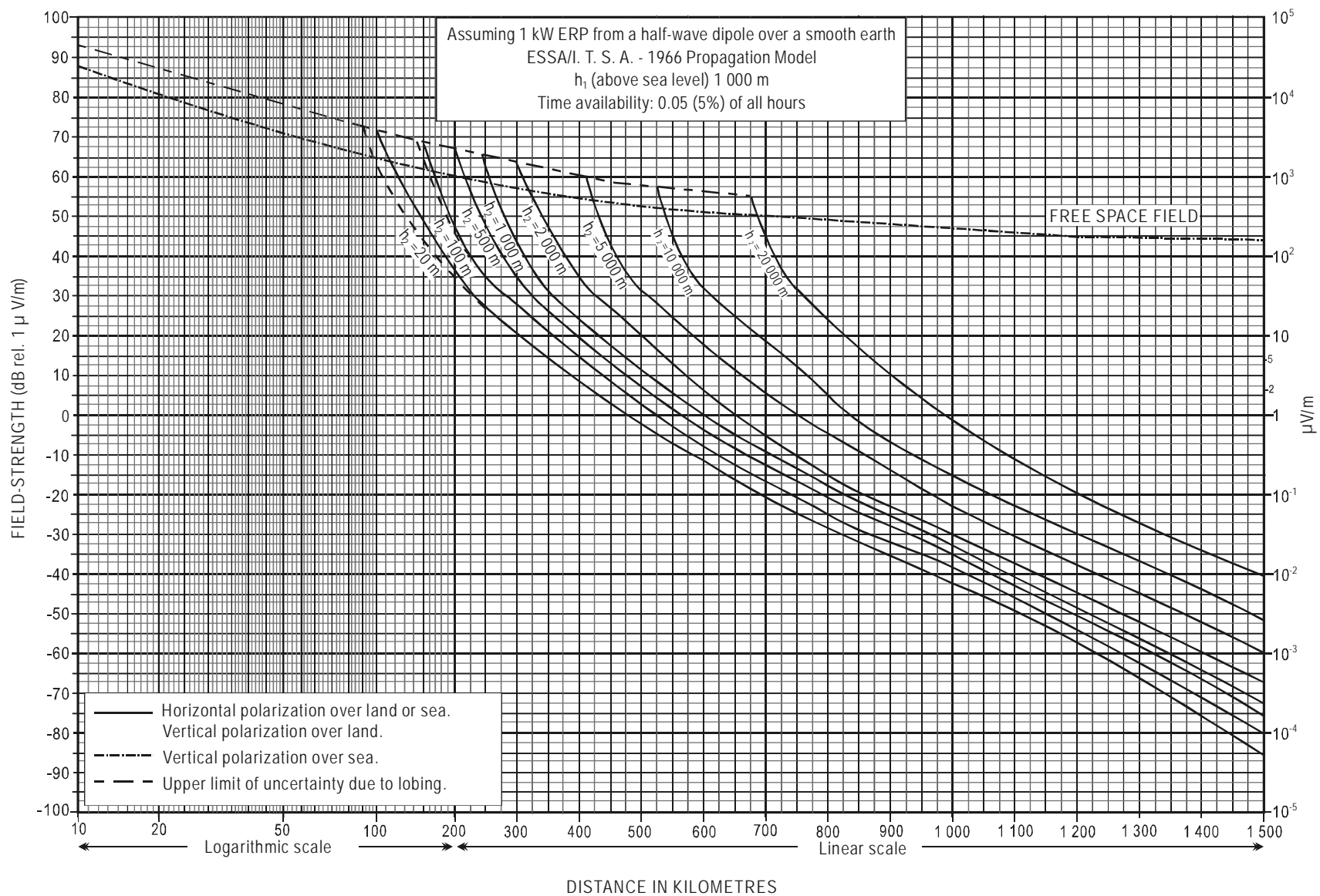


Figure A-10

PROPAGATION CURVES FOR STANDARD ATMOSPHERE (301) FOR FREQUENCY OF 127 MHz



ATT A-13

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Figure A-11

PROPAGATION CURVES FOR STANDARD ATMOSPHERE (301) FOR FREQUENCY OF 127 MHz

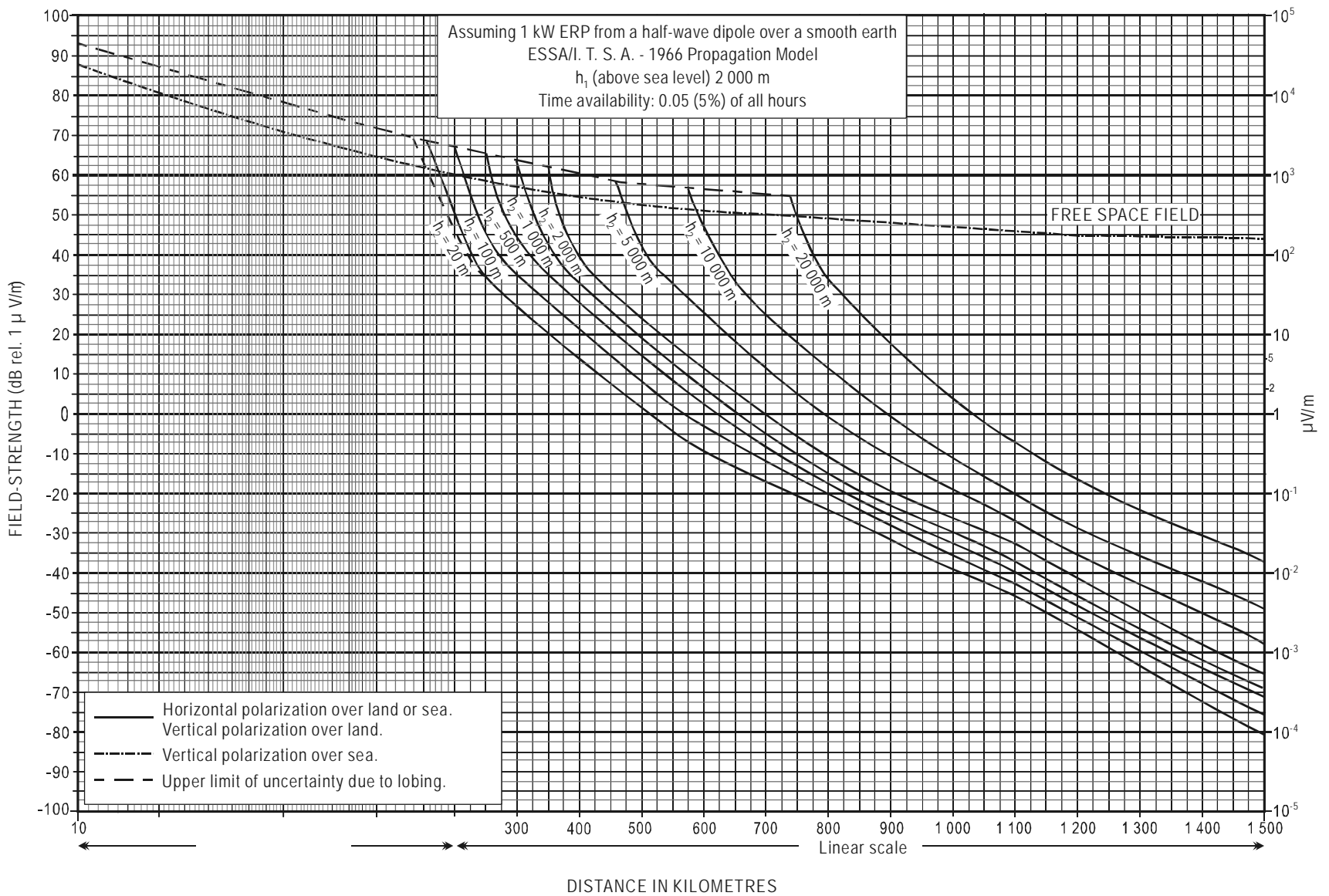


Figure A-12

PROPAGATION CURVES FOR STANDARD ATMOSPHERE (301) FOR FREQUENCY OF 127 MHz

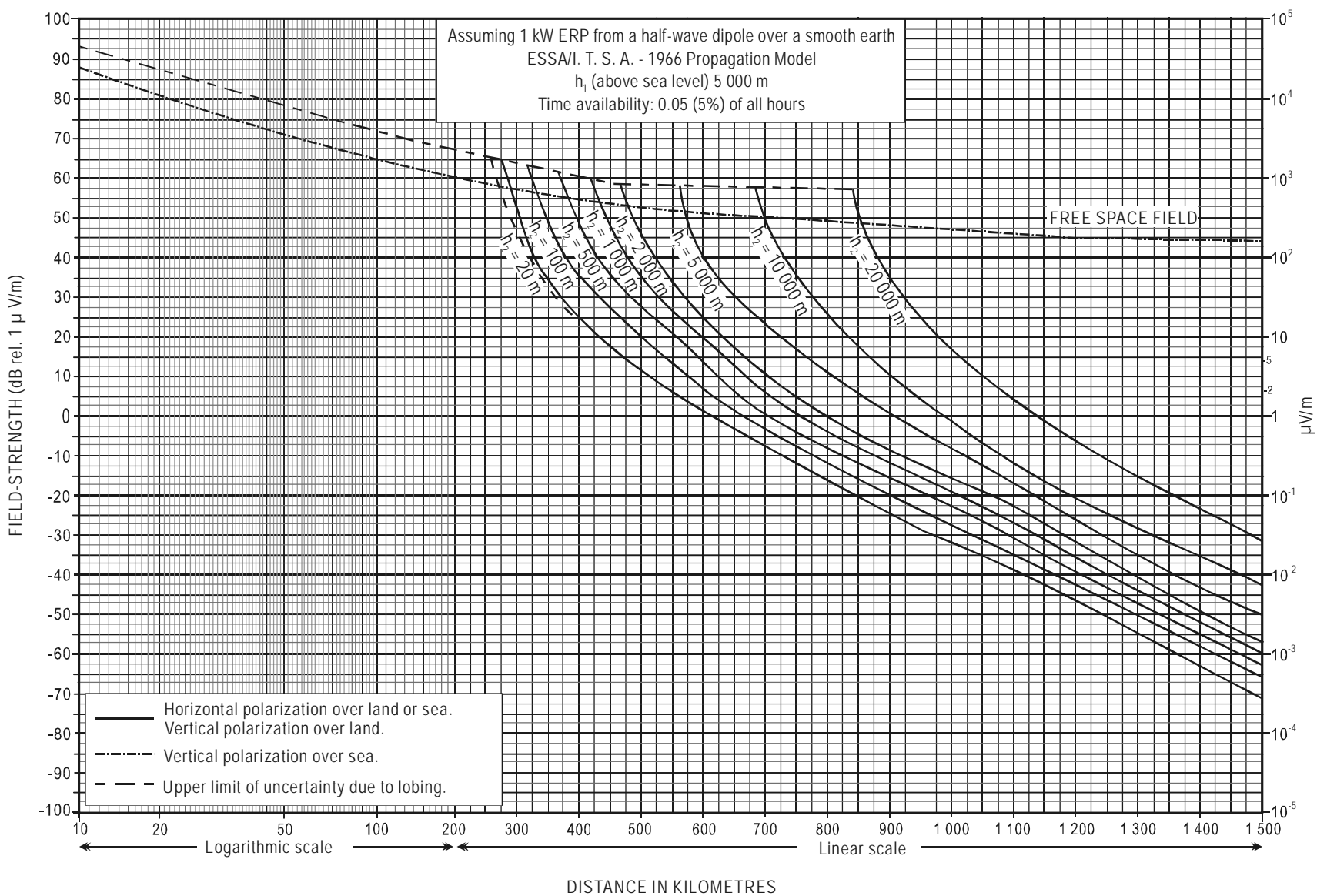


Figure A-13

ATT A-15

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Attachment A

Annex 10 — Aeronautical Telecommunications

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ATT A-16

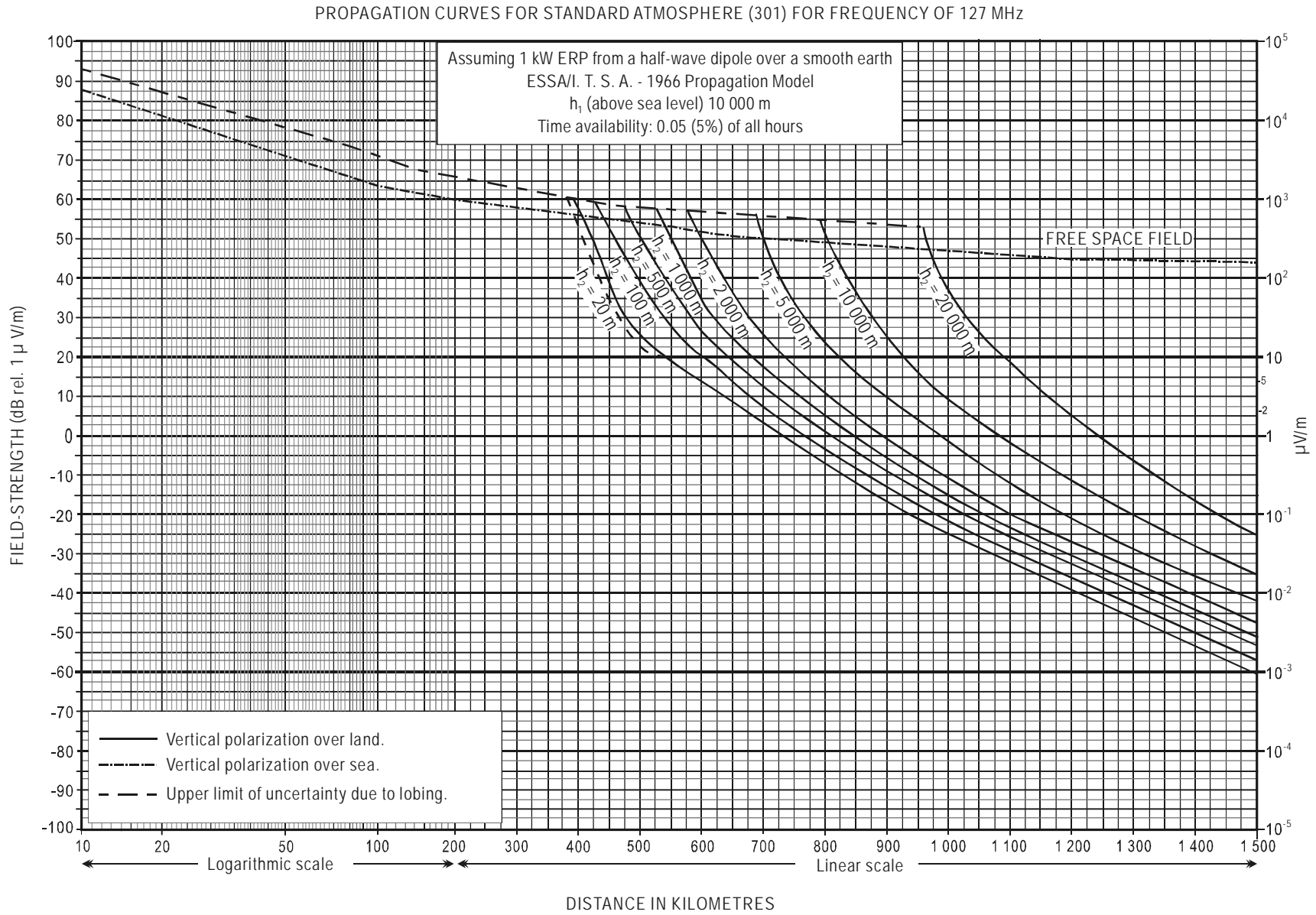


Figure A-14

ATT A-17

1/11/01

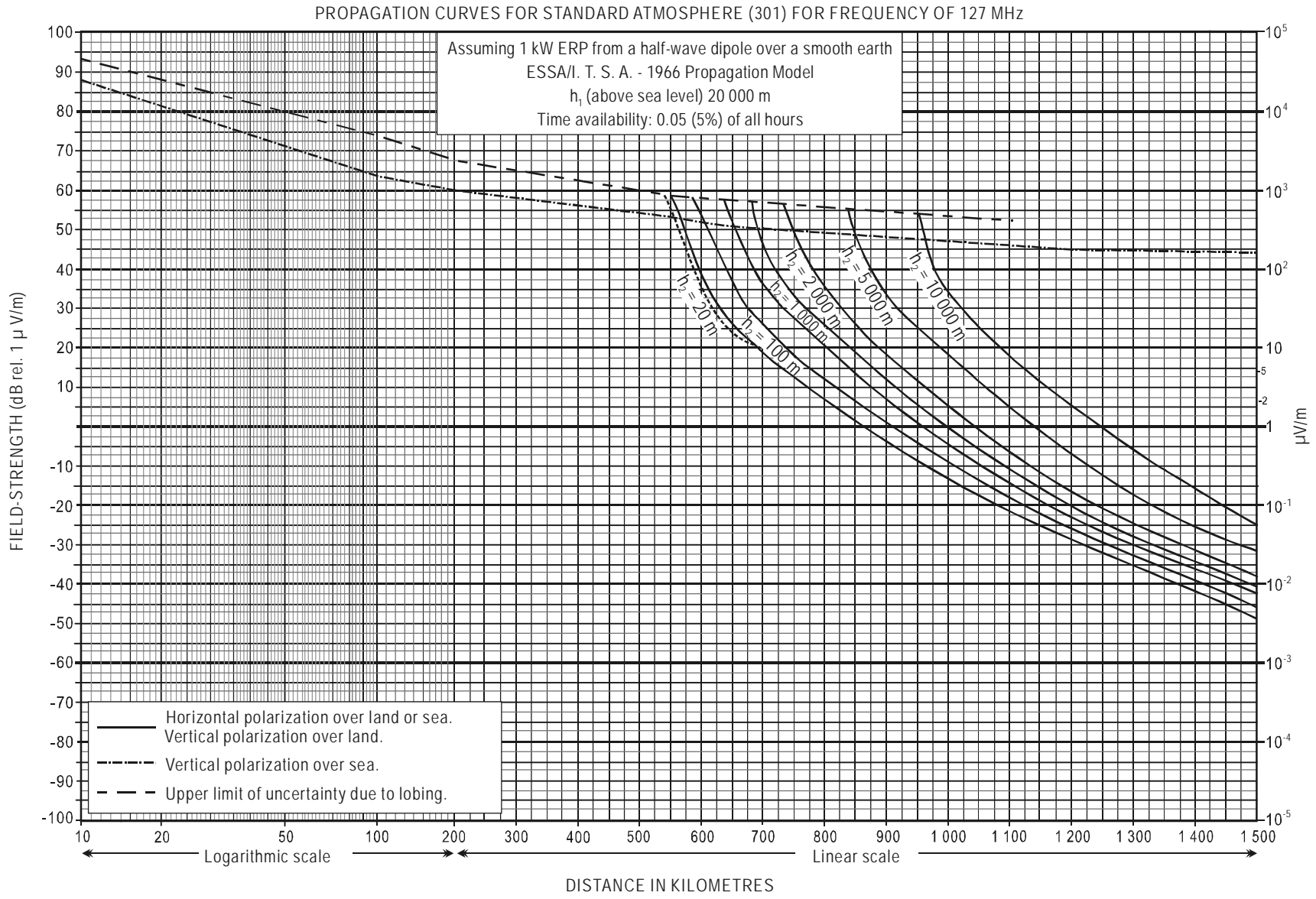


Figure A-15

ATTACHMENT B. CONSIDERATIONS AFFECTING THE DEPLOYMENT OF LF/MF FREQUENCIES AND THE AVOIDANCE OF HARMFUL INTERFERENCE

1. Particularly in areas of high density of NDBs, it is recognized that efficient planning is essential in order to: a) ensure satisfactory operation of ADF equipment, and b) provide the most efficient usage of the limited frequency spectrum available for the NDB service. It is axiomatic that regional meetings will so plan facilities as to ensure that all facilities will receive the best possible protection from harmful interference. Nevertheless, in certain regions, congestion of facilities has been such that regional meetings have had to plan in terms of a *minimum* protection ratio.

Regional meetings include in their planning consideration of such factors as:

- a) the possibility of reducing the number of NDBs required, by coordination of system plans;
- b) the possibility of reducing the coverage where a lesser grade of service than that obtainable within the rated coverage is acceptable;
- c) the characteristics of ADF equipment in use;
- d) the atmospheric noise grades, appropriate to the area concerned;
- e) ground conductivity; and
- f) interference protection required at the edge of the rated coverage.

Of the foregoing factors, that which is most susceptible to improvement of a technical kind is c).

2. The 1979 World Administrative Radio Conference adopted regulations concerning the assignment of frequencies for aeronautical radio beacons operating in the LF/MF frequency bands. A minimum protection ratio (wanted/unwanted signal ratio) of 15 dB is to be used as the basis for frequency assignment planning (RR Appendix S12). The following data concerning the attenuation characteristics of ADF equipment was used in the EUR region to aid in the frequency assignment process:

| <i>Frequency difference (kHz)</i> | <i>Attenuation (dB)</i> |
|---------------------------------------|-----------------------------|
| 0 | 0 |
| 1 | 1 |
| 2 | 6 |
| 2.4 | 10 |
| 3 | 20 |
| 3.6 | 30 |
| 4.3 | 40 |
| 5 | 50 |
| 6 | 65 |
| 7 | 80 |

The above figures (or distance separation criteria derived from them) have also been applied in other regions in determining the minimum protection ratio.

Where a bearing accuracy of ± 5 degrees is required at the edge of cover, a minimum protection of 15 dB by day should be used as the basis for LF/MF channel assignment planning.

3. In view of the fact that in many regions there is a need to improve the planning criteria it is considered that the main source from which improvement can be derived is recognition of higher attenuation figures than those given above. Regional meetings are accordingly advised that, when the congestion is such that the use of the above figures no longer permits efficient planning of the LF/MF frequency spectrum available, the following figures represent from a technical point of view the best that can be accepted in determining distance separation criteria:

| <i>Frequency difference (kHz)</i> | <i>Attenuation (dB)</i> |
|---------------------------------------|-----------------------------|
| 0 | 0 |
| 1 | 6 |
| 3 | 35 |
| 5 | 65 |
| 6 | 80 |

When using these figures, it should be noted that the RF selectivity of modern ADF equipment is in general better

than these figures and that, while the RF selectivity of older ADF equipment is not better than these figures, consideration of the dynamic characteristic of this older equipment shows this to be better. It could therefore be expected that frequency planning based on the new figures would considerably improve the service provided to users of modern equipment, and would not materially reduce the service presently provided to those aircraft using the older equipment.

Nevertheless, in their planning, regional meetings would need to consider this question most carefully.

4. It is further noted that, in certain regions, many NDBs are used with voice channels and that this usage is aligned with the Note at the head of Volume I, 3.4.6. It is expected that regional meetings will take this fact into account when establishing criteria for frequency planning.

ATTACHMENT C. GUIDING PRINCIPLES FOR LONG DISTANCE OPERATIONAL CONTROL COMMUNICATIONS

Note.— The numerical sequence of the clauses below does not signify any order of relative importance.

1. Aeronautical Operational Control (AOC) HF Stations should be authorized where no other means for the exercise of long distance operational control are available or where the use of the normal communication services provided for safety and regularity of flights are unsuitable or inadequate.

2. The total number of ground stations on the worldwide radio channels should be kept to a minimum consistent with economic and operational efficiency. Consequently,

- a) there should normally be not more than one station per State; and
- b) where an agreed affinity of interest exists between adjoining States, a single station may be provided by agreement among them to serve the needs of all the aircraft operating agencies requiring a service into those States.

3. Depending on the national policy of the State or States, aeronautical stations could be operated by States on behalf of one or more aircraft operating agencies provided that the agencies' requirements for flexibility and direct communication to their aircraft can be met, or aeronautical stations

could be operated by an aircraft operating agency or a communication agency serving the interests of one or more aircraft operating agencies and operating under licence issued by the State or States concerned.

4. The licences should be issued on a regular renewal basis and, pursuant to RR S4.11 and in accordance with RR S43.4, should prohibit "public correspondence", or point-to-point type traffic, or other communications traffic not meeting the definition of operational control communications.

5. VHF (general purpose or AOC channels) and not HF should be used when an aircraft is within the coverage of an appropriate VHF aeronautical station.

Note.— The specific categories of messages that may be handled on aeronautical mobile (R) service channels are prescribed in Annex 10, Volume II, Chapter 5, 5.1.8. The same chapter defines the standard communications procedures for the service including the requirements for maintaining watch in Annex 10, Volume II, Chapter 5, 5.2.2. In accordance with RR S18.6 of the ITU Radio Regulations, licences should define the purpose of the station for aeronautical operational control (as defined in Annex 6, Part I) and should specify the general characteristics in accordance with Appendix S27 of the Radio Regulations.

— END —

ICAO TECHNICAL PUBLICATIONS

The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the Aeronautical Chart Catalogue or the Meteorological Tables for International Air Navigation.

International Standards and Recommended Practices are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications contained in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

Procedures for Air Navigation Services (PANS) are approved by the Council for worldwide application. They contain, for the most part, operating procedures regarded as not yet having attained a sufficient degree of

maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome.

Regional Supplementary Procedures (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

Technical Manuals provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

Air Navigation Plans detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

ICAO Circulars make available specialized information of interest to Contracting States. This includes studies on technical subjects.
