World Administrative Radio Conference
for the planning of the HF bands allocated
to the broadcasting service
First Session, Geneva, 1984

REPORT TO THE
SECOND SESSION OF THE CONFERENCE

(See Resolution PLEN./1)

General Secretariat
of the
International Telecommunication Union
Geneva, 1984

FIRST SESSION OF THE
WORLD ADMINISTRATIVE RADIO CONFERENCE
FOR THE PLANNING OF THE HF BANDS
ALLOCATED TO THE BROADCASTING SERVICE
Geneva, 1984

Geneva, 11 February 1984

The Chairman
of the Second Session of the
World Administrative Radio
Conference for the Planning of the
HF Bands allocated to the
Broadcasting Service

Dear Sir,

In accordance with the provisions of Resolution PLEN/1 adopted at the First Session of the World Administrative Radio Conference for the Planning of the HF Bands allocated to the Broadcasting Service, Geneva, 1984, I enclose the Report of the First Session for transmission to the Second Session of the Conference.

K. BJÖRNSJÖ
Chairman

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CHAPTER 1

INTRODUCTION

1. The World Administrative Radio Conference (Geneva, 1979), in its Resolution 508, resolved that the use of the HF Bands Allocated to the Broadcasting Service should be the subject of planning by a World Administrative Radio Conference and invited the Administrative Council to take all necessary steps for the convening of the Conference. It also resolved that the Conference should be held in two sessions, that :

- the First Session should establish the technical parameters to be used for planning and the principles governing the use of the HF Bands Allocated to the Broadcasting Service and should decide on the planning principles to be used and the method of planning to be adopted by the Second Session; and that

- the Second Session should carry out the planning according to the principles and the method established at the First Session and should review and, where necessary, revise the relevant provisions of the Radio Regulations relating to broadcasting in the HF bands.

2. The Administrative Council, at its 36th Session (1981), proposed that the First Session of the Conference be held in Geneva for five weeks in January/ February 1984. It also drew up a tentative agenda for this First Session. Following a consultation with the Members of the Union, the Administrative Council, at its 37th Session (1982), modified this agenda. This modified Conference agenda was, after further consultation, approved by a majority of the Members of the Union.

3. In conformity with Resolution 1 of the Union's Plenipotentiary Conference (Nairobi, 1982), the Administrative Council, at the opening meeting of its 38th Session (Nairobi, 1982), adopted Resolution 874 confirming the agenda of the First Session of the Conference to open on 10 January 1984 for five weeks, in Geneva.

4. Consequently, the First Session of the World Administrative Radio Conference for the Planning of HF Bands Allocated to the Broadcasting Service was held in Geneva from 10 January to 11 February 1984.

5. This First Session, under the terms of reference contain in its agenda, decided :

a) to adopt the present report for submission to the Second Session of the Conference;

b) to establish the guidelines for the work to be carried out by the IFRB and the CCIR before the commencement of the Second Session of the Conference (including the time schedules for the completion of this work) as indicated in Chapters 3 and 4 of, and Resolution COM5/2 and Recommendation COM5/1 annexed to the present report;

c) to urge administrations to submit to the Union their requirements, for use in planning, in the form referred to and within the time limits indicated in Chapter 4 of, and Resolution COM5/3 annexed to the present report;

d) to request the Administrative Council to consider the resources and facilities required for this work, as well as the tentative agenda for the Second Session of the Conference, as indicated in Recommendation COM5/2 annexed to the present report;

e) to adopt also Resolutions COM5/1, PLEN./1 and PLEN./2 annexed to the present report; and

f) to request the Secretary-General to bring the present report to the attention of the administations of all the Members of the Union.

CHAPTER 2

DEFINITIONS

The First Session of the Conference considered that certain definitions contained in the Radio Regulations, Geneva, 1979 (identified below by their Radio Regulations number) might be useful for the planning of the high frequency broadcasting service.

It also adopted a number of definitions for the sole purpose of such planning.

2.1 Terms relating to emission

- Emission (RR 132)
- Class of emission (RR 133)
- Single-sideband emission (RR 134)
- Full-carrier single-sideband emission (RR 135)
- Reduced-carrier single-sideband emission (RR 136)
- Suppressed-carrier single-sideband emission (RR 137)
- Out-of-band emission (RR 138)
- Reduced carrier : Carrier emitted at a power level reduced by at least 6 dB below the peak envelope power.

2.2 Term relating to frequency

- Frequency tolerance (RR 145)

2.3 Term relating to bandwidth

- Necessary bandwidth (RR 146)

2.4 Terms relating to power

- Power (RR 150)
- Peak envelope power (RR 151)
- Mean power (RR 152)
- Carrier power (RR 153)
- Gain of an antenna (RR 154)
- Equivalent isotropically radiated power (e.i.r.p.) (RR 155)

2.5 Term relating to zones of reception

- Geographical zones for broadcasting[1] (Annex to Appendix 1 of the Radio Regulations)

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[1] Commonly known as CIRAF zones.

2.6 Terms relating to propagation

- Operational MUF : The highest frequency that would permit acceptable operation of a radio service between given terminals at a given time under specified working conditions (such as antenna types, transmitter power, class of emission and required signal-to-noise ratio).

- Optimum working frequency (OWF) : The lower decile of the daily values of operational MUF at a given time over a specified period, usually a month. That is, the frequency that is exceeded by the operational MUF during 90% of the specified period.

- Basic MUF : The highest frequency by which a radio wave can propagate between given terminals, on a specified occasion, by ionospheric refraction alone.

2.7 Terms relating to reliability

- Circuit reliability : Probability for a circuit that a specified performance is achieved at a single frequency.

- Reception reliability : Probability for a receiver that a specified performance is achieved by taking into account all transmitted frequencies.

- Broadcast reliability : Probability for a service area that a specified performance is achieved by taking into account all transmitted frequencies.

Note 1 - In the above terms circuit means a one-way transmission from one transmitter to one receiving location.

Note 2 - The above terms are preceded by the word "basic" when the background is noise alone and by "overall" when the background is noise and interference.

Note 3 - When the background is noise and interference, the above terms may relate either to the effects of a single interferer or to multiple interference from co-channel and adjacent-channel transmissions.

Note 4 - A given value of signal-to-noise ratio or signal-to-(noise and interference) ratio is the specified performance.

Note 5 - The above terms relate to one or more periods of time which shall be stated.

2.8 Terms relating to field-strength

- Minimum usable field-strength (E_{min})[1] : Minimum value of the field-strength necessary to permit a desired reception quality, under specified receiving conditions, in the presence of natural and man-made noise, but in the absence of interference from other transmitters.

- Usable field-strength (E_u)[1] : Minimum value of the field-strength necessary to permit a desired reception quality, under specified receiving conditions, in the presence of noise and interference, either in an existing situation or as determined by agreements or frequency plans.

- Reference usable field-strength (E_{ref}) : The agreed value of the usable field-strength that can serve as a reference or basis for frequency planning.

2.9 Terms relating to the ratio of wanted and unwanted signals

- Audio-frequency (AF) signal-to-interference ratio : The ratio (expressed in dB) between the values of the voltage of the wanted signal and the voltage of the interference, measured under specified conditions[2], at the audio-frequency output of the receiver.

- Audio-frequency (AF) protection ratio : The agreed minimum value of the audio-frequency signal-to-interference ratio considered necessary to achieve a subjectively-defined reception quality.

- Radio-frequency (RF) wanted-to-interfering signal ratio : The ratio, expressed in dB, between the values of the radio-frequency voltage of the wanted signal and the interfering signal, measured at the input of the receiver under specified conditions[2].

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1 The terms "minimum usable field strength" and "usable field strength" refer to the specified field strength values which a wanted signal must have in order to provide the required reception quality.

In determining whether these requirements are met, the median value (50%) of a fading signal should be used.

2 The specified conditions include such diverse parameters as : spacing ΔF of the wanted and interfering carrier, emission characteristics (type of modulation, modulation depth, carrier-frequency tolerance, etc.), receiver input level, as well as the receiver characteristics (selectivity, susceptibility to cross-modulation, etc.).

- Radio-frequency (RF) protection ratio : The value of the radio-frequency wanted-to-interfering signal ratio that enables the audio-frequency protection ratio to be obtained at the output of the receiver under specified conditions[1].

- Relative radio-frequency protection ratio : The difference, expressed in dB, between the protection ratio when the carriers of the wanted and unwanted transmitters have a frequency difference of ΔF (Hz or kHz) and the protection ratio when the carriers of these transmitters have the same frequency.

- Selectivity of a receiver : A measure of its ability to discriminate between a wanted signal to which the receiver is tuned and unwanted signals on other frequencies.

- Sensitivity of a receiver : A measure of its ability to receive weak signals and to produce an output having usable strength and acceptable quality.

- Noise-limited sensitivity of a receiver : The ability of the receiver's radio-frequency part to receive weak signals. It is equal to the minimum level of the radio-frequency input signal, expressed is dB(μV/m) modulated 30% at the standard reference frequency, which produces in the output power a chosen value of AF signal-to-noise ratio.

2.10 Term relating to the service area

- Required service area (in HF broadcasting) : The area within which an administration proposes to provide a broadcasting service.

2.11 Term relating to planning

- Broadcasting requirement : A requirement indicated by an administration to provide a broadcasting service at specified periods of time to a specified reception area from a particular transmitting station.

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1 The specified conditions include such diverse parameters as : spacing ΔF of the wanted and interfering carrier, emission characteristics (type of modulation, modulation depth, carrier-frequency tolerance, etc.), receiver input level, as well as the receiver characteristics (selectivity, susceptibility to cross-modulation, etc.).

CHAPTER 3

TECHNICAL CRITERIA

3.1 Double sideband (DSB) system specifications

After a review of administrations' proposals and the study of this matter by the CCIR, the Conference adopted the following double sideband (DSB) system specifications.

3.1.1 Transmission characteristics

3.1.1.1 Audio-frequency bandwidth

The upper limit of the audio-frequency bandwidth of the transmitter shall not exceed 4.5 kHz and the lower limit shall be 150 Hz, with an attenuation of 6 dB per octave for frequencies lower than 150 Hz.

3.1.1.2 Necessary bandwidth

The necessary bandwidth shall not exceed 9 kHz.

3.1.1.3 Characteristics of modulation processing

The audio-frequency signal shall be processed so that the modulating signal retains a dynamic range of not less than 20 dB. Excessive amplitude compression, together with improper peak limitation, leads to excessive out-of-band radiation and thus to adjacent channel interference, and is therefore to be avoided.

3.1.2 Channel spacing

Channel spacing for double sideband (DSB) shall be 10 kHz.

In the interest of spectrum conservation, it is also permissible to interleave double sideband transmissions midway between two adjacent channels, i.e. with 5 kHz separation between carrier frequencies, provided that the interleaved transmission is not to the same geographical area as either of the transmissions between which it is interleaved.[1]

3.1.3 Nominal carrier frequencies

Carrier frequencies shall be integral multiples of 5 kHz.

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1 For SSB emissions see section 3.9.1.4 (page 61).

3.1.4 Receiver characteristics

3.1.4.1 Overall selectivity of the receiver

The overall selectivity of the receiver as shown in Figure 3-1 below, shall be used for planning purposes.

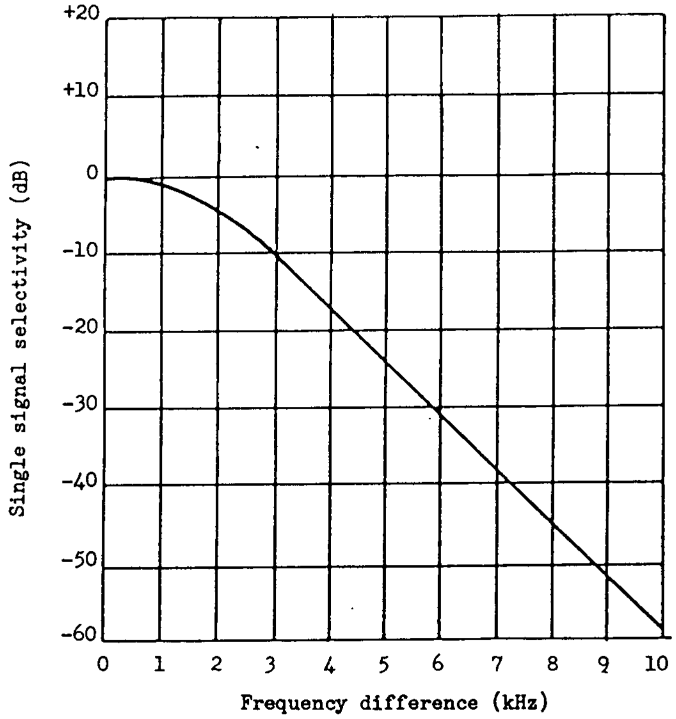

FIGURE 3-1

Overall frequency response of the reference receiver

3.1.4.2 Noise limited sensitivity of the receiver

The value of the noise limited sensitivity of the receiver for planning purposes shall be 40 dB(μV/m).

3.2 Propagation, radio noises and solar index

3.2.1 The method to be used to determine the sky-wave field strength for HF broadcast planning purposes

3.2.1.1 Introduction

The field strength prediction method is in two parts : for ranges up to 7,000 km and for ranges beyond 9,000 km. In the interval 7,000 to 9,000 km an interpolation procedure is used.

Owing to the diurnal variations in ionospheric conditions, predictions shall be made at different times of day at intervals not exceeding one hour.

3.2.1.2 Ionospheric parameters

Values of selected ionospheric parameters (foE, foF2 and M(3000)F2) are needed together with the derived parameters (E-layer basic MUF and F-layer basic MUF) in order to determine the field strength of sky-wave modes reflected from the ionosphere. For total path lengths between 0 and 4,000 km, the basic MUF of an E mode is predicted. For all path lengths the basic MUF for the F2 mode is predicted. Where appropriate the higher of the two values gives the basic MUF for the path.

The vertical radiation angle is also needed in the calculation of sky-wave field strength. The vertical radiation angle is used to determine the appropriate mode of propagation and is also used in conjunction with the antenna gain to determine the proper field strength.

The transmitting antennas in use will have gains which vary with the vertical radiation angle and some antennas, intended for shorter distance broadcasting, radiate very poorly at low angles. It is important to associate the antenna gain at the appropriate radiation angle with the propagation prediction for that particular mode.

3.2.1.2.1 E-layer parameters

3.2.1.2.1.1 E-layer data

For paths up to 2,000 km foE is evaluated at the path mid-point. For ranges greater than 2,000 km foE is evaluated at two control points, each 1,000 km along the path from the transmitter and receiver respectively. At these points the solar zenith angle X, in degrees, is determined, then :

$$foE = 0.9 \left[(180 + 1.44R_{12}) \cos X' \right]^{0.25} \quad \text{MHz}$$

where : $X' = X$ for $0 \leq X \leq 80$

$$X' = 90 - \frac{e^{0.13(116-X)}}{10.8} \text{ for } 80 < X < 116$$

$$X' = 89.907 \text{ for } X \geq 116$$

R_{12} is the 12 month running mean sunspot number.

3.2.1.2.1.2 E-layer basic MUF prediction (E(D) MUF)

The foE value at the mid-point of the path (for paths up to 2,000 km) or the lower of the foE values at the two control points (for paths longer than 2,000 km) is taken for the computation of the E-layer basic MUF.

The MUF for a path of length D is given as :

$$E(D)MUF = foE. \sec i_{110}$$

With i_{110} = angle of incidence at a height of 110 km evaluated in accordance with CCIR Report 252.

3.2.1.2.1.3 E-layer screening frequency (f_s)

The foE value at the middle point of the path (for paths up to 2,000 km), or the higher of the foE values at the two control points 1,000 km from each end of the path (for paths longer than 2,000 km), is taken for calculation of the E-layer screening frequency.

$$f_s = 1.05 \text{ foE} \sec \varphi_s$$

in which $\varphi_s = \arcsin \left[\frac{R \cos\Delta_F}{R + 110} \right]$

R is the radius of the Earth, (6,371 km),

Δ_F is the vertical radiation angle for F2-layer mode (see section 3.2.1.2.3)

3.2.1.2.2 F-layer parameters

3.2.1.2.2.1 F2-layer data

Numerical maps of the parameters foF2 and M(3000)F2, for solar index values R_{12} = 0 and 100 and for each month are presented in CCIR Report 340. This prediction method uses the Oslo coefficients to determine the values of foF2 and M(3000)F2 for the required locations and times. It may be desirable to calculate in advance the values of these parameters at specific grid intervals of latitude, longitude and times and to use an interpolation procedure to obtain values for the required location and time between appropriate grid points. The use of a grid may be appropriate for other ionospheric parameters as well.

3.2.1.2.2.2 F2-layer basic MUF prediction (F2(D)MUF)

3.2.1.2.2.2.1 For paths up to 4,000 km

The F2-layer basic MUF is calculated from

$$F2(ZERO)MUF = foF2 + f_H/2$$

$$F2(4000)MUF = 1.1 \text{ foF2.M(3000)F2}$$

where f_H is the electron gyro-frequency given in terms of parameters of the Earth's magnetic field. A numerical representation is available in Report 340 of the CCIR.

At the midpoint of the great-circle path between the transmitter and receiver determine the above values for the solar index values $R_{12} = 0$ and $R_{12} = 100$. Interpolate or extrapolate linearly for required index values between $R_{12} = 0$ and 150. For higher sunspot activity use $R_{12} = 150$.

Interpolate for the length of the path using the relationship :

$$F2(D)MUF = F2(ZERO)MUF + \left[F2(4000)MUF - F2(ZERO)MUF\right] \cdot M(D)$$

where $M(D) = 1.64 \cdot 10^{-7} D^2$ for $0 \leq D < 800$ and

$$M(D) = 1.26 \cdot 10^{-14} D^4 - 1.3 \cdot 10^{-10} D^3 + 4.1 \cdot 10^{-7} D^2 - 1.2 \cdot 10^{-4} D$$

for $800 \leq D \leq 4000$.

where D is in km.

This gives the median F2-layer basic MUF.

3.2.1.2.2.2.2 For paths longer than 4,000 km

For these paths (which may be the longer great-circle path), control points are taken at 2,000 km from each end of the path. At these points, values of F2(4000)MUF, interpolating for sunspot number, are determined and the lower value is selected. This gives the median F2-layer basic MUF.

3.2.1.2.3 Vertical radiation angle

The radiation angle is taken into account in the prediction of field strength. It is given, approximately, by :

$$\Delta = \arctan \left(\cot \frac{d}{2R} - \frac{R}{R + h'} \operatorname{cosec} \frac{d}{2R} \right)$$

where d = hop length of an n hop mode given by $d = \frac{D}{n}$
h' = 110 km for the E-layer or h' is as given in 3.2.1.3.1.1 for the F2-layer.

In the method for shorter path lengths (0 to 7,000 km - section 3.2.1.3.1) the radiation angles calculated are used in the determination of antenna gain. For the longer path lengths (greater than 9,000 km) the appropriate procedure is described in section 3.2.1.3.2.

3.2.1.3 The prediction of the median field strength

3.2.1.3.1 Method for path lengths of 0 to 7,000 km

CCIR Report 252-2 details the geometrical considerations, the reflection areas used and the method of performing ray-path calculations.

The procedure is based on the ray-path geometry with mirror reflections in the ionosphere. The method determines the field strengths of the two strongest modes propagated via the F2 region and the strongest mode propagated via the E region. The resultant field strength from these modes is obtained by power addition. In circumstances where a low-order F2 mode is screened by the E-layer, as determined in the ray-path calculations, or where an antenna is specified which only radiates sufficiently at high angles, the next higher-order mode must be considered.

It is recognized that multi-hop E region propagation suffers substantial absorption losses and E modes are not considered at ranges beyond 4,000 km.

The appropriate procedure for incorporating these concepts into a computer program is as follows.

3.2.1.3.1.1 For the path length, d(km), determine the minimum number of hops for an F2 region mode. This is given approximately as ((the integer part of d ÷ 4,000) + 1) or better, by calculating the ray-path geometry using the height hpF2 given by :

$$hpF2 = \frac{1490}{M(3000)F2} - 176 \text{ km}$$

The equivalent reflection height h', which is a function of time, location and path length, is used for the ray-path calculations for F2-modes. It is given by :

$$h' = 358 - (11 - 100a)\ (18{,}8 - \frac{320}{x^5}) + ad\ (0{,}03 + \frac{14}{x^4}) \text{ km}$$

or 500 km, whichever is the smaller,

a = 0.04 or (1/M(3000)F2) - 0.24, whichever is the larger and

x = foF2/foE, determined at the control point with the lowest value of foF2, or 2, whichever is the larger.

3.2.1.3.1.2 For the given mode, determine the vertical radiation angle from section 3.2.1.2.3 and then determine the transmitting antenna gain G_t at that angle and the appropriate azimuth, relative to an isotropic antenna.

3.2.1.3.1.3 Compute the median field strength for that mode using the formula :

$$E_{ts} = 136.6 + P_t + G_t + 20 \log f - L_{bf} - L_i - L_m - L_g - L_h - 12.2^1 \text{ dB}(\mu V/m)$$

where f is the transmitting frequency in MHz and P_t is the transmitter power in dB relative to 1 kW. L_{bf} is the basic free space transmission loss in dB, given by :

$$L_{bf} = 32.45 + 20 \log f + 20 \log P'$$

where P' is the virtual slant range in km

$$P' = \left[2R \sum_n \frac{\sin \frac{d}{2R}}{\cos\left(\Delta + \frac{d}{2R}\right)} \right]$$

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[1] This term contains those effects of sky-wave propagation not otherwise included in this fast simple method. A value of 12.2 dB is recommended on the basis of the data available. It is noted, however, that the value may need to be changed by those implementing this procedure to take account of additional calibrated data which become available.

It should also be taken into account that an improved result may be obtained by using a term which varies with distance or geographical area.

See Recommendation COM5/1.

L_i is the absorption loss in dB given in CCIR Report 252-2. It is determined for each hop and the results are added. For frequencies above the basic MUF, it continues to vary with frequency and is calculated assuming ray paths similar to those at the MUF.

L_m is the "above-the-MUF" loss. For frequencies, f, above the basic MUF (f_b) of a given mode :

$$L_m = 130 \left(\frac{f}{f_b} - 1 \right)^2 \quad \text{dB}$$

L_m is independent of the number of hops, but is limited to a value of 81 dB.

L_g is the ground reflection loss at intermediate reflection points. It is given as 2 dB for each intermediate ground reflection, i.e. :

for one-hop paths $L_g = 0$;

two-hop paths $L_g = 2$ dB;

three-hop paths $L_g = 4$ dB.

L_h is the factor to allow for auroral and other signal losses and is given in Tables 3-1 and 3-2 using the methods given in Report 252-2 to determine the local mean time, the geomagnetic latitude and the locations at which it is applied.

3.2.1.3.1.4 Repeat the procedure of 3.2.1.3.1.2 and 3.2.1.3.1.3 using successively higher order modes (increasing the number of hops by one each time) until the predicted mode field strength reaches a maximum. Select the two strongest F2 region modes, noting the field strength and radiation angles.

3.2.1.3.1.5 For the E region the lowest order mode is 1E for ranges 0 - 2,000 km and 2E for ranges 2,000 to 4,000 km. The E mode radiation angle and field strength are again obtained as in sections 3.2.1.2.3 and 3.2.1.3.1.3.

3.2.1.3.1.6 Repeat the E mode calculations for successively higher modes until a maximum is found.

3.2.1.3.1.7 The resultant of combining the field strengths of the two strongest F2 modes and the strongest E mode is obtained by calculating the square root of the sum of the squares of the numerical values of the field strengths.

3.2.1.3.2 <u>Method for path lengths greater than 9,000 km</u>

At long ranges, generally with low radiation angles, the method of prediction using geometric ray-hops is inadequate at present. The method used for long distances is based on an empirical fit of observations. In this method the antenna gain term, G_{tl}, is the greatest value of antenna gain in dBi which occurs in the range of vertical radiation angles from 0° to 8° at the appropriate azimuth.

TABLE 3-1

L_h for paths less than 2,500 km

GEOM LAT.	01-04LMT	04-07LMT	07-10LMT	10-13LMT	13-16LMT	16-19LMT	19-22LMT	22-01LMT
	WINTER (NOVEMBER, DECEMBER, JANUARY, FEBRUARY in the Northern Hemisphere) (MAY, JUNE, JULY, AUGUST in the Southern Hemisphere)							
00-40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40-45	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0
45-50	0.1	0.3	0.6	0.0	0.1	0.1	0.3	0.1
50-55	0.6	0.8	1.6	0.1	0.3	0.6	1.0	0.3
55-60	1.5	2.1	4.4	0.7	0.8	2.2	2.5	1.3
60-65	4.8	8.2	10.5	2.7	1.6	5.7	7.3	5.2
65-70	6.7	11.0	13.5	3.0	1.7	5.8	8.6	6.0
70-75	5.7	7.9	10.7	1.7	0.9	3.6	4.1	4.0
75-80	2.5	5.0	7.1	0.9	0.3	1.9	2.3	2.0
	EQUINOX (MARCH, APRIL, SEPTEMBER, OCTOBER)							
00-40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40-45	0.0	0.1	0.2	0.1	0.1	0.3	0.2	0.1
45-50	0.4	0.4	0.9	0.6	0.4	1.3	0.9	0.8
50-55	1.0	1.0	2.7	1.8	1.2	2.7	2.1	2.1
55-60	2.0	3.0	6.2	3.7	2.6	4.5	4.0	5.0
60-65	4.7	5.0	12.0	7.5	5.6	7.8	9.0	11.8
65-70	6.8	11.6	19.6	8.8	6.3	7.8	10.3	14.6
70-75	4.9	11.7	20.0	6.2	3.3	4.9	7.7	9.5
75-80	2.0	7.5	9.2	3.9	1.6	3.0	4.2	4.1
	SUMMER (MAY, JUNE, JULY, AUGUST in the Northern Hemisphere) (NOVEMBER, DECEMBER, JANUARY, FEBRUARY in the Southern Hemisphere)							
00-40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40-45	0.1	0.1	0.0	0.1	0.1	0.2	0.1	0.0
45-50	0.5	0.4	0.5	0.4	0.5	1.1	1.0	0.4
50-55	1.3	1.1	1.4	1.0	1.1	3.0	2.9	0.7
55-60	2.9	2.4	3.0	2.6	2.9	5.8	5.8	1.8
60-65	6.0	4.1	6.0	5.3	4.3	8.4	7.6	4.3
65-70	6.0	4.6	7.3	5.0	4.2	7.2	8.8	5.0
70-75	3.7	3.8	5.0	3.5	3.2	4.8	6.0	3.4
75-80	2.4	2.8	3.1	2.7	2.3	3.8	4.3	2.1

TABLE 3-2

L_h for paths greater than 2,500 km

GEOM LAT.	01-04LMT	04-07LMT	7-10LMT	10-13LMT	13-16LMT	16-19LMT	19-22LMT	22-01LMT
	WINTER (NOVEMBER, DECEMBER, JANUARY, FEBUARY in the Northern Hemisphere) (MAY, JUNE, JULY, AUGUST in the Southern Hemisphere)							
00-40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40-45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45-50	0.1	0.1	0.1	0.0	0.1	0.1	0.2	0.2
50-55	0.4	0.4	0.2	0.0	0.4	0.4	0.9	0.8
55-60	1.1	1.8	0.9	0.2	1.2	1.4	2.0	2.3
60-65	3.3	6.2	2.6	1.3	2.6	3.4	3.6	7.6
65-70	5.5	6.4	4.1	2.0	4.1	3.6	4.4	9.9
70-75	3.9	4.6	3.3	1.3	4.0	2.2	3.1	8.0
75-80	2.2	3.2	1.9	0.7	2.7	1.2	1.2	2.9
	EQUINOX (MARCH, APRIL, SEPTEMBER, OCTOBER)							
00-40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40-45	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0
45-50	0.2	0.2	0.3	0.2	0.1	0.5	0.6	0.4
50-55	0.5	0.6	0.5	0.6	0.5	1.6	1.8	1.1
55-60	1.0	1.3	1.3	1.7	1.3	3.4	3.8	2.4
60-65	2.9	3.8	4.2	4.1	2.9	6.3	8.4	7.3
65-70	4.3	5.6	6.4	5.1	4.4	6.3	9.2	9.3
70-75	3.0	4.7	5.0	3.0	2.4	3.4	5.4	4.8
75-80	1.3	1.9	2.2	0.8	0.8	0.8	1.2	1.1
	SUMMER (MAY, JUNE, JULY, AUGUST in the Northern Hemisphere) (NOVEMBER, DECEMBER, JANUARY, FEBRUARY in the Southern Hemisphere)							
00-40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40-45	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
45-50	0.5	0.3	0.4	0.2	0.4	0.1	0.6	0.5
50-55	1.1	1.1	1.1	0.6	1.2	0.4	1.9	1.3
55-60	2.5	2.9	2.6	1.1	2.5	1.2	3.8	2.9
60-65	4.9	7.5	6.2	2.2	3.8	2.6	5.2	5.0
65-70	5.0	7.8	6.1	2.3	3.8	2.7	4.8	5.0
70-75	3.2	5.4	3.4	1.5	2.2	0.9	2.6	3.2
75-80	2.0	4.3	1.5	1.1	0.8	0.1	0.9	1.4

The overall median field strength is given by :

$$E_{tl} = E_o \left[1 - \frac{(f_M+f_H)^2}{(f_M+f_H)^2 + (f_L+f_H)^2} \left(\frac{(f_L+f_H)^2}{(f+f_H)^2} + \frac{(f+f_M)^2}{(f_M+f_H)^2} \right) \right] - 36.4 + P_t + G_{tl} + G_{ap} - 0.8^{1} \quad dB(\mu V/m)$$

$E_o = 139.6 - 20 \log P'$, and the height used in the determination of P' is 300 km.

It is assumed within this procedure that there is a hypothetical ray path with a number of equal length hops, each less than 4,000 km.

G_{ap} is the increase in field strength due to focussing at long distances. In the case of propagation to very long distances with D, the great-circle distance between transmitter and receiver, greater than $\pi R/2$, this focussing is taken into account by means of the following formula :

$$G_{ap} = -20 \log \left(\left| 1 - \frac{n\pi R}{D} \right| \right) \quad dB$$

for

$$\left(\frac{2n-1}{2} \right) \pi R < D < \left(\frac{2n+1}{2} \right) \pi R \qquad \text{with } n = 1 \text{ and } 2.$$

As G_{ap} tends to infinity for $D = n\pi R$ it is limited arbitrarily to the value of 30 dB.

f_M is the upper limit frequency. It is determined separately for the first and last hops of the path and the lower value is taken.

$$f_M = K \cdot f_b \quad MHz$$

$$K = 1.2 + W \frac{f_b}{f_{b,noon}} + X \left(\sqrt[3]{\frac{f_{b,noon}}{f_b}} - 1 \right) + Y \left(\frac{f_{b,min}}{f_{b,noon}} \right)^2$$

f_b is the basic MUF determined by the method given in section 3.2.1.2.2.2.

$f_{b,noon}$ is the value of f_b for a time corresponding to local noon at the control point

$f_{b,min}$ is the lowest value of f_b for the hop which occurs during the 24 hours

W, X and Y are given in Table 3-3. The azimuth of the great-circle path is determined at the centre of the whole path and this angle is used for linear interpolation in angle between the east-west and north-south values.

---

1 This term contains those effects of sky-wave propagation not otherwise included in the method. A value of 0.8 dB is recommended on the basis of the data available. It is noted however that this value may need to be changed by those implementing this procedure to take account of additional calibrated data which become available.

It should also be taken into account that an improved result may be obtained by using a term which varies with distance or geographical area.

See Recommendation COM5/1.

TABLE 3-3

Values W, X, Y used for the determination of the correction factor K

	W	X	Y
East-West	0.1	1.2	0.6
North-South	0.2	0.2	0.4

f_L is the lower limit frequency when the path is in daylight

$$f_L = \left(5.3 \cdot I \left[\frac{(1 + 0.009R_{12}) \sum_{IN} \cos^{\frac{1}{2}} \chi}{\cos i_{90} \ln \left(\frac{9.5 \cdot 10^6}{P'} \right)} \right]^{\frac{1}{2}} - f_H \right) \cdot A_W \quad \text{MHz}$$

In the summation, χ is determined for each traverse of the ray path through the height of 90 km.

when $\chi > 90^\circ$, $\cos^{\frac{1}{2}} \chi$ is taken as zero

i_{90} is the angle of incidence at a height of 90 km

I is given in Table 3-4.

A_W is a winter-anomaly factor determined at the path mid-point which is unity for geographic latitudes 0 to 30° and at 90° and reaches the maximum values given in Table 3-5 at 60°. The values at intermediate latitudes are found by linear interpolation.

As the path progressively becomes dark, the values of f_L are calculated until the time t_n when $f_L \leq 2f_{LN}$ where $f_{LN} = \sqrt{\frac{D}{3000}}$ (MHz). During the subsequent three hours f_L is calculated from $f_L = 2f_{LN}e^{-0.23t}$ where t is the time in hours after t_n. For the remainder of the night hours $f_L = f_{LN}$ until the time when the daylight equation gives a higher value.

TABLE 3-4

Values of I used in the equation for f_L

Latitudes		Month											
Terminal 1	Terminal 2	J	F	M	A	M	J	J	A	S	O	N	D
>35°N	>35°N	1.1	1.05	1	1	1	1	1	1	1	1	1.05	1.1
>35°N	35°N-35°S	1.05	1.02	1	1	1	1	1	1	1	1	1.02	1.05
>35°N	>35°S	1.05	1.02	1	1	1.02	1.05	1.05	1.02	1	1	1.02	1.05
35°N-35°S	35°N-35°S	1	1	1	1	1	1	1	1	1	1	1	1
35°N-35°S	>35°S	1	1	1	1	1.02	1.05	1.05	1.02	1	1	1	1
>35°S	>35°S	1	1	1	1	1.05	1.1	1.1	1.05	1	1	1	1

TABLE 3-5

Values of the winter-anomaly factor, A_w, at 60° geographical latitude used in the equation for f_L

Month

hemisphere	J	F	M	A	M	J	J	A	S	O	N	D
Northern	1.30	1.15	1.03	1	1	1	1	1	1	1.03	1.15	1.30
Southern	1	1	1	1.03	1.15	1.30	1.30	1.15	1.03	1	1	1

3.2.1.3.3 Method for path lengths between 7,000 and 9,000 km

In this range of distances, the field strengths E_{ts} and E_{tl} are determined by both of the above procedures and the resultant is found by appropriate mathematical interpolation. The interpolation procedure is given as :

$$E_{ti} = E_{ts} + \frac{D-7000}{2000}(E_{tl} - E_{ts}) \quad dB(\mu V/m)^{1}$$

[1] Taking account of the data that become available, an alternative form for this interpolation may be envisaged.

See Recommendation COM5/1.

3.2.1.4 Selection of optimum frequency band

The optimum frequency band for a high frequency broadcasting service is that which has the highest median value of radio-frequency signal-to-noise ratio at the test points in the required service area.

The optimum combination of bands, if needed by the planning method, is that which gives the highest value of basic broadcast reliability in the required service area.

3.2.2 Atmospheric and man-made radio noise data

3.2.2.1 Atmospheric radio noise data

The hourly median values of atmospheric noise intensity as contained in CCIR Report 322-2 are adopted.

The method of implementation of the data may be :

- a direct calculation as required based upon a numerical representation of the maps;
- a grid representation similar to that currently in use by the IFRB, except that the grid should have a size of 10° latitude by 15° longitude in all parts of the world;
- the precalculation of values appropriate for each test point.

The option selected should be such as to minimize the calculation time required during the operation of the planning method.

3.2.2.2 Man-made radio noise data

The median value of the man-made noise power (F_{am}) to be adopted, expressed in dB above thermal noise at T_o = 288K, is given by :

$$F_{am} = 60.4 - 28.15 \log f$$

where f is the frequency in MHz.

3.2.2.3 The combination of atmospheric and man-made noise

In each case the values of atmospheric noise and man-made noise intensities shall be compared and the greater one shall be used.

3.2.3 Signal fading

3.2.3.1 Short-term (within the hour) fading

The upper-decile amplitude deviation from the median of a single signal is to be taken as 5 dB and the lower-decile deviation is to be taken as -8 dB.

3.2.3.2 Long-term (day-to-day) fading

The magnitude of the long-term fading, as determined by the ratio of the operating frequency to the basic MUF, is given in Table 3-6.

TABLE 3-6

Decile deviations from the predicted monthly median value of signal field strength, in dB, arising from day-to-day variability

Corrected geomagnetic latitude[1]	< 60°		≥ 60°	
Transmitting frequency/ predicted basic MUF	Lower decile	Upper decile	Lower decile	Upper decile
≤ 0.8	-8	6	-11	9
1.0	-12	8	-16	11
1.2	-13	12	-17	12
1.4	-10	13	-13	13
1.6	-8	12	-11	12
1.8	-8	9	-11	9
2.0	-8	9	-11	9
3.0	-7	8	-9	8
4.0	-6	7	-8	7
≥ 5.0	-5	7	-7	7

[1] If any point on that part of the great circle which passes through the transmitter and the receiver and which lies between control points located 1,000 km from each end of the path reaches a corrected geomagnetic latitude of 60° or more, the values for ≥ 60° have to be used. The relationship of corrected geomagnetic latitude to the geographical coordinates is shown in Figures 3-2 and 3-3.

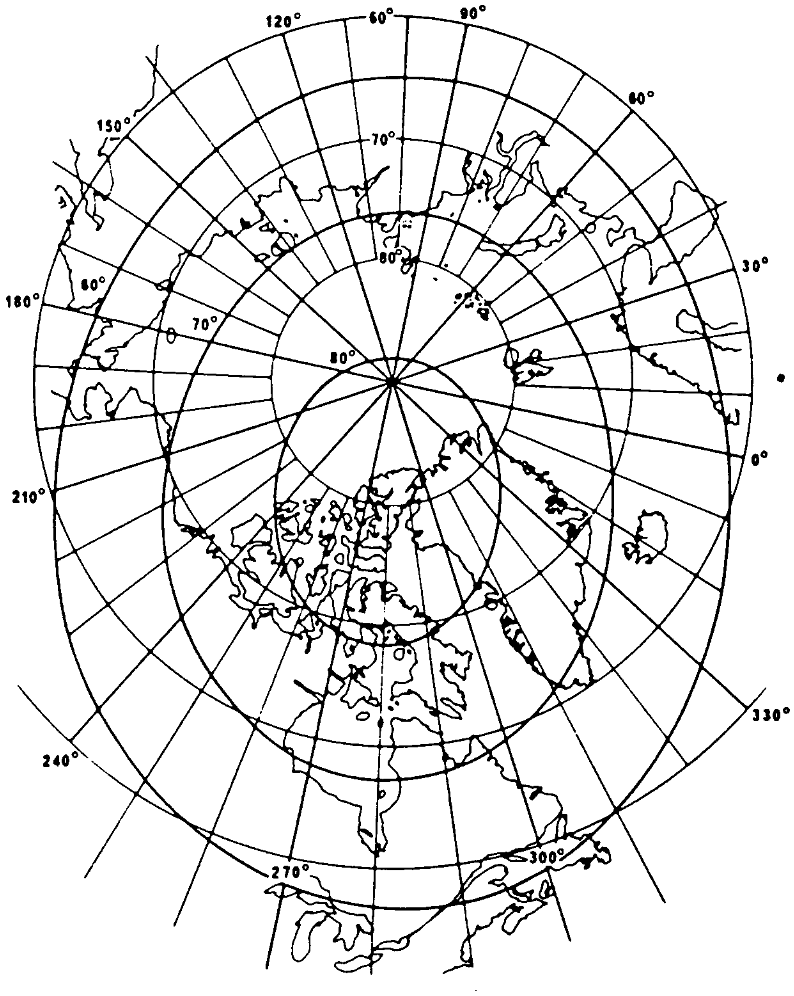

FIGURE 3-2

Corrected geomagnetic latitude in the northern hemisphere

(Geographical latitude and longitude are also displayed for reference)

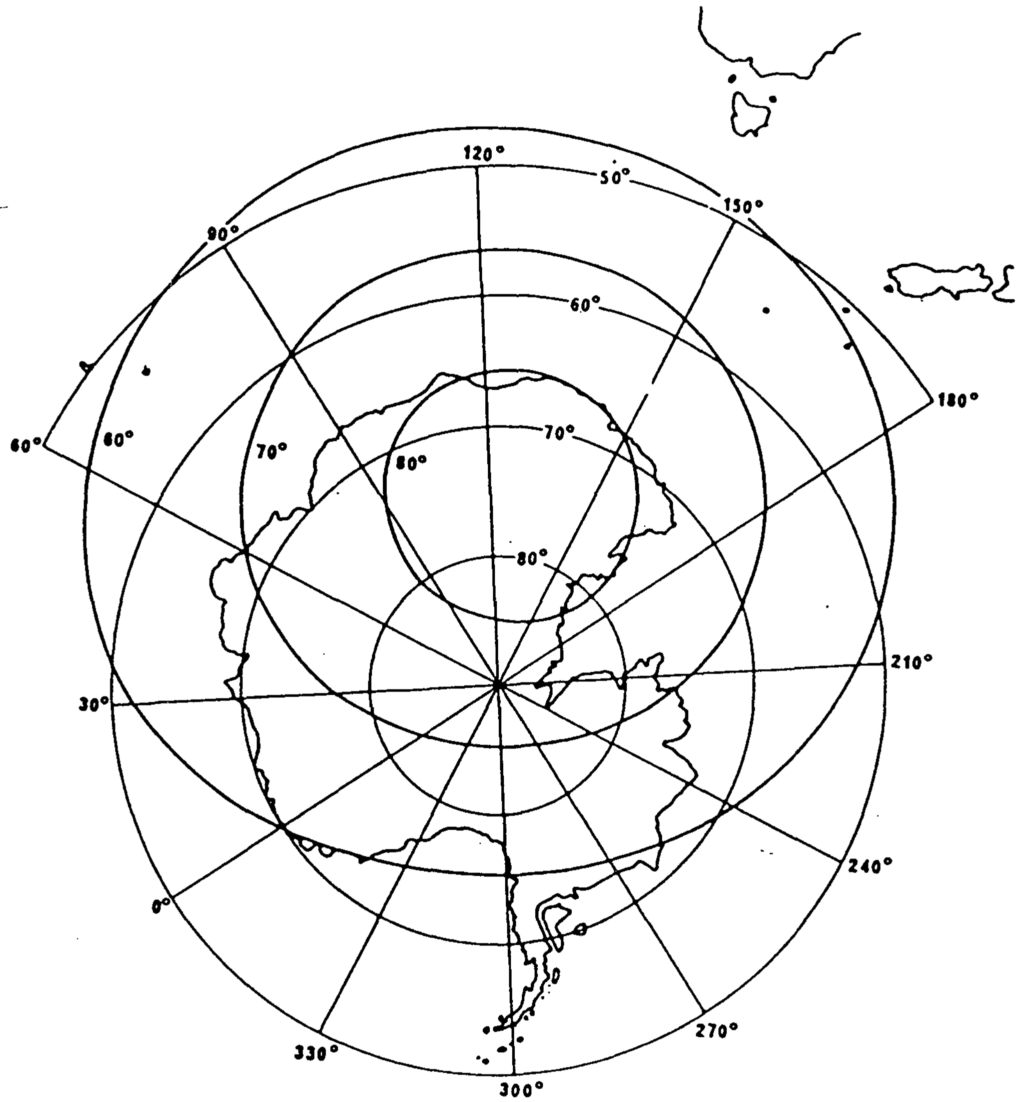

FIGURE 3-3

Corrected geomagnetic latitude in the southern hemisphere

(Geographical latitude and longitude are also displayed for reference)

3.2.3.3 Calculation of fading allowances for different percentages of time

Fading allowances for other percentages of the time may be expressed, in terms of the decile deviation F_{90}, by the expression

$$F_x = c \cdot F_{90}$$

where F_x is the deviation for x% of time.

Values of c for x in the range 50-90% are given in Table 3-7.

TABLE 3-7

The parameter c

x(%)	c
50	0
60	0.18
70	0.36
80	0.63
90	1

3.2.4 Reliability[1]

3.2.4.1 Calculation of basic circuit reliability (BCR)

The process for calculating basic circuit reliability is indicated in Table 3-8. The median value of field strength for the wanted signal at step (1) is determined by the field strength prediction method. The upper and lower decile values (2) through (5) are also determined, taking account of long-term (day-to-day) and short-term (within the hour) fading. The combined upper and lower deciles of the wanted signal are then calculated in steps (6) and (7) in order to derive the signal levels exceeded for 10% and 90% of the time at steps (8) and (9).

The wanted signal probability distribution, assumed to be log-normal, is illustrated in Figure 3-4, which indicates the signal level (in decibels) versus the probability that the value of signal level is exceeded (plotted on a normal probability scale). This distribution is used to obtain the basic circuit reliability (11), which is the value of probability corresponding to the minimum usable field strength (10).

---

[1] Abbreviations of the English terms are used in the formulas throughout the three languages in order to facilitate the practical implementation of the methods described in this section.

TABLE 3-8

Parameters used to compute basic circuit reliability

STEP	PARAMETER	DESCRIPTION	SOURCE
(1)	$E_W(50)$ dB (μV/m)	Median field strength of wanted signal	Prediction method (section 3.2.1)
(2)	$D_U(S)$ dB	Upper decile of slow fading signal (day-to-day)	(section 3.2.3.2, Table 3-6)
(3)	$D_L(S)$ dB	Lower decile of slow fading signal (day-to-day)	(section 3.2.3.2, Table 3-6)
(4)	$D_U(F)$ dB	Upper decile of fast fading signal (within the hour)	5 dB (section 3.2.3.1)
(5)	$D_L(F)$ dB	Lower decile of fast fading signal (within the hour)	-8 dB (section 3.2.3.1)
(6)	$D_U(E_W)$ dB	Upper decile of wanted signal	$\sqrt{D_U(S)^2 + D_U(F)^2}$
(7)	$D_L(E_W)$ dB	Lower decile of wanted signal	$\sqrt{D_L(S)^2 + D_L(F)^2}$
(8)	$E_W(10)$ dB (μV/m)	Wanted signal exceeded 10% of the time	$E_W + D_U(E_W)$
(9)	$E_W(90)$ dB (μV/m)	Wanted signal exceeded 90% of the time	$E_W - D_L(E_W)$
(10)	E_{min} dB (μV/m)	Minimum usable field strength	section 3.4
(11)	BCR	Basic circuit reliability	Figure 3-4

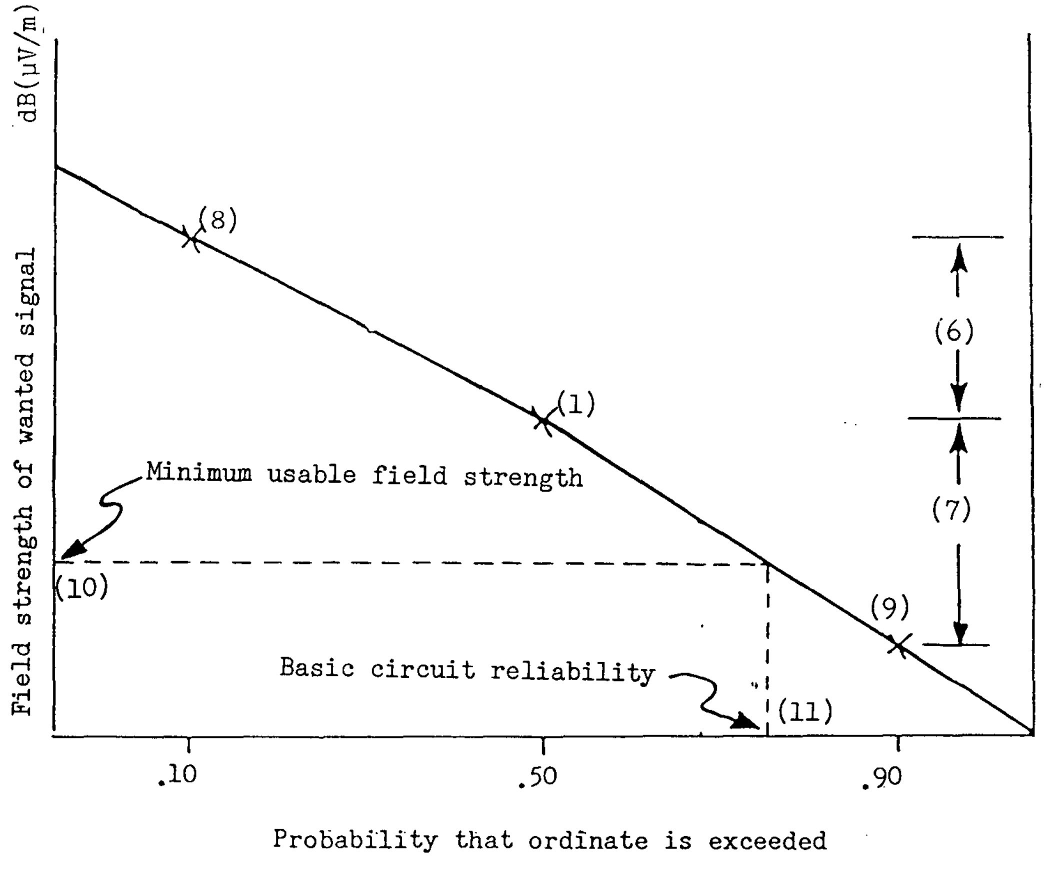

FIGURE 3-4

Parameters used to compute basic circuit reliability

(Figures appearing in brackets refer to step numbers as shown in Table 3-8)

The basic circuit reliability is given by the expression :

$$BCR = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\gamma} \exp(-\tau^2/2)\, d\tau$$

when $E_W \geq E_{min}$

$$\gamma = \frac{E_W - E_{min}}{\sigma_L}$$

$$\sigma_L = D_L(E_W)/1.282$$

when $E_W < E_{min}$

$$\gamma = \frac{E_W - E_{min}}{\sigma_U}$$

$$\sigma_U = D_U(E_W)/1.282$$

3.2.4.2 Calculation of overall circuit reliability (OCR)

The method is outlined in Table 3-9. In step (1), the median wanted signal level is computed by the signal strength prediction method.

In step (2), the median field strength levels (E_i) of each interfering source are obtained from the prediction method. In step (3), for a single source of interference the predicted median field strength is used; for multiple sources of interference the median field strength is calculated as follows : the field strengths of the interfering signals E_i are listed in decreasing order. Successive r.s.s. additions of the field strengths E_i are computed, stopping when the difference between the resultant field strength and the next field strength is greater than 6 dB. In step (3), the resultant field strength I is taken as the last computed value.

The values of the wanted signal and interference determined in steps (1) and (3) are combined in step (4) to derive the median signal-to-interference ratio. The 10% and 90% fading allowances are included in steps (5) and (6) in order to derive the signal-to-interference ratio exceeded for 10% and 90% of the time in steps (7) and (8).

The probability distribution for the signal-to-interference ratio may now be determined as shown in Figure 3-5. The ratios are presented in decibels on a linear scale versus the probability that the value of the signal-to-interference ratio is exceeded on a normal probability scale. In Figure 3-5, the value of probability corresponding to the required signal-to-interference ratio (9) is the circuit reliability in the presence of interference only (ICR). The overall circuit reliability (OCR, step (12)) is the minimum value of either ICR (step (10)) or BCR (step (11)), whichever produces the lower value.

The mathematical treatment of the calculation of ICR can be given in terms of the probability density distribution of the protection ratio. These functions are taken to be log normal, as is the resulting distribution of the signal-to-interference ratio.

The parameter ICR is given by the following expression :

$$ICR = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\gamma} \exp(-\tau^2/2)\, d\tau$$

when for $E_W - I \geqslant RSI$

$$\gamma = \frac{E_W - I - RSI}{\sigma_L}$$

$$\sigma_L = D_L(SIR)/1.282$$

and for $E_W - I < RSI$

$$\gamma = \frac{E_W - I - RSI}{\sigma_U}$$

$$\sigma_U = D_U(SIR)/1.282$$

Values of the various parameters in the above expressions are found in the steps indicated below of Table 3-9.

E_W	step 1
I	step 3
$D_U(SIR)$	step 5
$D_L(SIR)$	step 6
RSI	step 9

TABLE 3-9

Parameters used to compute overall circuit reliability

STEP	PARAMETER	DESCRIPTION	SOURCE
1	E_W dB (μV/m)	Median field strength of wanted signal	Prediction method (section 3.2.1)
2	E_i dB (μV/m)	Median field strength of interfering signals $E_1, E_2, \ldots E_i$	Prediction method (section 3.2.1)
3	I dB (μV/m)	Resultant field strength of interference (see text)	$I = \sqrt{E_1^2 + E_2^2 + E_3^2 + \ldots}$
4	SIR(50)dB	Median signal to interference ratio	$E_W - I$
5	D_U(SIR)dB	10% fading allowance	10 dB(<60°), 14 dB(≥60°)[1,2]
6	D_L(SIR)dB	90% fading allowance	10 dB(<60°), 14 dB(≥60°)[1,2]
7	SIR(10)dB	Subjective signal-to-interference ratio exceeded 10% of the time	SIR(50) + D_U(SIR)
8	SIR(90)dB	Subjective signal-to-interference ratio exceeded 90% of the time	SIR(50) - D_L(SIR)
9	RSI dB	Required RF protection ratio	(section 3.3.1)
10	ICR	Circuit reliability in presence of interference only (without noise)	See figure 3-5
11	BCR	Basic circuit reliability	See figure 3-4
12	OCR	Overall circuit reliability	Min(ICR, BCR)

Note 1 - If any point on that part of the great circle which passes through the transmitter and the receiver and which lies between control points located 1,000 km from each end of the path reaches a corrected geomagnetic latitude of 60° or more, the values for ≥ 60° have to be used. The relationship of corrected geomagnetic latitude to the geographical coordinates is shown in figures 3-2 and 3-3 of paragraph 3.2.3.2.

Note 2 - These values apply for overall circuit reliabilities not exceeding 80%.

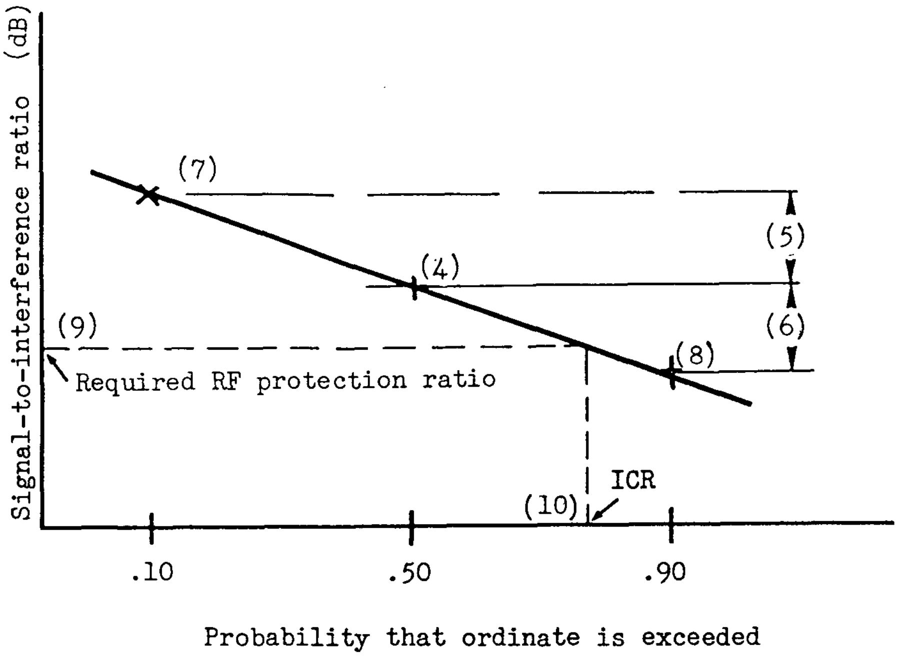

FIGURE 3-5

Parameters used to compute overall circuit reliability

(Figures appearing in brackets refer to step numbers as shown in Table 3-9).

3.2.4.3 Basic reception reliability (BRR)

The method for computing basic reception reliability is outlined in Table 3-10. With a single frequency, basic reception reliability (BRR) is the same as the basic circuit reliability (BCR) defined in the section 3.2.4.1. With multiple frequencies, the interdependence between propagation conditions at different frequencies leads to the computation method given in Table 3-10. In steps (4) and (6), BCR (n) is the basic circuit reliability for frequency n, where $n = F_1$, F_2, etc. The basic reception reliability is obtained in step (2) for a single frequency, in step (4) for a set of two frequencies and in step (6) for a set of three frequencies.

3.2.4.4 Overall reception reliability (ORR)

The method for computing overall reception reliability is outlined in Table 3-11. With a single frequency, overall reception reliability (ORR) is the same as the overall circuit reliability (OCR) defined in section 3.2.4.2. With multiple frequencies, the interdependence between propagation conditions at different frequencies leads to the computation method given in Table 3-11. In steps (4) and (6), OCR (n) is the overall circuit reliability for frequency n, where $n = F_1$, F_2, etc. The overall reception reliability is obtained in step (2) for a single frequency, in step (4) for a set of two frequencies and in step (6) for a set of three frequencies.

TABLE 3-10

Basic reception reliability

The following parameters are involved :

Single-frequency operation

Step	Parameter	Description	Source
(1)	BCR (F_1) %	Basic circuit reliability for frequency F_1	step 11, Table 3-8
(2)	BRR (F_1) %	Basic reception reliability	BCR (F_1)

Two-frequency operation[1]

(3)	BCR (F_2) %	Basic circuit reliability for frequency F_2	step 11, Table 3-8
(4)	BRR (F_1) (F_2) %	Basic reception reliability	$1-\prod_{n=F_1}^{F_2}(1-BCR(n))$

[1] The two frequencies F_1 and F_2 shall be situated in different frequency bands allocated to the HF broadcasting service.

TABLE 3-10 (continued)

Basic reception reliability

Three-frequency operation[1]

Step	Parameter	Description	Source
(5)	BCR (F_3) %	Basic circuit reliability for frequency F_3	Step 11, Table 3-8
(6)	BRR $(F_1)(F_2)(F_3)$ %	Basic reception reliability	$1-\prod_{n=F_1}^{F_3} (1-BCR(n))$

[1] The three frequencies F_1, F_2 and F_3 shall be situated in different frequency bands allocated to the HF broadcasting service.

TABLE 3-11

Overall reception reliability

The following parameters are involved :

Single-frequency operation

Step	Parameter	Description	Source
(1)	OCR (F_1) %	Overall circuit reliability for frequency F_1	Step 12, Table 3-9
(2)	ORR (F_1) %	Overall reception reliability	OCR (F_1)

Two-frequency operation [1]

(3)	OCR (F_2) %	Overall circuit reliability for frequency F_2	Step 12, Table 3-9
(4)	ORR (F_1) (F_2) %	Overall reception reliability	$1-\prod_{n=F_1}^{F_2}(1-OCR(n))$

[1] The two frequencies F_1 and F_2 shall be situated in different frequency bands allocated to the HF broadcasting service.

TABLE 3-11 (continued)

Overall reception reliability

Three-frequency operation [1]

Step	Parameter	Description	Source
(5)	OCR (F_3) %	Overall circuit reliability for frequency F_3	Step 12, Table 3-9
(6)	ORR (F_1) (F_2) (F_3) %	Overall reception reliability	$1-\prod_{n=F_1}^{F_3} (1-OCR(n))$

[1] The three frequencies F_1, F_2 and F_3 shall be situated in different frequency bands allocated to the HF broadcasting service.

3.2.4.5 Basic and overall broadcast reliability

The determination of basic broadcast reliability involves the use of test points within the required service area. The basic broadcast reliability is an extension of the basic reception reliability concept to an area instead of a single reception point. The method for computing basic broadcast reliability is outlined in Table 3-12. In step (1), the basic reception reliabilities BRR, (L_1), BRR (L_2), --- BRR (L_N) are computed as described in Table 3-10 at each test point L_1, L_2 ---L_N. These values are ranked in step (2) and the basic broadcast reliability is the value associated with a percentile X specified in paragraph 4.2.4 (page 78).

In a similar way, the overall broadcast reliability is computed as described in Table 3-13 and it is the value associated with a percentile X specified in 4.2.4.

Broadcast reliability is associated with the expected performance of a broadcast service at a given hour. For periods longer than an hour, computation at one-hour intervals is required.

TABLE 3-12

Basic broadcast reliability

The following parameters are involved :

Step	Parameter	Description	Source
(1)	BRR (L_1), BRR (L_2) --- BRR (L_N) %	Basic reception reliability at all test points considered in the required service area	Step (2), (4) or (6), as appropriate, from Table 3-10
(2)	BBR (X) %	Basic broadcast reliability associated with percentile X[1]	Any percentile chosen from the values ranked from (1) of this Table

TABLE 3-13

Overall broadcast reliability

The following parameters are involved :

Step	Parameter	Description	Source
(1)	ORR (L_1), ORR (L_2) --- ORR (L_N) %	Overall reception reliability at all test points considered in the required service area	Step (2), (4) or (6), as appropriate, from Table 3-11
(2)	OBR (X) %	Overall broadcast reliability associated with percentile X[1]	Any percentile chosen from the values ranked from (1) of this Table

[1] See section 4.2.4 (page 78).

3.2.4.6 Proportionally reduced protection

3.2.4.6.1 The basic circuit reliability shall be calculated at any test point within the required service area at which the median wanted field strength is equal to or greater than E_{min} (BCR ≥ 0.5). Test points where E_{min} is not reached for 50% of the time are disregarded.

3.2.4.6.2 If in any frequency band the basic circuit reliability is less than 0.5 at all the test points of the required service area, a proportionally reduced protection shall be afforded.

In this situation, the overall broadcast reliability shall be calculated at all test points where the median wanted field strength is :

$E \geq E_{min} - Z(dB)$ [1]

In such cases, the "required protection ratio" used in the calculations of the overall broadcast reliability (step (9) of Table 3-9 (page 28) and Figure 3-5 (page 29) in the calculation of overall circuit reliability) shall be reduced by $(E_{min} - E)$ dB.

3.2.5 Values of the appropriate solar index and the seasonal periods on which planning shall be based

3.2.5.1 Seasonal divisions of the year and representative months

The year shall be sub-divided into four seasons for propagation prediction purposes. These seasons are listed in the Table 3-14. When predictions are made for a single month to represent a season, the month selected shall be as indicated in the second column of the Table.

TABLE 3-14

Season	Representative month
November-February	January
March-April	April
May-August	July
September-October	October

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1 The value of Z shall be determined by the second session of the Conference. For the purpose of intersessional work, Z will be 5 dB. The IFRB shall indicate in its report to the second session the results of the applications of this paragraph, accompanied by any appropriate recommendation.

3.2.5.2 Solar index values

3.2.5.2.1 The 12-month running mean sunspot number R_{12} shall be the solar index to be used for planning.

3.2.5.2.2 The seasonal plan shall be prepared in accordance with the values of R_{12} predicted for the period. The lowest value of R_{12} predicted for any of the months in that season shall be used.[1]

3.2.5.2.3 For the purposes of the intersessional work the reference values of R_{12} to be used shall be the five values given in Table 3-15. This Table also states the range of applicability of each of the reference values.

When a seasonal plan is to be selected from the set of plans prepared in accordance with the reference values of R_{12}, the applicable plan shall be selected on the basis of the lowest value of R_{12} predicted for any of the months in that season.[1]

TABLE 3-15

Selection of R_{12} index values for intersessional work

Index values	Range of applicability of predicted R_{12}
5	0-14
30	15-44
60	45-74
90	75-104
120	105 and above

[1] Predicted values of the 12-month running mean sunspot number R_{12} are prepared for periods up to six and twelve months ahead of the current month. The predicted values are obtainable from the CCIR Secretariat.

3.3 Radio-frequency protection ratios

After a careful review of administrations' proposals and the extensive study of this matter by the CCIR, the Conference adopted recommendations which take account of subjective tests comparing the quality of listener satisfaction for various protection ratio levels. The decisions taken also took account of the fact that the number of requirements and the limited amount of allocated spectrum space would require a reduction of the desired protection ratio commensurate with the number of requirements to be satisfied. With these considerations in mind, the following decisions were made.

3.3.1 Co-channel protection ratios and frequency tolerances

For stable conditions where the frequency difference between wanted and unwanted carriers does not exceed 100 Hz, the value of 27 dB is adopted as a value to be achieved if feasible. If this protection ratio value is unobtainable, the values in Figure 3-6 provide planners with advice on the resultant quality of service when protection ratios are less than 27 dB.

Transmitter frequency tolerances are contained in Appendix 7 of the Radio Regulations. To ensure that the frequency difference between wanted and unwanted carriers referred to above does not exceed 100 Hz, administrations are urged to use a frequency tolerance of no more than ± 50 Hz.

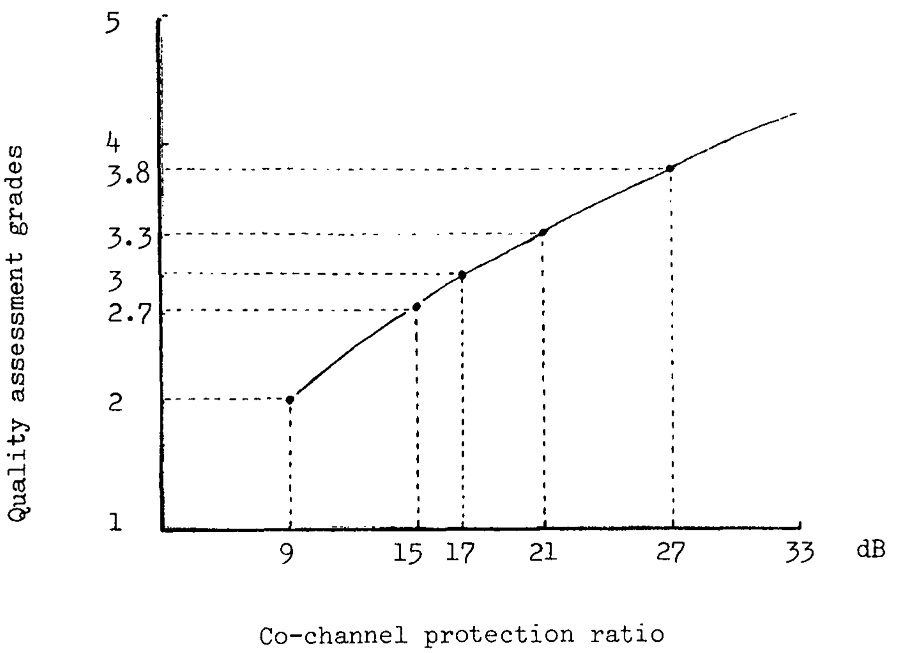


FIGURE 3-6

Relationship between reception quality and co-channel RF protection ratio

Table 3-16 indicates the five quality and impairment assessment grades.

TABLE 3-16

Quality	Impairment
5 Excellent 4 Good 3 Fair 2 Poor 1 Bad	5 Imperceptible 4 Perceptible, but not annoying 3 Slightly annoying 2 Annoying 1 Very annoying

3.3.2 Relative values of protection ratio as a function of carrier frequency separation

Once a value for the co-channel radio-frequency protection ratio has been determined, the radio-frequency protection ratio, expressed as a function of the carrier frequency spacing, shall be determined by adding the value given in the curve in Figure 3-7 to the value of the co-channel RF protection ratio.

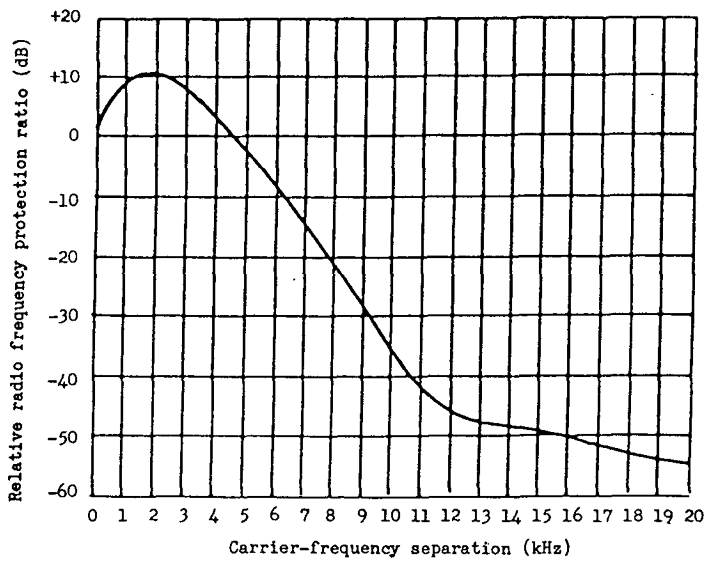


FIGURE 3-7

Relative value of the radio-frequency protection ratio as a function of the carrier-frequency separation

3.4 Values of minimum usable and reference usable field strength

3.4.1 Minimum usable field strength

The minimum usable field strength shall be determined numerically by using the atmospheric noise data, man-made noise data, or the intrinsic receiver noise level, and by adding to it the value of the required radio-frequency signal-to-noise ratio.

3.4.1.1 Atmospheric radio noise data

See 3.2.2.1 (page 19).

3.4.1.2 Man-made radio noise data

See 3.2.2.2 (page 19).

3.4.1.3 Intrinsic receiver noise level

The intrinsic receiver noise level E_i^o shall be calculated by :

$$E_i^o \text{ (dB } (\mu V/m)) = E_c \text{ (dB } (\mu V/m)) + 20 \log m - SNR \text{ (dB)}$$

where E_c = noise limited sensitivity of the receiver = 40 dB(μV/m)

m = modulation depth = 0.3

SNR = audio-frequency signal-to-noise ratio = 26 dB.[1]

For these conditions : E_i^o = 3.5 dB(μV/m).

3.4.1.4 Comparison of the intrinsic receiver noise level, the atmospheric and man-made radio noise

In each case the values of atmospheric noise, man-made noise and intrinsic receiver noise intensities shall be compared and the greatest one shall be used.

3.4.1.5 Audio-frequency signal/noise ratio

For planning purposes, the value of the audio-frequency signal/noise ratio shall be 24 dB.

[1] The value of the signal-to-noise ratio in this paragraph is the value used for the measurements of the noise-limited sensitivity of the receiver carried out in accordance with CCIR Report 617-2 (this value is not to be confused with the value of the AF signal-to-noise ratio recommended for planning purposes in 3.4.1.5.

3.4.1.6 Radio-frequency signal/noise ratio

The required radio-frequency (input) signal-to-noise ratio is approximately 10 dB greater than the required audio-frequency (output) signal-to-noise ratio for the reference receiver (IF bandwidth 4 kHz) with 30% modulation of the received signal under stable propagation conditions. The basis for the establishment of this ratio is such that it is not appropriate to consider variability in time.

In these conditions, for planning purposes, the value of the radio frequency signal/noise ratio shall be 34 dB.

3.4.2 Reference usable field strength

The reference usable field strength shall be $E_{ref} = E_{min} + 3$ dB.

3.5 Antennas and power

The combined effect of transmitter power and antenna characteristics which determines the equivalent isotropically radiated power (e.i.r.p.) is the main factor in computations for HF broadcasting planning. The most directional antenna possible which is appropriate to the broadcasting requirement should be chosen when selecting power and associated antennas. The power required must be as low as possible to achieve broadcasting objectives.

3.5.1 Antenna characteristics

In HF broadcasting the antenna is the means by which the radio-frequency energy is directed towards the required service area. The selection of the right type of antenna will enhance the signal in this area, while reducing radiation in unwanted directions. This will protect other users of the radio-frequency spectrum operating on the same channel or adjacent channels to another service area. The use of directional antennas with well-defined radiation patterns is thus recommended as far as possible.

Non-directional antennas can be used when the transmitter is located within the required service area. In this case the required service area as seen by the transmitter extends over an azimuthal angle greater than 180°.

Directional antennas serve a double purpose. The first is to prevent interference to other users of the spectrum by means of their directivity. The second is to provide sufficient field-strength for satisfactory reception by means of their power gains.

Although rhombic antennas are used, they should be discouraged because of the size and number of their sidelobes, which could create technically avoidable interference.

3.5.1.1 Choice of optimum antennas for various types of service

A chart in Figure 3-8 gives some general guidelines for the choice of optimum antennas for a given type of service according to the required distance range. Two different categories are considered : short distance and medium/long-distance services.

A short distance service is understood here to have a range of up to about 2,000 km. The corresponding area can be covered with either a non-directional or a directional antenna whose beamwidth can be selected according to the sector to be served. In the case of directional antennas, both horizontal dipole curtain and logarithmic-periodic antennas can be employed. The latter type is multiband array with a wide operating frequency range, a low-to-medium gain and a large horizontal beamwidth.

Medium and long distance services can be considered to reach distances greater than approximately 2,000 km. Such coverage can be provided by antennas whose main-lobe elevation angle is small (6°-13°) and whose horizontal beamwidth - depending on the area to be served - is either wide between 65° and 95° (generally 70°) or narrow between 30° and 45° (generally 35°).

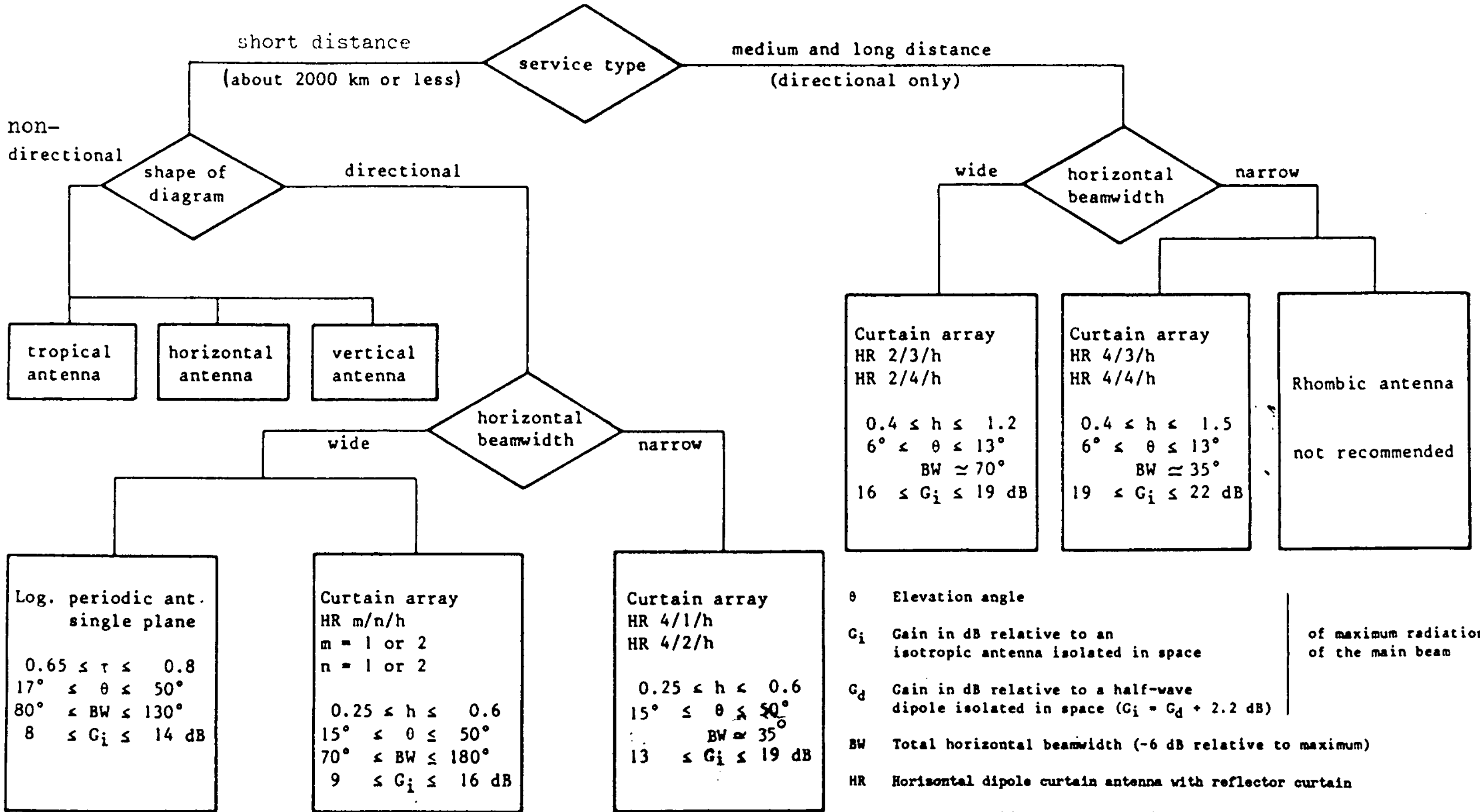
The value of the field-strength in the reception area is influenced by the radiation characteristics of the antennas, and this will be optimized if the most suitable type of antenna is used. The direction of radiation of the main lobe of a short-wave antenna, its elevation angle and maximum gain are principally dependent upon the type of array and its height above ground.

Figure 3-9 illustrates the way in which these parameters vary for horizontal dipole curtain antennas fitted with reflectors and for arrays with most of the commonly-used arrangements of dipoles when operated close to their design frequency. The way in which the maximum gain and elevation angle of the main lobe of rhombic antennas vary with height above ground is also shown.

Figure 3-10 shows the angle of elevation involved in the propagation of short-wave signals via the F-layer for distances up to 10,000 km. It can be seen that the angles tend to be less than 10° for all distances beyond 5,000 km and angles above about 20° are only suitable for distances of less than 2,000 km. Figure 3-9 shows that low angle arrays whose maximum radiation is at angles of 10° or less tend to have the highest gains, and that low-gain antennas have their maximum radiation at the high angles most suitable for short-distance services.

3.5.1.2 A set of representative types of antenna

Antenna patterns used for planning purposes need to take account of practical considerations; they should be standardized for reference purposes and they should be representative of the large range of types of antenna in common use. For a set of representative antenna types recommended for planning purposes, based on single band antennas, Table 3-17 indicates, according to the vertical and azimuthal characteristics, the gain and the elevation angle of maximum radiation. Details of the total horizontal beamwidth (between -6 dB points) for the different types of antenna are also given in Table 3-18.



θ Elevation angle

G_i Gain in dB relative to an isotropic antenna isolated in space — of maximum radiation of the main beam

G_d Gain in dB relative to a half-wave dipole isolated in space ($G_i = G_d + 2.2$ dB)

BW Total horizontal beamwidth (-6 dB relative to maximum)

HR Horizontal dipole curtain antenna with reflector curtain

m Number of half-wave elements in each row

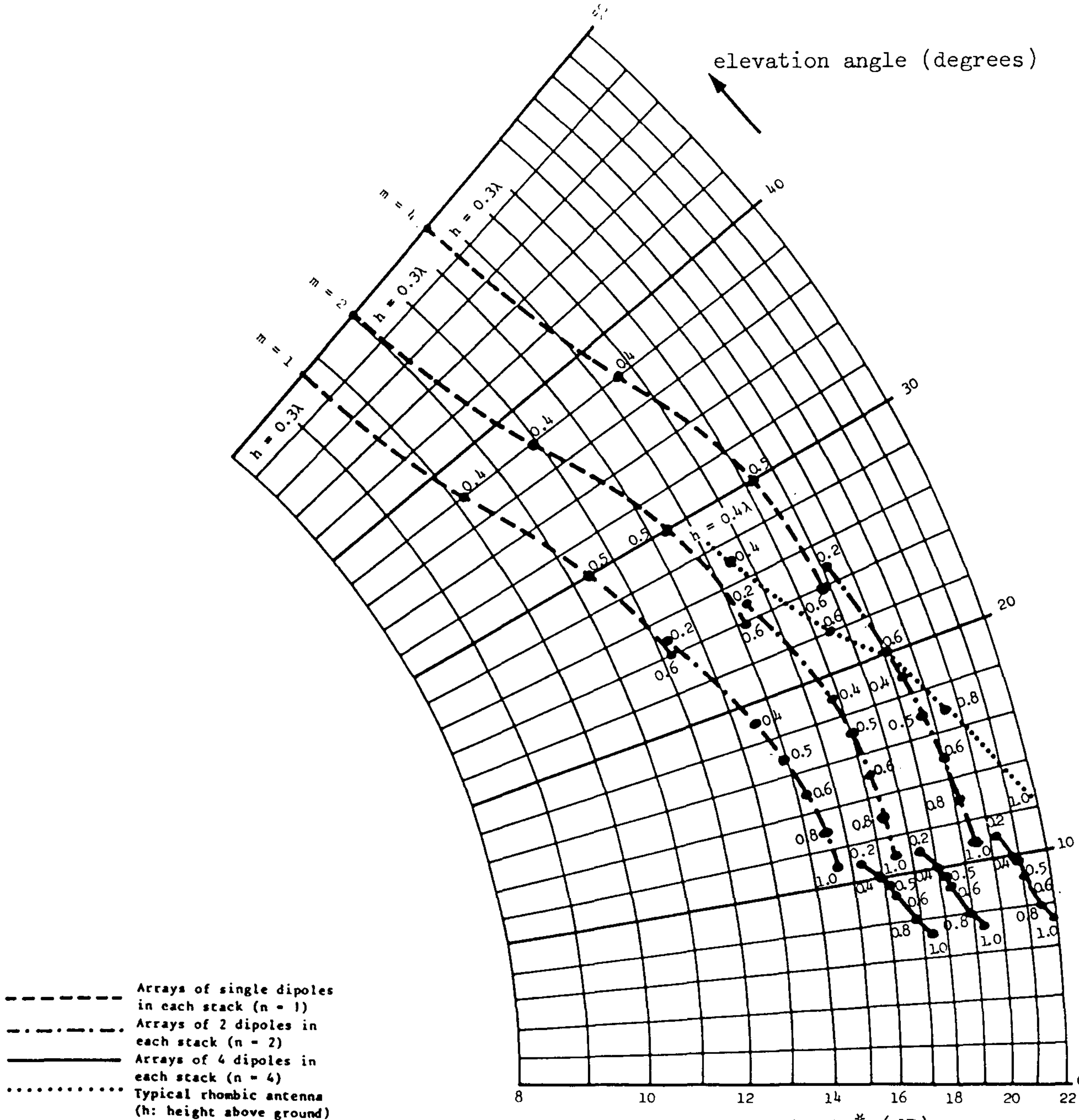
n Number of half-wave elements in each stack (one above the other)

h Height above ground in full wavelengths of the bottom row of elements

τ Taper ratio of log. periodic antenna

FIGURE 3-8

Antenna selection chart



Nomenclature according to Appendix 2, page 7 of the Radio Regulations (1982 edition)

HR : horizontal dipole curtain antenna with reflector curtain
m/ : number of half-wave elements in each row
/n/ : number of half-wave elements in each stack (one above the other)
/h : height above ground in full wavelengths of the bottom row of elements, or of typical rhombic antennas

FIGURE 3-9

Variation of maximum isotropic gain with elevation angle, for horizontal dipole curtain arrays fitted with reflectors and for typical rhombic antennas, above a perfect earth

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* $G_i = G_d + 2.2$ dB

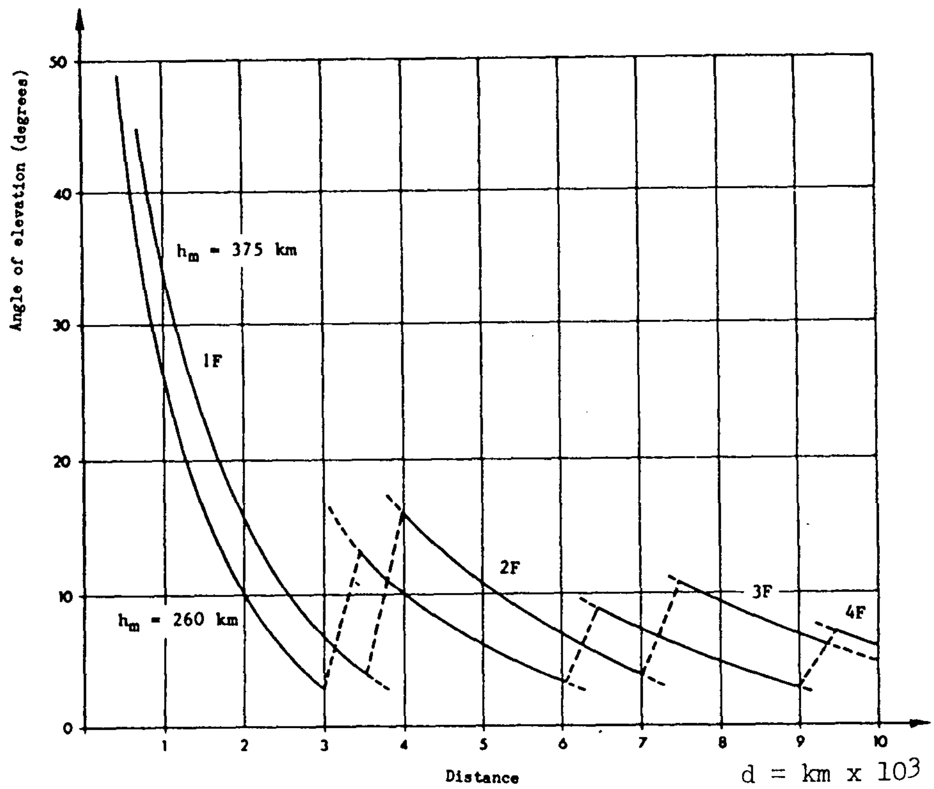

FIGURE 3-10

Variation of elevation angle with distance for representative F-layer heights h_m

Principal characteristics of the set of representative types of antenna

TABLE 3-17

Gain and elevation angle in the direction of maximum radiation

TYPE OF ANTENNA / VERTICAL CHARACTERISTIC ---/m/n/h	IN THE DIRECTION OF MAXIMUM RADIATION					
	AZIMUTHAL CHARACTERISTIC					ELEVATION ANGLE θ (DEGREES)
	HR4 GAIN G_i (dB)*	HR2 GAIN G_i (dB)*	HR1 GAIN G_i (dB)*	H2 GAIN G_i (dB)*	H1 GAIN G_i (dB)*	
-/4/1	22	19				7
-/4/0.8	22	19				8
-/4/0.5	21	19				9
-/3/0.5	20	18				12
-/2/0.5	19	16	14		11	17
-/2/0.3	18	15	13		10	20
-/1/0.5		14	12	11	9	28
-/1/0.3		11	10			44
				9	7	47

* $G_i = G_d + 2.2$ dB

TABLE 3-18

Total horizontal beamwidth at the elevation angle of maximum radiation (for single band antennas)

TYPE OF ANTENNA / ---/m/n/h	TOTAL HORIZONTAL BEAMWIDTH (-6 dB) (DEGREES)				
	HR4	HR2	HR1	H2	H1
ALL TYPES -/4/1 to -/2/0.5	35	70	108		112
-/2/0.3	35	70	110		116
-/1/0.5		74	114	78	126
-/1/0.3		90	180	180	180

For antennas not included in Table 3-17 the equivalent representative type whose performance is nearest to that of the antenna under consideration can be determined by reference to Table 3-19.

TABLE 3-19

Determination of the representative antenna having a radiation pattern most similar to that of any non-representative one, on the basis of the value of the parameters n and h

h	HR m/n/h				H m/n/h	
	n=4	n=3	n=2	n=1	n=2	n=1
h ≥ 0.9	m/4/1	m/4/0.8	m/3/0.5	-	-	-
0.9 > h ≥ 0.65	m/4/0.8	m/4/0.5	m/3/0.5	-	-	-
0.65 > h ≥ 0.4	m/4/0.5	m/3/0.5	m/2/0.5	m/1/0.5	m/2/0.5	m/1/0.5
0.4 > h	m/3/0.5	m/2/0.5	m/2/0.3	m/1/0.3	m/2/0.3	m/1/0.3

(m=4, 2 or 1, where appropriate)

3.5.1.3 Multi-band antennas

In the case of multi-band antennas, (curtain and log periodic) a single value of h, an important parameter with regard to the vertical radiation pattern and the angle of maximum radiation, no longer corresponds to the physical height of the bottom row of elements of the antenna over the range of operating frequencies. The equivalent value h at the required frequency of operation can be found in the following way : in Figure 3-11 enter the vertical angle of maximum radiation, taken from the antenna diagram for the respective frequency band, into the ordinate. Choose the curve with the appropriate value of n. Read from the abscissa the equivalent height h. The equivalent type of antenna can then be determined by entering this new value of h in Table 3-19.

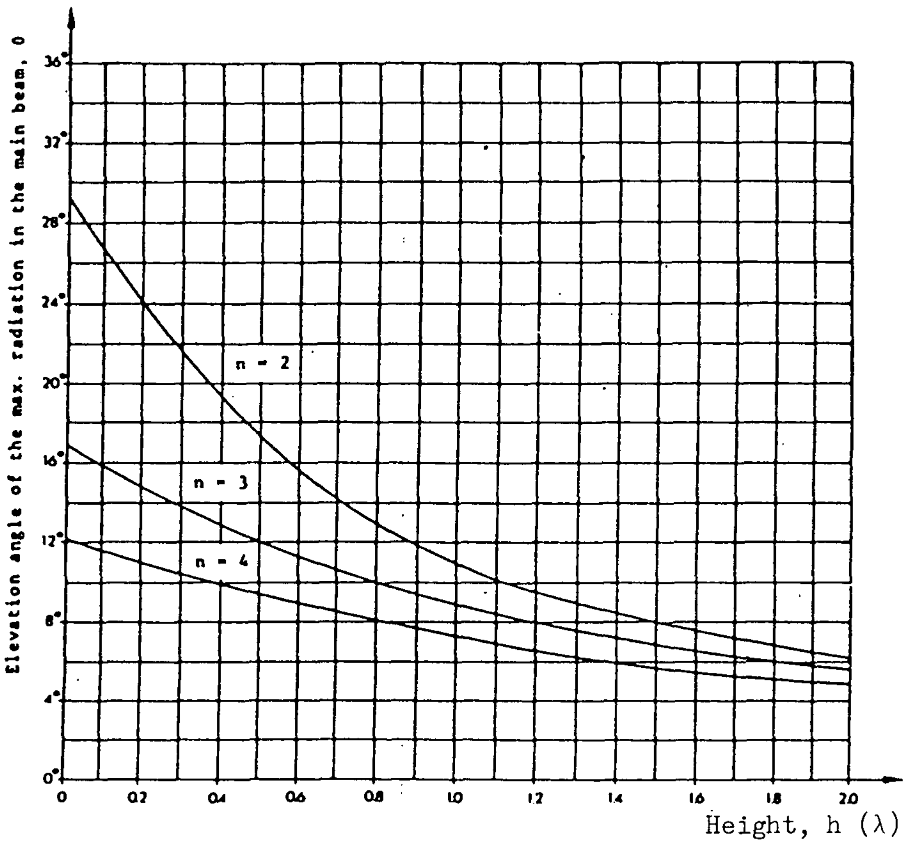

FIGURE 3-11

Diagram enabling the equivalent value of the parameter h to be determined for a multiband antenna having n half-wave elements in each stack

Additional data relating particularly to the azimuthal performance over the operating range of a multi-band antenna are required for later inclusion in Table 3-20 as they become available. Between the two sessions, therefore, administrations are requested to submit to the CCIR accurate data in the format given in Table 3-20.

3.5.1.4 Simplified antenna patterns for planning purposes

The vertical pattern and azimuthal pattern of the antennas listed in Table 3-17 can be represented by values of the relative attenuation in dB below maximum gain, each value being relative to the maximum radiation in both elevation and azimuth and to the maximum gain of the array. The attenuations, in dB, relative to maximum gain, for the azimuthal pattern are listed in Table 3-20 and those for the vertical pattern are listed in Tables 3-21, 3-22 and 3-23.

When an antenna is slewed horizontally, the main beam may be considered as unchanged in shape. It can, therefore, be assumed that the azimuth of maximum radiation of the main beam in the slewed mode coincides with the horizontal angle $\psi = 0$ (see paragraph 3.5.1.5) in Table 3-20. The radiation outside the main beam should be represented in a similar tabulated form and the CCIR Secretariat is requested to provide the appropriate values, based on the data contained in the CCIR Antenna Handbook.

3.5.1.5 Representation of antenna patterns

Antenna diagrams are conventionally used to represent the spatial radiation distribution of an antenna or an array of antennas. The CCIR uses a sinusoidal projection, called "SANSON-FLAMSTEAD PROJECTION" where the hemisphere and the contours are represented in a single plane.

The formulas from which these patterns have been developed are extremely complex.

The three-dimensional radiation pattern of an antenna can be derived from :

a) the vertical radiation pattern within the plane normal to the horizontal plane comprising the azimuth of maximum radiation $G(\theta)|_{\varphi = 0^\circ}$

b) the azimuthal radiation pattern.

A graphic representation of the angles θ and φ is given in Figure 3-12.

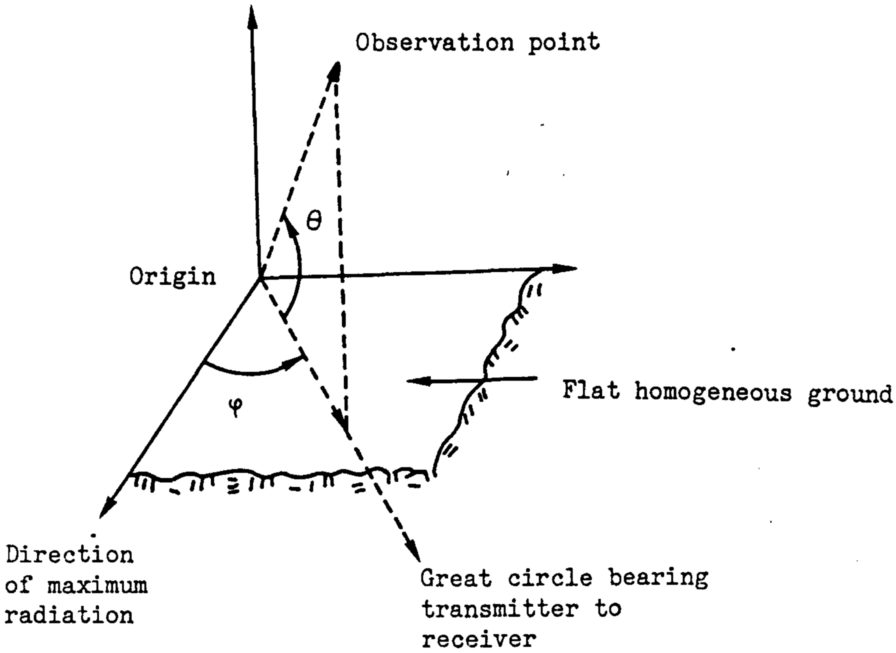

FIGURE 3-12

Graphic representation of the angles θ and φ

For planning purposes it is more convenient and much faster in any computation process to use tabulated information.

A suitable set of antenna patterns in the form of reference tables has been prepared giving values for the antenna radiation patterns which are in close agreement with those given by the CCIR.

This set of antenna patterns uses a conversion technique to obtain the true radiation pattern from the respective values of vertical and azimuthal attenuation factors.

It can be shown that by appropriate substitution of $\sin \varphi \cos \theta = \sin \psi$ in the azimuthal components of the full formula, the three-dimensional radiation pattern of an antenna can be represented by two expressions, one representing the horizontal pattern as a function of ψ and the other representing the vertical pattern as a function of θ.

Tables can therefore be compiled showing the attenuation relative to the maximum gain varying with angle. Table 3-20 represents the horizontal pattern as a function of ψ and Tables 3-21, 3-22 and 3-23 represent the vertical pattern as a function of θ.

In obtaining the attenuation for any angle of elevation and azimuth, the angle ψ must be calculated using the following formula :

ψ = arc sin (sin φ cos θ) for $|\varphi| \leq 90°$ or

ψ = 180 - arc sin (sin φ cos θ) for $\varphi > 90°$

ψ = -180 - arc sin (sin φ cos θ) for $\varphi < -90°$

where

φ = angular difference between great circle bearing transmitter to receiver and azimuth of maximum radiation of the antenna.

θ = angle of vertical radiation.

The attenuation values for ψ and θ can then be determined from the appropriate tables.

The antenna gain in the required direction is then calculated as follows :

Step 1 - Sum the attenuations for the appropriate values of θ and ψ (Tables 3-20, 3-21, 3-22 and 3-23).

Step 2 - If appropriate, according to the conditions in a) i) and b) i) given below, limit the total attenuation obtained in step 1 to a value not exceeding 30 dB.

Step 3 - Subtract the total attenuation from the maximum gain (Table 3-17) for the antenna under consideration and, if appropriate according to condition a) ii) given below, limit the resultant antenna gain to a value not below -8 dBi.

a) Forward radiation

i) For angles of elevation less than the vertical angle of maximum radiation, the total attenuation should not exceed a value of 30 dB.

ii) For angles of elevation equal to or greater than the vertical angle of maximum radiation, the resultant antenna gain shall not fall below -8 dBi.

b) Reverse radiation

i) For HR m/n/h antennas, at all angles of elevation, the total attenuation should not exceed a value of 30 dB.

TABLE 3-20

Antenna attenuation relative to the gain in the direction of maximum radiation, at angles of azimuth relative to the direction of maximum radiation, for planning purposes

Angle (ψ) (degrees)	Horizontal attenuation (dB)				
	HR4/n/h	HR2/n/h	HR1/n/h	H2/n/h	H1/n/h
0	0	0	0	0	0
±5	0.7	0.4	0.3	0.2	0.1
±10	2.3	1.0	0.7	0.5	0.2
±15	5.1	1.8	1.1	1.2	0.5
±20	9.3	2.9	1.6	2.1	0.8
±25	16.5	4.0	2.0	3.3	1.2
±30	30	5.8	2.8	4.5	1.4
±35	20.6	7.8	3.7	6.7	2.6
±40	17.2	9.9	4.5	8.7	3.5
±45	16.5	12.1	5.1	11.2	4.3
±50	17.7	15.1	6.2	13.7	5.0
±55	20.2	18.7	7.7	15.0	4.2
±60	23.2	22.4	8.8	18.0	4.7
±65	26.2	25.8	12.0	25.3	8.9
±70	30	30	11.9	29.5	9.8
±75	30	30	11.9	30	10.4
±80	30	30	15.3	30	15.4
±85	30	30	18.7	30	16.3
±90	30	30	18.5	30	16.2
±95	30	30	18.3	Bidirectional antennas	
±100	30	30	17.5		
±105	30	30	17.2		
±110	30	30	16.2		
±115	30	30	15.2		
±120	27.7	26.9	14.7		
±125	26.0	24.5	13.5		
±130	25.2	22.6	13.7		
±135	25.5	21.2	14.1		
±140	27.2	20.0	14.9		
±145	30	18.6	14.9		
±150	30	18.2	15.2		
±155	30	17.5	15.4		
±160	23.2	16.7	15.4		
±165	19.3	16.1	15.3		
±170	16.9	15.5	15.2		
±175	15.5	15.2	15.1		
±180	15.0	15.0	15.0		

TABLE 3-21

Antenna vertical attenuation relative to the gain in the direction of maximum radiation at various angles of elevation, for planning purposes (antenna type : HR m/4/h).

Elevation angle (θ) (degrees)	Vertical attenuation (dB)		
	h = 0.5	h = 0.8	h = 1.0
0	30	30	30
3	6.0	4.9	4.2
6	1.3	0.6	0.3
* 8	0.7	0	0.8
9	0	0.1	0.5
12	0.8	2.4	4.3
15	8.1	8.2	15.0
18	8.6	25.0	15.7
21	18.4	16.0	10.6
24	28.7	14.2	12.3
27	24.3	18.8	19.3
30	30	30	30
33	20.1	22.3	30
36	14.6	21.9	26.4
39	12.7	30	16.5
42	13.0	21.0	12.0
45	15.2	14.9	11.5
48	19.7	12.4	12.3
51	27.4	11.8	15.0
54	24.3	12.5	20.2
57	20.1	14.4	29.2
60	18.5	17.2	26.4
63	18.3	21.1	22.7
66	19.2	26.3	21.9
69	20.9	30	22.6
72	23.2	30	24.5
75	26.4	30	27.4
78	30	30	30
81	30	30	30
84	30	30	30
87	30	30	30
90	30	30	30

* The values corresponding to this angle have been inserted to facilitate the evaluation of G_{tl}, as per paragraph 3.2.1.3.2 (page 13).

TABLE 3-22

Antenna vertical attenuation relative to the gain in the direction of maximum radiation, at various angles of elevation, for planning purposes (antenna types : HR m/3/0.5, HR m/2/h, HR m/1/0.5 and HR m/1/0.3)

Elevation angle (θ) (degrees)	Vertical attenuation (dB)				
	m/3/0.5	m/2/h		m/1/h	
		h = 0.3	h = 0.5	h = 0.3	h = 0.5
0	30	30	30	30	30
3	7.9	12.3	10.6	18.2	14.7
6	2.8	6.6	5.0	12.3	8.8
* 8	1.1	4.4	3.0	9.9	6.6
9	0.6	3.6	2.2	9.0	5.6
12	0	1.8	0.7	6.7	3.6
15	0.6	0.7	0.7	5.0	2.1
18	2.4	0.1	0.1	3.7	1.1
21	5.4	0.4	0.6	2.7	0.5
24	10.3	0.2	1.8	1.9	0.1
27	18.9	0.8	3.5	1.3	0
30	27.2	1.7	6.0	0.8	0.1
33	20.1	2.9	9.4	0.5	0.3
36	19.9	4.4	14.4	0.2	0.8
39	24.4	6.2	22.0	0.1	1.4
42	30	8.3	21.5	0	2.2
45	22.6	10.9	16.8	0	3.2
48	17.4	13.9	14.6	0.1	4.4
51	15.1	17.4	13.7	0.2	5.8
54	14.1	21.0	13.6	0.3	7.3
57	14.1	25.9	14.1	0.5	9.0
60	14.9	29.3	15.1	0.7	11.0
63	16.2	30	16.6	1.0	13.1
66	18.1	30	18.4	1.3	15.1
69	20.5	30	20.7	1.6	16.7
72	23.2	30	23.5	1.9	17.3
75	25.3	30	26.8	2.2	17.2
78	26.0	30	30	2.6	16.8
81	25.6	30	30	2.9	16.4
84	24.9	30	30	3.2	16.1
87	24.6	30	30	3.6	16.1
90	24.6	30	30	3.6	16.1

* The values corresponding to this angle have been inserted to facilitate the evaluation of G_{tl}, as per paragraph 3.2.1.3.2 (page 13).

TABLE 3-23

Antenna vertical attenuation relative to the gain in the direction of maximum radiation at various angles of elevation, for planning purposes (antenna type : H m/n/h)

Elevation angle (θ) (degrees)	Vertical attenuation (dB)			
	H m/1/0.3	H m/1/0.5	H m/2/0.3	H m/2/0.5
0	30	30	30	30
3	18.4	14.7	12.3	10.6
6	12.5	8.9	6.6	5.0
* 8	10.1	6.6	4.4	3.0
9	9.2	5.7	3.6	2.2
12	7.0	3.6	1.8	0.7
15	5.2	2.2	0.7	0.1
18	3.9	1.2	0.1	0.1
21	2.9	0.5	0	0.7
24	2.1	0.1	0.2	1.8
27	1.5	0.1	0.8	3.5
30	1.0	0.1	1.6	6.0
33	0.7	0.3	2.8	9.4
36	0.4	0.7	4.3	14.3
39	0.2	1.3	6.1	21.9
42	0.1	2.1	8.2	21.3
45	0	3.0	10.7	16.6
48	0	4.1	13.6	14.3
51	0	5.4	17.0	13.3
54	0.1	6.9	21.0	13.1
57	0.2	8.5	25.4	13.6
60	0.3	10.4	28.7	14.5
63	0.4	12.3	29.6	15.8
66	0.6	14.2	29.5	17.5
69	0.7	15.6	29.9	19.7
72	0.8	16.0	30	22.2
75	0.9	15.8	30	25.3
78	1.1	15.1	30	30
81	1.1	14.4	30	30
84	1.2	13.9	30	30
87	1.2	13.6	30	30
90	1.4	14.0	30	30

* The values corresponding to this angle have been inserted to facilitate the evaluation of G_{tl}, as per paragraph 3.2.1.3.2 (page 13).

3.5.2 Transmitter power and equivalent isotropically radiated power appropriate for satisfactory service

The propagation prediction method described in section 3.2.1 shall be used to determine the appropriate transmitter power to achieve satisfactory service. The appropriate transmitter power varies with propagation conditions which in turn are functions of the time of day, the season and the solar cycle period as well as the geographical location.

The equivalent isotropically radiated power appropriate for providing the reference usable field strength ($E_{ref} = E_{min} + 3$ dB) shall be calculated, considering the basic circuit reliability, at the 80 and 90[1] percentiles of the test points within the required service area. The reference values of the basic circuit reliability shall be 80% and 90%[1].

3.6 Use of synchronized transmitters

3.6.1 The use of synchronized transmitters, where appropriate, is an efficient means of economizing frequency spectrum. When synchronized transmitters are used, the carrier frequency difference shall be 0.1 Hz or less when the same programme is broadcast to partially overlapping or non-overlapping service areas.

3.6.2 Protection ratios in the range of 3 to 11 dB give satisfactory reception when the carrier frequency difference is 0.1 Hz or less. For planning purposes a value of 8 dB shall be used.

When the synchronized transmitters are driven by a common oscillator and use antennas with similar vertical radiation characteristics, a lower protection ratio of 3 dB shall be adopted for planning.

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[1] These values may be reviewed and modified, if necessary, by the Second Session of the Conference, in the light of the results obtained by the IFRB during the intersessional period.

3.7 Reception zones and test points

3.7.1 Reception zones

In specifying the reception area, reference shall be made to a CIRAF zones, or any part thereof.

If necessary, CIRAF zones may be divided into four quadrants NW, NE, SE and SW to define more precisely the service area of a transmission. This is achieved by defining an appropriate reference point in each CIRAF zone with the dividing lines described precisely by the lines of latitude and longitude passing through such a reference point. Any combination of the four quadrants may be used where the service area is greater than one quadrant but less than a whole CIRAF zone.[1] This procedure may be used when the service area includes parts of different adjacent CIRAF zones.

Ten maritime broadcasting areas (provisionally designated as A to J) are defined as shown in Figure 3-13[2].

3.7.2 Test points

For the purposes of the technical examination the IFRB shall determine an adequate number of test points distributed throughout each CIRAF zone and, where appropriate, subdivisions of CIRAF zones. These test points shall form part of the IFRB Technical Standards and will be distributed for comment by administrations (Nos. 1001 and 1001.1 of the Radio Regulations).

As the computer facilities available to the IFRB improve, the Board shall make further improvements by increasing the number of test points.

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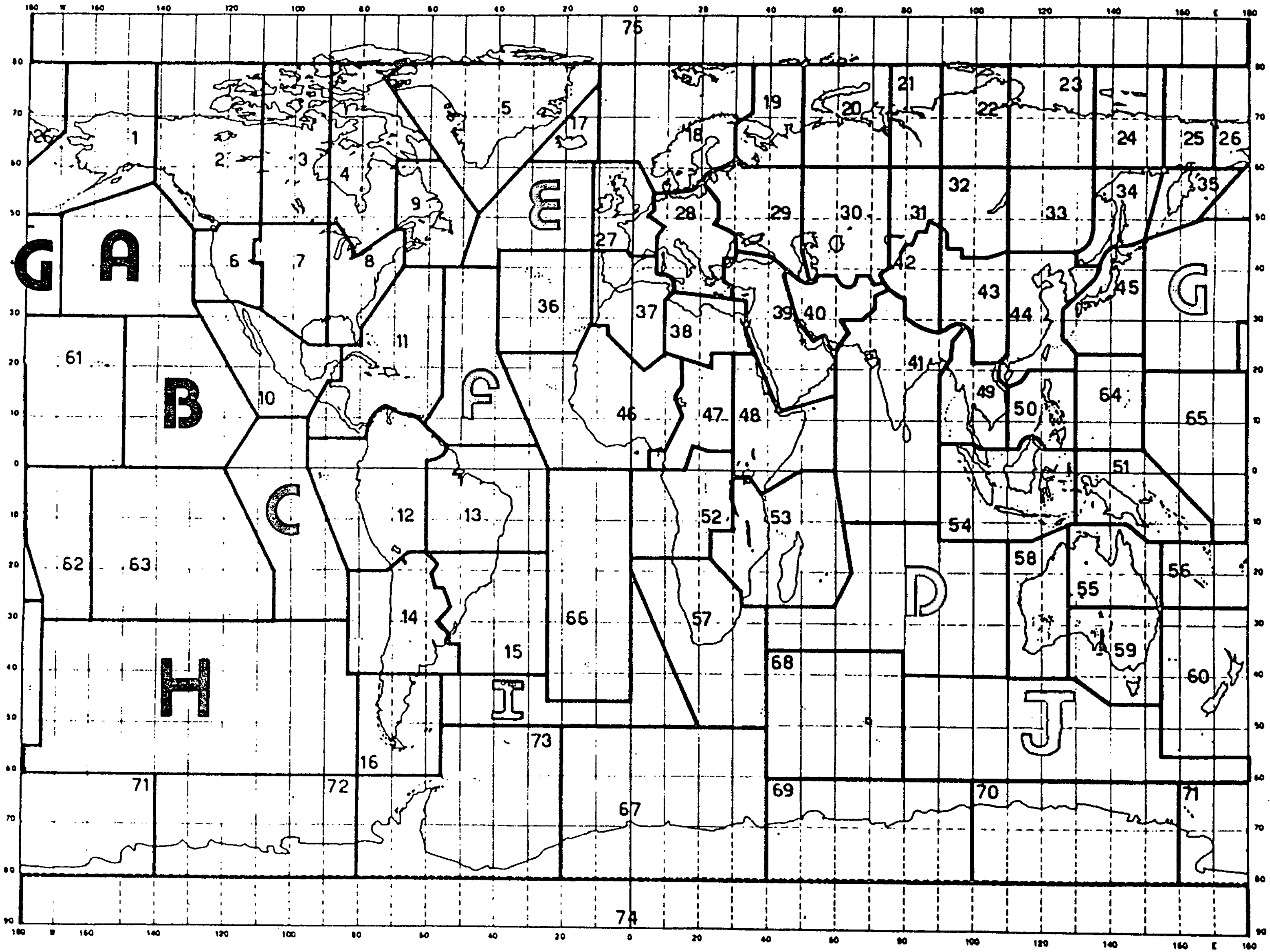
[1] In exceptional cases when it is necessary to specify a reception area which is smaller than an entire zone or a subdivision of a zone, this may be done by specifying an azimuth and a maximum service range in km. See Appendix 2 of the Radio Regulations.

[2] During the intersessional period the IFRB is requested to study the impact of requirements in the new maritime zones on HF broadcasting in CIRAF zones 1 to 75 and to submit a report on this matter to the second session of the Conference.



GEOGRAPHICAL ZONES FOR BROADCASTING

FIGURE 3-13

3.8 Maximum number of frequencies required for broadcasting the same programme to the same zone

3.8.1 Introduction

Wherever possible, only one frequency should be used to broadcast a particular programme to a given reception area. In certain special circumstances, it may be found necessary to use more than one frequency per programme, i.e. :

- over certain paths, e.g. very long paths, those passing through the auroral zone, or paths over which the MUF is changing rapidly;
- areas where the depth of the area extending outwards from the transmitter is too great to be served by a single frequency;
- when highly directional antennas are used to maintain satisfactory signal-to-noise ratios, thereby limiting the geographical area covered by the station concerned.

The decision to use more than one frequency per programme should be made on the merits of the particular case concerned.

3.8.2 Use of additional frequencies[1]

The number of frequencies needed to achieve the specified level of basic broadcast reliability shall be determined by the method given below. If the calculated basic broadcast reliability for a single frequency does not reach the adopted value, it is necessary to consider whether it could be improved by a combination of frequencies in separate bands and whether the improvement would justify the use of additional frequencies.

In cases where the basic broadcast reliability obtained with one frequency is between 50% and 80%, an additional frequency shall be tested[2]. If the basic broadcast reliability calculated for two frequencies exceeds the limit specified in Figure 3-14, the additional frequency may be used.

In those special cases where the basic broadcast reliability using two frequencies remains below 80%, the above calculation procedure shall be repeated to test for a third frequency.

Use of synchronized transmitters should be encouraged whenever possible with a view to minimizing the need for additional frequencies.

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[1] These criteria may be modified by the Second Session of the Conference in the light of the calculation results obtained by the IFRB during the intersessional period.

[2] For calculation of the basic broadcast reliability, see paragraph 3.2.4.5 (page 34).

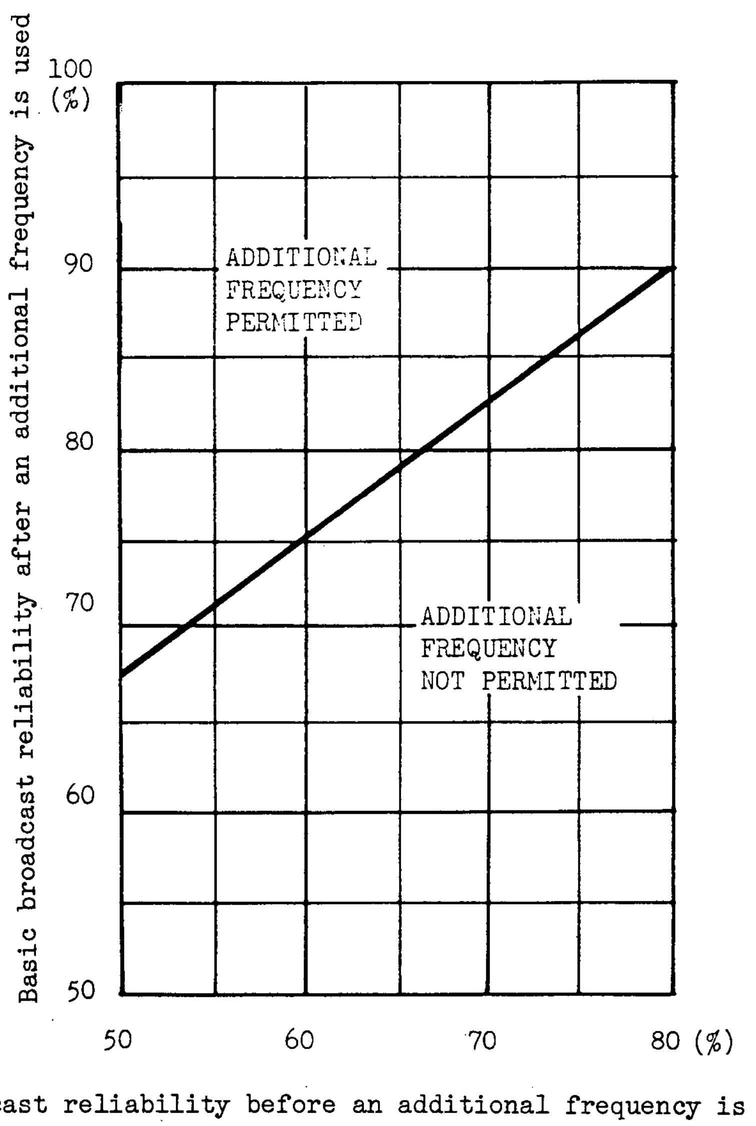

FIGURE 3-14

Limits for use of an additional frequency

3.9 Specifications and progressive introduction of an SSB system

Considering the advantages of SSB transmission, such as :

- a more efficient utilization of the frequency spectrum by a reduction of interference;
- the capability of improving the required protection ratio between adjacent channels in the case of a sufficient carrier reduction;
- the capability of improving the quality of reception, in particular under poor propagation conditions (selective fading), with SSB receivers;
- the possibility of producing the same sideband power as a current DSB transmitter with less capital and operational costs,

the Conference adopted the following SSB system specifications under the assumption of a progressive introduction of receivers with synchronous demodulation. With respect to a necessary transition period from DSB to SSB, some consideration must also be given to the reception of SSB signals with reduced carrier by receivers with envelope detection. At the end of the transition, all the advantages of SSB transmissions mentioned above could then be realized.

3.9.1 SSB system specifications

3.9.1.1 Audio-frequency bandwidth

The upper limit of the audio-frequency bandwidth of the transmitter shall not exceed 4.5 kHz with a further slope of attenuation of 35 dB/kHz and the lower limit shall be 150 Hz with lower frequencies attenuated at a slope of 6 dB per octave.

3.9.1.2 Necessary bandwidth

The necessary bandwidth shall not exceed 4.5 kHz.

3.9.1.3 Characteristics of modulation processing

The audio-frequency signal shall be processed so that the modulating signal retains a dynamic range of not less than 20 dB. Excessive amplitude compression, together with improper peak limitation, leads to excessive out-of-band radiation and thus to adjacent channel interference, and is therefore to be avoided.

3.9.1.4 Channel spacing

During the transition period, the channel spacing for SSB shall be 10 kHz. In the interest of spectrum conservation, during the transition period, it is also permissible to interleave SSB transmissions midway between two adjacent DSB channels, i.e., with 5 kHz separation between carrier frequencies, provided that the interleaved transmission is not to the same geographical area as either of the transmissions between which it is interleaved (see also section 3.1.2, page 7)[1].

After the end of the transition period the channel spacing and carrier frequency separation shall be 5 kHz.

[1] In this case the channel spacing remains 10 kHz.

3.9.1.5 Nominal carrier frequencies

Carrier frequencies for SSB shall be integral multiples of 5 kHz.

3.9.1.6 Sideband to be emitted

The upper sideband shall be used.

3.9.1.7 Suppression of the unwanted sideband

With respect to the relative RF protection ratio, the degree of suppression of the unwanted sideband (lower sideband) and of intermodulation products in that part of the transmitter spectrum shall be at least 35 dB relative to the wanted sideband signal level. Because of the large difference of signal amplitudes in adjacent channels in practice, however, a greater suppression is recommended (e.g. 50 dB in the exciter producing the SSB signal at low power level and 40 dB suppression of unwanted intermodulation products in the RF power amplifier of the transmitter).

3.9.1.8 Degree of carrier reduction (relative to peak envelope power)

During the transition period the carrier reduction of the SSB emission shall be 6 dB, to allow SSB transmissions to be received by conventional DSB receivers with envelope detection without significant deterioration of the reception quality.

At the end of the transition period the carrier reduction of the SSB emission shall become 12 dB.

3.9.1.9 Frequency tolerance

The frequency tolerance of the SSB carriers shall be ± 10 Hz[1].

3.9.1.10 Overall selectivity of the receiver

The reference receiver shall have an overall bandwidth of 4 kHz, with a slope of attenuation of 35 dB/kHz[2].

Slope of attenuation	SSB receiver audio-frequency bandwidth
25 dB/kHz	3300 Hz
15 dB/kHz	2700 Hz

---

1 This frequency tolerance is acceptable only under the assumption that future SSB receivers will be equipped with a device locking the locally re-inserted carrier for synchronous demodulation to the carrier of the SSB emission (see also paragraph 3.9.1.11).

2 Other combinations of bandwidth and slope of attenuation as given below are possible producing the same relative RF protection ratio of about -27 dB at 5 kHz carrier difference.

3.9.1.11 <u>Detection system of SSB receivers</u>

SSB receivers shall be equipped with a synchronous demodulator, using for the carrier acquisition a method whereby a carrier is regenerated by means of a suitable control loop which pulls the receiver to the incoming carrier. Such receivers must work equally well with conventional DSB transmissions and with SSB transmissions having a carrier reduced to 6 or 12 dB relative to peak envelope power.

3.9.1.12 <u>Equivalent sideband power</u>

During the transition period an equivalent SSB emission is one giving the same loudness level as the corresponding DSB emission, when it is received by a DSB receiver with envelope detection. This is achieved when the sideband power of the SSB emission is 3 dB larger than the total sideband power of the DSB emission. (The peak envelope power of the equivalent SSB emission as well as the carrier power are the same as that of the DSB emission.)

After the end of the transition period, the equivalent sideband power can be reduced by 3 dB.

3.9.1.13 <u>RF protection ratios</u>

Assuming that the SSB and DSB emissions correspond to the technical characteristics specified above, the following RF protection ratios shall be applied :

- <u>during the transition period</u> :

<u>RF co-channel protection ratio</u>

Given the need to increase the radiated sideband power by 3 dB in the case of equivalent SSB emissions, there is a consequent need to make an allowance of the same 3 dB in the co-channel protection ratio for the case of a wanted DSB signal interfered with by an SSB signal, if the same quality of reception is to be maintained (see paragraph 3.9.2.3).

<u>Relative RF protection ratios</u>

(For the following protection ratios SSB emissions with equivalent sideband power are assumed.)

a) If a wanted <u>DSB signal is received by a conventional DSB receiver</u> with envelope detection which is <u>interfered with by an SSB emission</u>.

According to the resulting RF protection ratio, reception of the wanted DSB signal in the lower channel (interfering carrier for example at $\Delta F = +5$ kHz) will be impaired by about 1 dB, while under the same conditions reception of the wanted DSB signal in the upper adjacent channel (interfering carrier for example at $\Delta F = -5$ kHz) will be impaired by about 4 dB in comparison to the present RF protection ratios, as specified in Figure 3-7 (page 39).

The corresponding value for $\Delta F = \pm 10$ kHz will be 3 dB impairment.

b) In the case of a wanted SSB signal interfered with by a DSB signal, values of Figure 3-7 (page 39) shall be used.

c) In the case of a wanted SSB signal interfered with by an SSB signal, the values mentioned in a) above shall be applied.

- after the end of the transition period (both the wanted and the interfering signals are SSB signals) :

RF co-channel protection ratio

The RF protection ratio is the same as that applied for the DSB system.

Relative RF protection ratios

Relative RF protection ratios shall be as shown in Figure 3-15.

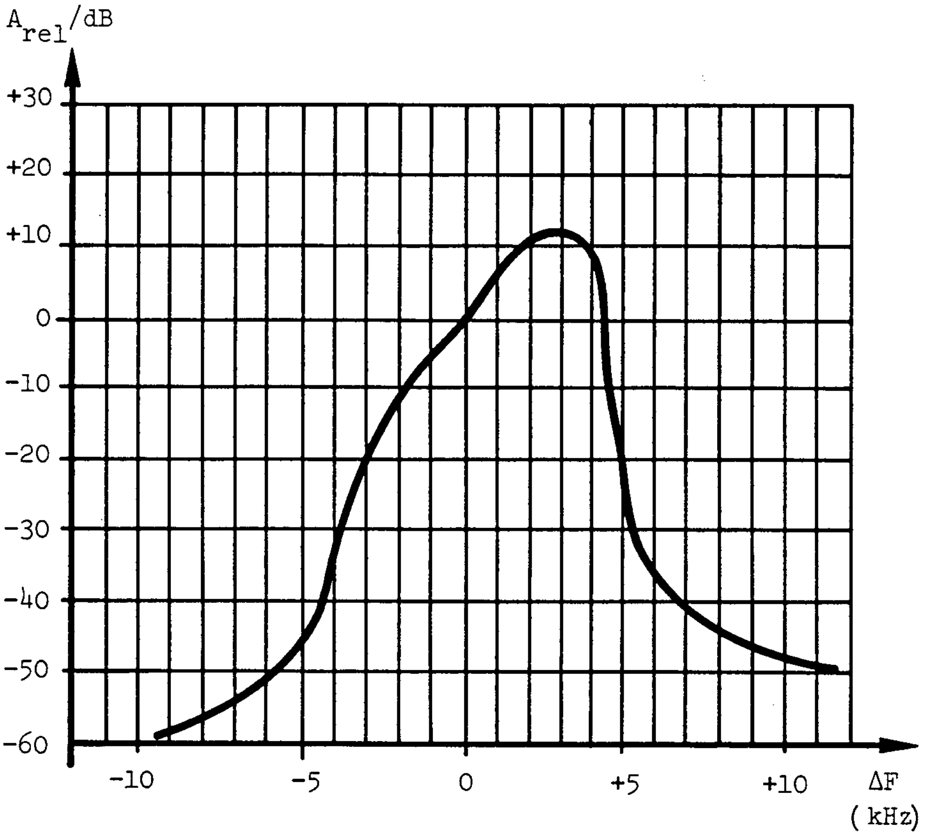

FIGURE 3-15

Relative RF protection ratios A_{rel} are given with respect to the frequency difference ΔF between the interfering carrier f_i and the wanted carrier f_w.

$$\Delta F = f_i - f_w$$

Thus positive ΔF describes interference from the upper adjacent channel.

3.9.2 Progressive introduction of SSB transmissions (Technical aspects)

3.9.2.1 Transmitters

It should be recognized that :

a) converting an existing DSB transmitter to an SSB transmitter which delivers equivalent sideband power with 6 dB carrier reduction is technically not possible;

b) it is economically unattractive to convert existing conventional DSB transmitters for operation to SSB mode with 6 dB carrier reduction even if 3 dB less sideband power is accepted;

c) it is possible and feasible to convert unconventional DSB transmitters of recent design (using amplitude modulation systems such as pulse duration modulation) to SSB mode with 6 dB carrier reduction and the same sideband power as in DSB mode without significant loss of efficiency;

d) from the technical point of view conventional DSB transmitters can, in some cases, also be converted to SSB mode with 12 dB carrier reduction and can provide the necessary equivalent sideband power. Whether the conversion is economically attractive will depend on the type and age of the transmitter concerned;

e) the technical and/or economic lifetime of a transmitter can be estimated at twenty years.

3.9.2.2 Receivers

It should be recognized that :

a) current technological progress will make it possible within the next ten years to mass-produce DSB/SSB receivers at a reasonable price;

b) during the transition period it would be useful to have SSB receivers offering selection of either the upper or the lower sideband of a DSB transmission, in order to reject adjacent channel interference;

c) the technical and economic lifetime of a receiver is considered to be in the order of ten years;

d) envelope detection should be abandoned as soon as possible and synchronous demodulation be introduced.

3.9.2.3 Evaluation of compatibility aspects of the proposed SSB system during the transition period

During the transition period, SSB transmissions will be mainly received by conventional DSB receivers using envelope detection. To obtain with a conventional DSB receiver using envelope detection the same loudness level with both SSB and DSB, the sideband power of the SSB emission has to be 3 dB higher (equivalent sideband power) than the total sideband power of the DSB emission. Alternatively, if the sideband power of the SSB emission cannot be increased, one has to accept some reduction of the coverage area. Such an SSB emission, however, could replace any of the DSB emissions in the Plan without the interference situation deteriorating.

SSB emissions with equivalent sideband power replacing a DSB emission according to the Plan will cause a slight increase in adjacent channel interference (e.g. at ± 10 kHz channel spacing the relative RF-protection ratio would be changed by 3 dB from -36 dB to -33 dB) if reception is in the adjacent channels with a conventional DSB receiver having the selectivity of the DSB reference receiver (see paragraph 3.9.1.13).

In paragraph 3.9.1.13, a 3 dB allowance for co-channel interference between a DSB emission and an SSB emission with equivalent sideband power has been specified. Recent investigation shows, however, that taking into account the effect of coherent demodulation of the two sidebands of a DSB emission in an envelope detector, this allowance may be 0 dB[1]. Further study will be needed on this question during the inter-sessional period.

3.9.3 Progressive introduction of SSB transmissions (Planning aspects)

3.9.3.1 The eventual changeover to SSB will make for efficient utilization of the spectrum. SSB transmissions which administrations may wish to make may, however, be permitted in lieu of planned DSB transmissions, provided that the level of interference caused to DSB transmissions appearing in the Plan is not increased.

Since the criteria of compatibility between DSB and SSB are not yet completely known[2] and in view of the economic implications, this session is of the opinion that :

3.9.3.1.1 The second session of the Conference should fix the date of the beginning of the transition period as well as the duration of this period[3].

3.9.3.1.2 The duration of the transition period may be fixed at 20 years (and consideration will have to be given to the timely availability of the receivers required).

The date of the cessation of DSB emissions will therefore be known once the second session has fixed the date referred to in 3.9.3.1.1 above.

3.9.3.2 SSB should be introduced in the same bands as are used for DSB. It has also been recognized that no channels should be reserved exclusively for SSB.

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[1] See Recommendation COM5/1.

[2] See section 3.9.2.4.

[3] See section 3.9.2.

3.10 Theoretical capacity of the HF broadcasting bands

The theoretical capacity of the HF broadcasting bands is dependent on a variety of factors. These include the radio-frequency protection ratio, transmitter powers, the antenna directivities and the planning method.

The time period and the frequency band considered are also important for the channel capacity. On the basis of calculations carried out by several administrations and utilizing the data of the IFRB, the average capacity (available number of stations/ channel at a given time) was generally found to be in the range of three to four.

The capacity decreases in the higher frequency bands and for higher RF protection ratios. The range of capacity is from one to seven.

In general no single value for the capacity of any band can be determined since the capability to accommodate requirements is subject to factors which vary from one seasonal plan to another.

3.11 Minimum values of technical parameters

The following minimum values of technical parameters could be used by the IFRB for its intersessional studies. On the basis of the experience of the IFRB, the second session of the Conference could also draw on this information :

- co-channel radio-frequency protection ratio under stable conditions : 17 dB;

- audio-frequency signal/noise ratio : 19 dB;

- overall/basic reliability (both broadcast and reception reliability) : 50%;

- quality assessment grade : 3.

The relationship between the reception quality and the co-channel radio-frequency protection ratio is shown in Figure 3-6 (page 38).

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CHAPTER 4

PLANNING PRINCIPLES AND METHOD

Having considered the proposals of administrations on planning principles and method, the first session of the Conference concluded that the planning of the high frequency broadcasting service shall be based on four seasonal plans to be prepared annually or semi-annually using broadcasting requirements submitted periodically by the administrations. The seasonal plans shall be prepared on the basis of the following principles and planning method.

4.1 Planning principles

4.1.1 In accordance with the International Telecommunication Convention and with the Radio Regulations annexed thereto, the planning of the high frequency bands allocated to the broadcasting service shall be based on the principle of equal rights of all countries, large or small, to equitable access to these bands and to utilize them in accordance with the decisions taken by this Conference. In planning, an attempt shall also be made to achieve an efficient utilization of these frequency bands, account being taken of the technical and economical constraints that may exist in certain cases.

4.1.2 On the basis of the foregoing, the following planning principles shall be applied.

4.1.2.1 All the broadcasting requirements, current or future, formulated by the administrations, shall be taken into account and be treated on an equitable basis, so as to guarantee the equality of rights referred to in paragraph 4.1.1 above and to enable each administration to provide a satisfactory service.

4.1.2.2 All the broadcasting requirements, national[1] and international, shall be treated on an equal basis, with due consideration of the differences between these two kinds of broadcasting requirements.

4.1.2.3 In the planning procedure, an attempt shall be made to ensure, as far as practicable, the continuity of the utilization of a frequency or of a frequency band. However, such continuity should not prevent equal and technically optimum treatment of all broadcasting requirements.

4.1.2.4 The periodical planning process shall be based solely on the broadcasting requirements to become operational during the planning period. It shall furthermore be flexible to take into account new broadcasting requirements and modifications to the existing broadcasting requirements, in accordance with the modification procedures to be adopted by the Conference.

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1 An HF broadcasting use is considered as being for purposes of national coverage when the transmitting station and its associated required service area are both located within the territory of the same country. (There is a need for this note to appear in the Final Acts of the Conference.)

4.1.2.5 The planning procedure shall be based on DSB transmissions. SSB transmissions which administrations might wish to make may, however, be permitted in lieu of planned DSB transmissions, provided that the level of interference caused to DSB transmissions appearing in the Plan is not increased.

4.1.2.6 For efficient spectrum utilization, whenever possible, only one frequency should be used to meet a given broadcasting requirement in a given required service area and in any case the number of frequencies used should be the minimum necessary to provide satisfactory reception.

4.1.2.7 Those broadcasting requirements for which, through lack of the requisite technical facilities, the agreed minimum usable field strength is not ensured at any point of the required service area, could obtain proportionally reduced protection against interference as indicated in paragraph 3.2.4.6 (page 36).

4.1.2.8 In a first stage of the equitable application of the planning procedure, an attempt will be made to include the highest possible number of the submitted requirements so as to achieve the desired quality level. The remaining requirements would be processed on the understanding that lower quality levels would be acceptable.

4.1.2.9 The planning method shall satisfy on an equal basis a minimum of the broadcasting requirements submitted by administrations with the level of overall broadcasting reliability adopted by the Conference. Special consideration shall be given to administrations which, in the first instance, are unable to achieve the overall broadcasting reliability.

4.2 Planning method

4.2.1 Overview of planning method

After considering the various proposals to the Conference, the first session decided to establish the planning method which is described in Figure 4-1. The detailed description of each step of the planning process is contained in section 4.2.3. The procedures associated with this method will be developed at the second session on the basis of proposals submitted by administrations.

4.2.2 Definition of a broadcasting requirement

A requirement indicated by an administration to provide a broadcasting service at specified periods of time to a specified reception area from a particular transmitting station.

4.2.3 Description of the individual steps of the processing system

4.2.3.1 Step 1 - Requirements file

a) The requirements file will be created on the basis of data relating to operational and projected broadcasting requirements and the associated facilities submitted by administrations over a period of three years.[1]

This file will be updated in accordance with the procedures to be developed at the second session (see section 4.1.2.4).

b) This file shall contain :

Basic characteristics

1) name of the transmitting station

2) geographical coordinates of the transmitting station

3) symbol of the country or geographical area in which the transmitting station is located

4) required service area

5) hours of operation (UTC)

6) range of antenna characteristics

7) transmitter power (dBW)

8) class of emission

Optional supplementary characteristics

1) preferred frequency (in kHz)

2) preferred frequency band (in MHz)

3) equipment limitations

4) ranges of power capabilities

5) possible use of synchronized transmitters

[1] The second session could change this period, if necessary.

4.2.3.2 Step 2 - Broadcast requirements for the season under consideration

The broadcasting requirements to be used for each season shall be those contained in the requirements file which are to become operational during the season under consideration and which are confirmed and, if necessary, modified by the administration, in accordance with the procedure described in paragraph 4.2.3.1.

4.2.3.3 Step 3 - Propagation analysis and selection of the appropriate frequency band

The propagation prediction method described in paragraph 3.2 (page 9) will be used to calculate for each requirement, for the season and for the different times, the optimum frequency band. The appropriate frequency band(s) for each requirement at the different times will be selected on the basis of the results of the above calculations.

However, if an administration has indicated equipment limitations, they are to be taken into account in the selection of the appropriate frequency band.

If, at any time, the required basic broadcast reliability cannot be achieved with a single frequency band, a second frequency band shall be selected as long as the administration has indicated its ability to operate in two frequency bands simultaneously. (See paragraph 3.8.2, page 59).

4.2.3.4 Step 4 - Rules to be applied to broadcasting requirements in a given run

4.2.3.4.1 Optimization

The system must be optimized to ensure the maximum possible utilization of all available channels.

4.2.3.4.2 Preferred frequency

In accordance with the planning principles and without imposing constraints on planning, the following provisions shall be applied in the seasonal plans :

1) administrations may indicate the preferred frequency;

2) during the planning process, attempts shall be made to include the preferred frequency in the plan;

3) if this is impossible, attempts shall be made to select a frequency which is as close as possible to the preferred frequency in the same band.

Otherwise the automated system shall be used to select the appropriate frequencies in such a way as to accommodate the maximum number of requirements, taking into account the constraints imposed by the technical characteristics of the equipment.

4.2.3.4.3 Equipment constraint

The system shall take into account the technical constraints imposed by the equipment, namely :

4.2.3.4.3.1 Frequency

a) When an administration indicates that its facilities can operate only on a limited number of fixed specified frequencies, the process in steps 5, 6 and 7 shall be applied to one of these frequencies; should the final step result in an incompatibility, the adjustment process (step 10) shall try another of these frequencies. The plan shall contain that frequency among this limited number of frequencies which has the least degree of incompatibility.

b) If two such broadcasting requirements indicate the same frequency which, after analysis, results in an incompatibility, the case is referred to the administration(s) concerned.

4.2.3.4.3.2 Frequency band

a) When an administration indicates that its facilities can operate only in a given frequency band, only frequencies from that band shall be included in the plan.

b) When an administration indicates a preferred frequency band, the system shall attempt to select a frequency from this band. If this is impossible, frequencies from the nearest appropriate band shall be tried. Otherwise the system will select frequencies from the appropriate band, taking into account the equipment constraints referred to in paragraph 4.2.3.4.3.1.

4.2.3.4.3.3 Power

a) When an administration indicates only a single power value due to equipment constraints, it shall be used in the planning process.

b) When an administration indicates several possible power values, the appropriate value shall be used to achieve the basic circuit reliability.

4.2.3.4.3.4 Antenna

When an administration indicates that its antenna can operate only in a given frequency band, only frequencies from that band shall be included in the plan.

4.2.3.4.4 Limitation of frequency change

For the time block indicated for each broadcasting requirement, frequency changes should be essentially limited to those due to propagation factors. Frequency changes due to incompatibilities may also be permitted. In these cases, the number of frequency changes during any contiguous periods of operation shall be limited to the minimum necessary.

4.2.3.4.5 Rules for dealing with incompatible requirements

1. If the processing system cannot satisfy all requirements in a certain band, for a certain CIRAF zone or part of a CIRAF zone in a specific period of time, even after all possibilities of adjustments are exhausted, it shall identify administrations whose requirements cannot be completely satisfied with the agreed overall broadcasting reliability adopted by the Conference.

2. The IFRB will suggest changes which will be useful for the administrations concerned and which would reduce congestion (see paragraph 4.1.1).

3. In so doing, it shall take account of the principle expressed in paragraph 4.1.2.2 and in particular of the way in which administrations' requirements for longer transmission periods, mainly for national broadcasting purposes[1], can best be accommodated.

4. Administrations which fail to reply within a period to be determined by the second session or which refuse any modification shall be deemed to accept any reduction in overall broadcasting reliability that may result from the planning process.

5. The system shall satisfy a minimum number (n)[2] of broadcasting requirements of each administration with the overall broadcasting reliability adopted by the Conference.

6. The system shall satisfy all remaining requirements by means of the following approach, without adversely affecting the requirements already satisfied.

6.1 As many as possible of the remaining requirements shall be satisfied with the overall broadcasting reliability of X[3] to be determined.

6.2 The system shall then include in the plan any requirement still remaining with a lower overall broadcasting reliability, as close to X as possible, without adversely affecting the requirements already satisfied.

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1 An HF broadcasting use is considered as being for purposes of national coverage when the transmitting station and its associated required service area are both located within the territory of the same country. (There is a need for this note to appear in the Final Acts of the Conference.)

2 Expressed in terms of number of transmissions in the congested hour. If this fails to accommodate at least one requirement of each concerned administration, n may be expressed in number of frequency hours within a block of three hours centred on the congested hour. The tests shall include a range of values of n to enable a decision on this matter to be taken at the second session.

3 Various values of X are to be tested during the intersessional period and reported to the second session.

7. Administrations unable to agree to the reduced quality of broadcasting may propose improvements or request alternative frequencies in another band or in another time block; their requests must, where possible, be satisfied without adversely affecting the requirements already satisfied in the plan.

8. The system shall take into account the interaction between broadcasting requirements using the same frequency band in different zones.

9. The IFRB will test the above rules and report the results to administrations, for consideration and adoption of the rules at the second session subject to such modifications as may be necessary.

4.2.3.5 Step 5 - Selection of technical characteristics

The system shall be designed in such a way that, in cases where administrations communicate the power and characteristics which may vary in given ranges, the values to be used for these characteristics may be selected within the indicated ranges.

4.2.3.6 Step 6 - Compatibility analysis and frequency selection

The system shall be designed to apply the principles and rules contained in this report, including the technical criteria developed by the Conference.

4.2.3.7 Step 7 - Reliability analysis

The method described in section 3.2.4 shall be used to calculate the overall broadcast reliability.

4.2.3.8 Step 8 - Criteria and requirements met

The broadcasting requirements for the season under consideration will be analyzed to ascertain whether they have been met in conformity with the agreed criteria.

4.2.3.9 Step 9 - Seasonal plan

The timing of publication and the means of securing administrations' comments on seasonal plans will be considered by the second session of the Conference.

4.2.3.10 Step 10 - Adjustment process

The application of steps 3 to 8 indicates adjustments to be applied. These adjustments will be implemented in several loops which will be derived within the software process.

4.2.3.11 Step 11 - Additional procedures

In considering the planning method, the first session concluded that there may be a need for additional procedures to deal with :

a) modifications to the seasonal plan after it has been published;

b) the inclusion of additional requirements in the seasonal plan after it has been published;

c) the situation where, for some reason, certain administrations may be unable to accept the frequency assignments included in the seasonal plan.

The first session is of the view that this is a matter for consideration by the second session.

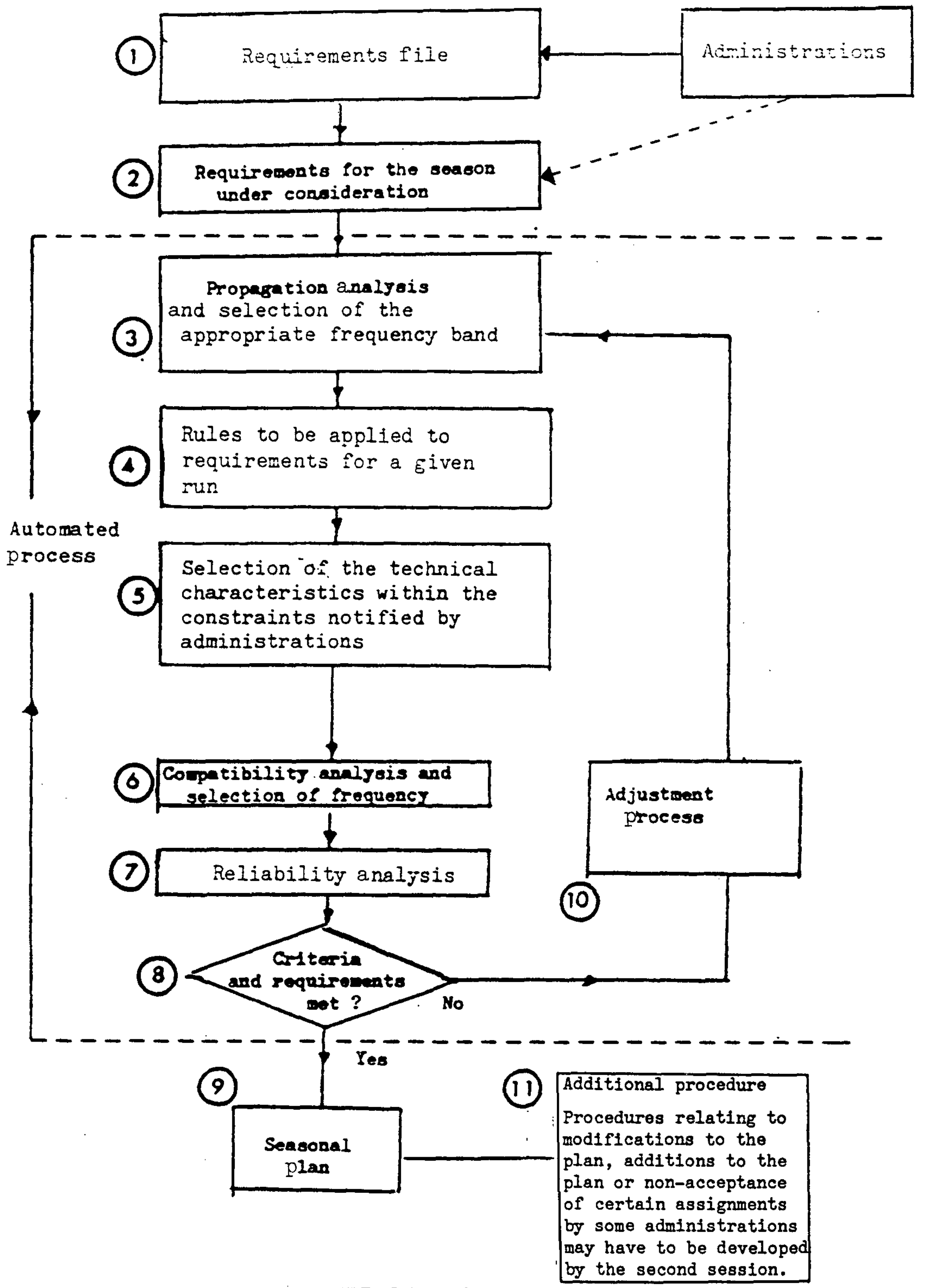


FIGURE 4-1

Flowchart of the automated process

4.2.4 Broadcast reliability for planning purposes

For the purposes of intersessional work, the IFRB will use two reference values for the overall broadcast reliability, namely 80% and 90%[1]. Lower values may be used if appropriate.

For the purposes of intersessional work, the IFRB will use two values of percentile of test points within the required service area when considering broadcast reliabilities (both basic and overall). These values shall be 80% and 90%[1].

4.2.5 Actions relating to harmful interference

In the event of harmful interference to an HF broadcasting service which is using an assignment in accordance with a current seasonal plan, the administration concerned shall have the right to request the prompt assistance of the IFRB in finding another frequency to help restore that service to the level of reliability achieved in the plan. Any new frequency proposed by the IFRB shall not adversely affect the seasonal plan in operation. The central automated system must be able to respond, as far as possible, to such requests from administrations. The cause of a situation of harmful interference shall find its definitive solution in accordance with Article 22 of the Radio Regulations. The original frequency shall be made available for future use once this problem has been solved.

1 These values may be reviewed and modified, if necessary, by the second session of the Conference, on the basis of the results obtained by the IFRB during the intersessional period.

Annex : 1

A N N E X

RESOLUTIONS

RECOMMENDATIONS

RESOLUTION PLEN./1

Relating to the Report of the First Session

The World Administrative Radio Conference for the Planning of the HF Bands Allocated to the Broadcasting Service (First Session, Geneva, 1984),

considering

the mandate entrusted to it by Resolution 874 of the Administrative Council and its agenda contained in "resolves", paragraph 4 thereof;

resolves

to approve the Report of the First Session of the Conference;

instructs

1. the Chairman of the First Session of the Conference to transmit under his signature the Report of the First Session to the Second Session of the Conference;

2. the Secretary-General to transmit the Report of the First Session to the Administrations of all Members of the Union and to the organizations which have participated in the First Session of the Conference.

RESOLUTION PLEN./2

Relating to the unauthorized use of frequencies in the HF bands allocated to services other than broadcasting

The World Administrative Radio Conference for the Planning of the HF Bands Allocated to the Broadcasting Service (First Session, Geneva, 1984),

considering

a) that Resolution 508 of the World Administrative Radio Conference, Geneva, 1979, invited the Administrative Council to take the necessary steps to convene a world administrative radio conference, to be held in two sessions, with a view to planning the HF bands allocated to the broadcasting service;

b) that Resolution 8 of that Conference envisaged the allocation of new frequency bands to the broadcasting service, subject to compliance with the procedures for the transfer of existing assignments outside those bands;

noting

a) that in planning the HF bands allocated to the broadcasting service, account should be taken of a considerable increase in the portions of the spectrum allocated to that service;

b) that in Resolution 309 the World Administrative Radio Conference, Geneva, 1979, urged administrations to ensure that stations of services other than the maritime mobile service abstain from using HF frequencies in distress and safety channels and their guardbands and in the bands allocated exclusively to the maritime mobile service;

c) that in Resolution 407 that Conference urged administrations to ensure that stations of services other than the aeronautical mobile (R) service refrain, except under specified conditions, from using frequencies in the bands allocated to this service, which is a safety service;

resolves to urge administrations

1. to comply with the provisions laid down in Resolutions 309 and 407 of the World Administrative Radio Conference, Geneva, 1979;

2. to ensure that stations of services defined in the Radio Regulations refrain from using frequency bands which have not been allocated to them except under conditions specified in the Radio Regulations and to ensure that such emissions cease as soon as harmful interference is produced;

3. to participate in the monitoring programmes which the IFRB will organize pursuant to the above-mentioned Resolutions 309 and 407 and the present Resolution;

to instruct the IFRB

1. to take the necessary steps with a view to the removal by administrations of emissions from stations of the broadcasting service operating in HF bands which have not been allocated to that service, as soon as harmful interference is produced;

2. to collect all available information on out-of-band emissions with a view to its publication by the Secretary-General;

3. to inform the Administrative Council annually of the results achieved in the application of this Resolution;

to request the Administrative Council

to study the matter in the light of the reports prepared by the IFRB and, if necessary, to place it on the agenda of an appropriate world administrative conference.

RESOLUTION COM5/1

Relating to the improvement in the use of the HF Bands Allocated to the Broadcasting Service by Avoiding Harmful Interference

The World Administrative Radio Conference for the Planning of the HF Bands Allocated to the Broadcasting Service (First Session, Geneva, 1984),

considering

a) Article 4 (No. 19) of the International Telecommunication Convention concerning the purposes of the Union;

b) Article 10 (Nos. 79 and 80) of the International Telecommunication Convention concerning the duties of the IFRB;

c) Article 35 (No. 158) of the International Telecommunication Convention concerning harmful interference;

d) Article 54 (No. 209) of the International Telecommunication Convention concerning the instructions which may be given to the IFRB by a world administrative radio conference;

e) Article 20 of the Radio Regulations concerning the international monitoring system;

f) Article 18 (No. 1798) of the Radio Regulations concerning measures against interference;

g) Article 22 of the Radio Regulations concerning the procedure in cases of harmful interference;

noting

a) that harmful interference has a negative impact on the use of the frequency spectrum in general and on the use of frequency channels available for high frequency broadcasting in particular;

b) that broadcasting on channels adjacent to those being affected directly may also be subject to interference;

c) that a considerable number of high frequency broadcasting channels in various parts of the world are rendered useless by harmful interference;

<u>recognizing</u>

a) that it is desirable for more detailed information on the extent and impact of harmful interference to be available before the second session of the Conference;

b) that an increase in the number of stations participating in the international monitoring system and a more effective use of the information obtained from such stations would be of considerable assistance;

<u>urges administrations</u>

to avoid harmful interference;

<u>instructs the IFRB</u>

in accordance with the Radio Regulations,

1. to organize monitoring programmes in the bands allocated to the high frequency broadcasting service with a view to identifying stations causing harmful interference;

2. to seek, as appropriate, the cooperation of administrations in identifying the sources of emissions which cause harmful interference and to provide this information to administrations;

3. to inform the second session of the Conference of the results of the activities referred to in 1 and 2 above;

<u>invites administrations</u>

1. to take part in monitoring programmes set up by the IFRB in accordance with the provisions of this Resolution;

2. to apply the provisions of Article 22 of the Radio Regulations in case of harmful interference.

RESOLUTION COM5/2

Relating to the Design, Development and Implementation of Computer Programs and Test Procedures for the Preparation of the Application of the Planning Method

The World Administrative Radio Conference for the Planning of the HF Bands Allocated to the Broadcasting Service (First Session, Geneva 1984),

considering

a) that Resolution 874 of the Administrative Council includes in the agenda of the First Session of the Conference the identification and adoption of specific guidelines for the preparatory tasks to be carried out before the commencement of the Second Session of the Conference;

b) the report to the Second Session of the Conference;

c) the proposed tentative agenda of the Second Session of the Conference;

d) the planning method established by the First Session and the need to develop and test the related computer programs;

requests the IFRB

1. to design, develop and implement computer programs for the application of the planning method and the technical criteria established by the First Session;

2. to test the planning method using the technical criteria established by the first session using the requirement file referred to in Resolution COM5/3;

3. to prepare progress reports on the intersessional work and send them periodically to all administrations at least around the dates indicated in the Annex to this Resolution. These reports shall include all the measures adopted by the IFRB concerning the application of the results of the First Session;

4. to invite administrations to send their comments on the reports to the IFRB, to be taken into account in the future work as appropriate;

5. to prepare a detailed final report to be sent to all administrations at least six months prior to the beginning of the Second Session;

6. to observe the timetable in the Annex to this Resolution for the organization and completion of the work to be carried out;

7. to invite the administrations which have prepared computer programs applicable to the planning method established by the First Session to communicate these programs to the IFRB for study and, if necessary, to second computer specialists to the IFRB for short periods in order to adapt the programs to the ITU computer;

8. to invite administrations to comment on the possibility for them to nominate experts whose services could be made available to the IFRB and indicate relevant details of their area(s) of expertise, together with an indication of the extent to which administrations could support the expert's travel expenses and subsistance allowance;

9. to prepare as soon as possible a report to the 39th session of the Administrative Council;

resolves

1. to invite administrations to provide assistance to the IFRB by making available to it experts in HF broadcasting planning and/or system analysis;

2. that these experts shall assist the IFRB under its full responsibility to carry out the tasks contained in "requests the IFRB" 1 and 2;

requests the Administrative Council

1. to consider the report prepared by the IFRB in accordance with "requests the IFRB" 9 and to decide in the light of this report either :

- to establish a panel of experts and decide on the dates, durations of its meetings as well as on any other administrative and financial questions;

  or

- to invite administrations to make experts available to the IFRB,

  or

- to find other means of assisting the IFRB during the intersessional period;

2. to ensure a balanced geographical distribution among the five regions (the Americas, Western Europe, Eastern Europe/Northern Asia, Africa and Asia/Australia) and a balanced expertise in system analysis and aspects of HF broadcasting planning;

3. to consider providing the necessary resources :

a) to enable the IFRB to carry out the indispensable tasks mentioned above;

b) for the experts' subsistance allowance and travel expenses, if required;

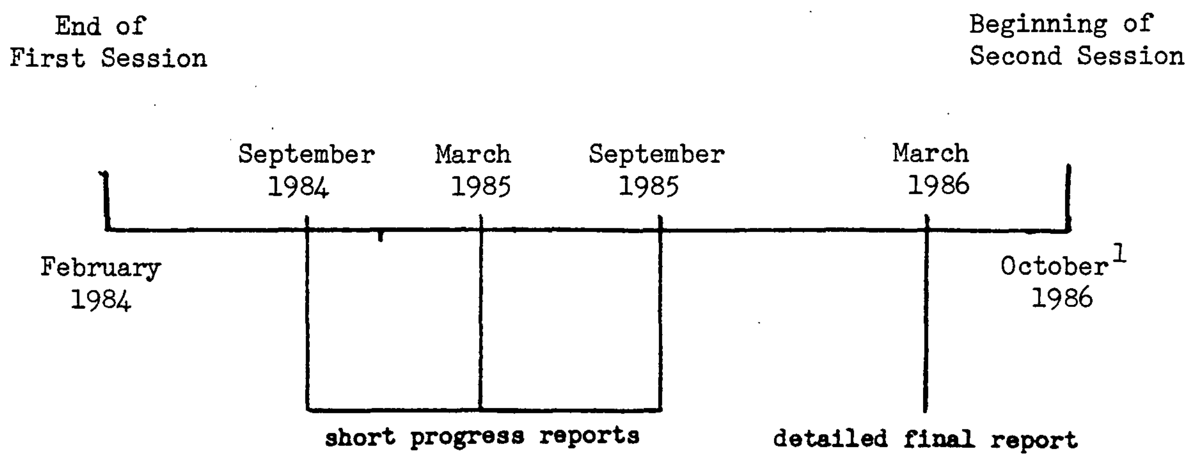
invites the Secretary-General

to communicate this Resolution to all administrations.

Appendix

to Resolution COM5/2

Timetable to be observed during the intersessional period



[1] The Administrative Council will determine the date of the Second Session.

RESOLUTION COM5/3

Relating to the Establishment of a Requirement file

The World Administrative Radio Conference for the Planning of the HF Bands Allocated to the Broadcasting Service (First Session, Geneva, 1984),

considering

a) that under Resolution 874 of the Administrative Council, one of the items on the agenda of the First Session of the Conference is to specify the form in which requirements for use in planning should be submitted to the Union;

b) the report of the First Session of the Conference;

c) the proposed tentative agenda of the Second Session of the Conference;

resolves

1. to invite the IFRB to devise the form for submitting to the Union requirements for use in planning and to draw up the instructions for completing the form, taking into account the structure of the Frequency Management System at present under development in the ITU;

2. that the form shall contain :

- the characteristics listed in paragraph 4.2.3.1 (page 71) of this Report; and

- any additional information that may be required for the intersessional work;

3. that the form and the instructions for completing the form shall be sent to administrations by 1 September 1984;

4. that administrations, using the above form, shall submit to the IFRB by 1 August 1985 their broadcasting requirements which are expected to be operational before 1 August 1988;

5. that the IFRB shall compile the requirements submitted by administrations in the form of a tentative requirement file and publish it as a Conference document for consideration by the second session;

6. that the IFRB will, however, use the requirements submitted by administrations in accordance with the provisions of Resolution COM5/2 .

RECOMMENDATION COM5/1

Relating to CCIR Activity Between the First and the Second Session of the Conference

The World Administrative Radio Conference for the Planning of the HF Bands Allocated to the Broadcasting Service (First Session, Geneva, 1984),

<u>considering</u>

a) that under Resolution 874 of the Administrative Council, one of the items on the agenda of the First Session of the Conference is to identify and to lay down specific guidelines for the preparatory tasks to be carried out before commencement of the second session of the Conference;

b) that the report of the First Session of the Conference refers to the need for further study of certain technical elements;

<u>requests the CCIR</u>

1. to provide data necessary to refine the numerical constants referred to in paragraphs 3.2.1.3.1.3 (page 12) and 3.2.1.3.2 (page 13), including the dependence on distance and geographical area, as well as to refine the interpolation procedure referred to in paragraph 3.2.1.3.3 (page 18) of the report of the First Session of the Conference, concerning the propagation prediction method adopted in that report;

2. to provide the relevant data regarding :

- the performance of multiband antennas in the set of representative type of antenna for planning purposes (paragraph 3.5.1.3, page 48 of the report of the First Session of the Conference);
- the performance of horizontally slewed antennas (paragraph 3.5.1.4, page 49 of the report of the First Session of the Conference);

3. to present to the Second Session the results of studies on the allowance needed for co-channel interference between DSB and SSB emissions using a coherent detector (paragraph 3.9.2.3, page 66 of the report of the First Session of the Conference);

4. to complete the above studies not later than the end of 1985 and distribute the results to administrations not later than six months before the beginning of the Second Session of the Conference;

5. to work by correspondence as far as possible;

<u>invites administrations</u>

to contribute relevant data to the CCIR studies.

RECOMMENDATION COM5/2

Relating to the Tentative Agenda for the Second Session of the Conference

The WARC for the Planning of the HF Bands Allocated to the Broadcasting Service (First Session, Geneva, 1984),

considering

a) Resolution 1 of the Plenipotentiary Conference, Nairobi, 1982, relating to future conferences of the Union;

b) Resolution 508 of the World Administrative Radio Conference, Geneva, 1979 (WARC-1979) relating to the convening of a World Administrative Radio Conference for the Planning of the HF Bands Allocated to the Broadcasting Service;

c) that Resolution 874 of the Administrative Council, Nairobi, 1982, includes in the agenda of the First Session of the Conference the proposal of a tentative agenda of the Second Session for consideration by the Administrative Council;

d) the report of the First Session of the Conference to the Second Session;

e) that the Second Session will need to consider the report from the IFRB on the work to be carried out during the intersessional period;

f) that the Second Session will need to consider the report from the CCIR;

recommends to the Administrative Council

1. the following tentative agenda for the Second Session :

On the basis of the report of the First Session and taking into account the reports on the intersessional work carried out by the IFRB (see Resolution COM5/2) and the CCIR (see Recommendation COM5/1) :

1.1 adopt the procedures for the preparation and implementation of seasonal plans for DSB operation based on the requirements submitted by administrations;

1.2 if possible, draw up a basic plan for the first season in accordance with 1.1;

1.3 adopt technical standards for future SSB operation and a schedule for the introduction;

1.4 review, and where necessary, revise the relevant provisions of the Radio Regulations relating to the HF bands allocated exclusively to the broadcasting service. Any revision of the Radio Regulations consequential to the decisions of the Conference shall in no way affect the other services to which the HF bands are allocated, in particular any revision of Article 8 shall be limited to the modifications of existing footnotes relating to bands exclusively allocated to the HF broadcasting service or the addition of such footnotes.

1.5 review, and where necessary, revise the relevant Resolutions and Recommendations of the Final Acts of WARC-1979; and

2. to provide for 7 weeks duration for the Second Session of the Conference.

LIST OF ITU MEMBER COUNTRIES WHICH PARTICIPATED IN THE FIRST SESSION

(in the alphabetical order of the French version of the country names)

AFGHANISTAN (Democratic Republic of)

ALBANIA (Socialist People's Republic of)

ALGERIA (People's Democratic Republic of)

GERMANY (Federal Republic of)

ANGOLA (People's Republic of)

SAUDI ARABIA (Kingdom of)

ARGENTINE REPUBLIC

AUSTRALIA

AUSTRIA

BANGLADESH (People's Republic of)

BELGIUM

BENIN (People's Republic of)

BYELORUSSIAN SOVIET SOCIALIST REPUBLIC

BOLIVIA (Republic of)

BOTSWANA (Republic of)

BRAZIL (Federative Republic of)

BULGARIA (People's Republic of)

BURUNDI (Republic of)

CAMEROON (Republic of)

CANADA

CENTRAL AFRICAN REPUBLIC

CHILE

CHINA (People's Republic of)

CYPRUS (Republic of)

VATICAN CITY STATE

COLOMBIA (Republic of)

COMOROS (Islamic Federal Republic of the)

CONGO (People's Republic of the)

KOREA (Republic of)

COSTA RICA

IVORY COAST (Republic of the)

CUBA

DENMARK

EGYPT (Arab Republic of)

EL SALVADOR (Republic of)

UNITED ARAB EMIRATES

ECUADOR

SPAIN

UNITED STATES OF AMERICA

ETHIOPIA

FINLAND

FRANCE

GABONESE REPUBLIC

GAMBIA (Republic of the)

GHANA

GREECE

GUATEMALA (Republic of)

GUYANA

HONDURAS (Republic of)

HUNGARIAN PEOPLE'S REPUBLIC

INDIA (Republic of)

INDONESIA (Republic of)

IRAN (Islamic Republic of)

IRAQ (Republic of)

IRELAND

ISRAEL (State of)

ITALY

JAMAICA

JAPAN

JORDAN (Hashemite Kingdom of)

KENYA (Republic of)

KUWAIT (State of)

LIBERIA (Republic of)

LIBYA (Socialist People's Libyan Arab Jamahiriya)

LUXEMBOURG

MADAGASCAR (Democratic Republic of)

MALAYSIA

MALAWI

MALI (Republic of)

MOROCCO (Kingdom of)

MAURITANIA (Islamic Republic of)

MEXICO

MONACO

NIGERIA (Federal Republic of)

NORWAY

NEW ZEALAND

OMAN (Sultanate of)

PAKISTAN (Islamic Republic of)

PAPUA NEW GUINEA

PARAGUAY (Republic of)

NETHERLANDS (Kingdom of the)

PERU

PHILIPPINES (Republic of the)

POLAND (People's Republic of)

PORTUGAL

QATAR (State of)

SYRIAN ARAB REPUBLIC

GERMAN DEMOCRATIC REPUBLIC

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

UKRAINIAN SOVIET SOCIALIST REPUBLIC

ROMANIA (Socialist Republic of)

UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND

RWANDESE REPUBLIC

SENEGAL (Republic of)

SINGAPORE (Republic of)

SOMALI DEMOCRATIC REPUBLIC

SRI LANKA (Democratic Socialist Republic of)

SWEDEN

SWITZERLAND (Confederation of)

SURINAME (Republic of)

SWAZILAND (Kingdom of)

TANZANIA (United Republic of)

CZECHOSLOVAK SOCIALIST REPUBLIC

THAILAND

TUNISIA

TURKEY

UNION OF SOVIET SOCIALIST REPUBLICS

VENEZUELA (Republic of)

VIET NAM (Socialist Republic of)

YEMEN ARAB REPUBLIC

YEMEN (People's Democratic Republic of)

YUGOSLAVIA (Socialist Federal Republic of)

ZAIRE (Republic of)

ZAMBIA (Republic of)

ZIMBABWE (Republic of)