INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

C.C.I.R.

DOCUMENTS OF THE

Xth PLENARY ASSEMBLY

GENEVA, 1963

VOLUME II

PROPAGATION

GENEVE
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Recommendations of Sub-section G.1 — Propagation over the surface of the earth and through the non-ionized regions of the atmosphere

Reports of Sub-section G.1 — Propagation over the surface of the earth and through the non-ionized regions of the atmosphere

Questions and Study Programmes allocated to Study Group V (Propagation over the surface of the earth and through the non-ionized regions of the atmosphere); Opinions and Resolutions of interest to this Study Group

List of documents of the Xth Plenary Assembly concerning Study Group V

Recommendations of Sub-section G.2 — Ionospheric propagation

Reports of Sub-section G.2 — Ionospheric propagation

Questions and Study Programmes allocated to Study Group VI (Ionospheric propagation); Opinions and Resolutions of interest to this Study Group

List of documents of the Xth Plenary Assembly concerning Study Group VI

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* This list includes only those Study Programmes which do not derive from Questions. A Study Programme derived from a Question carries the same serial number as this Questions followed by a letter (e.g., S.P. 102A (XII)). It is inserted in the book immediately after the Question from which it is derived.

ARRANGEMENT OF VOLUMES I TO VII OF THE DOCUMENTS OF THE Xth PLENARY ASSEMBLY OF THE C.C.I.R.

(Geneva, 1963)

Volume I	Emission. Reception. Vocabulary (Sections A, B, K and Study Groups I, II and XIV)
Volume II	Propagation (Section G and Study Groups V and VI)
Volume III	Fixed and mobile services. Standard frequencies and time signals. International monitoring (Sections C, D, H and J and Study Groups III, XIII, VII and VIII)
Volume IV	Radio-relay systems. Space systems and radioastronomy (Sections F and L and Study Groups IX and IV)
Volume V	Broadcasting, sound and television (Section E and Study Groups X, XI, XII and the C.M.T.T.)
Volume VI	Opinions and Resolutions of a general nature Reports to the Plenary Assembly List of participants List of documents in numerical order
Volume VII	Minutes of the Plenary Meetings.

Note 1. — To facilitate references, the pagination in the English and French texts is the same.

Note 2. — At the beginning of Volume VI will be found information concerning the Xth Plenary Assembly of the C.C.I.R. and the participation at this meeting, on the presentation of texts (Definitions, origins, numbering, complete lists, etc.) together with general information on the organization of the C.C.I.R.

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RECOMMENDATIONS OF SUB-SECTION G.2 (IONOSPHERIC PROPAGATION)

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RECOMMENDATIONS OF SUB-SECTION G.1 — PROPAGATION OVER THE SURFACE OF THE EARTH AND THROUGH THE NON-IONIZED REGIONS OF THE ATMOSPHERE

RECOMMENDATION 168 *

PRESENTATION OF ANTENNA RADIATION DATA

(Question 49)

The C.C.I.R., (London, 1953—Warsaw, 1956)

CONSIDERING

(a) that the aims pursued by the I.T.U. require a knowledge of the radiation in free space in all directions from the antennae used in international radiocommunication;

(b) that antenna radiation is well represented by diagrams showing the field strength or the power radiated in every direction of space;

(c) that, alternatively, the antenna radiation can be represented by the vectorial specific cymomotive force *F* in every direction in space (See Note);

UNANIMOUSLY RECOMMENDS

1. that, in diagrams of antenna radiation, contours representing the radiation in free space in all directions be labelled in terms of relative radiated power or field strength;
2. that an alternate method of presentation may also be employed consisting of diagrams of contours representing the radiation in all directions of space in terms of the vectorial specific cymomotive force *F*;
3. that the Director, C.C.I.R. should take account of the above considerations, when antenna diagrams are being drawn.

Note. — The specific cymomotive force, *F*, is a vector expressed in volts, defined as the product *E.d*, where *E* is the vectorial free-space field radiated by the antenna in a particular direction at a distance *d* from the centre of radiation of the antenna when the total radiated power is 1 kW.

Where the antenna dimensions are not negligible in relation to the wave-length, or to the distance at which the measurements are made, the limit of the product *E.d* as *d* approaches infinity, is regarded as the c.m.f. To measure the c.m.f. in these instances, the field measured at a finite distance must be modified by an appropriate correction factor **.

The radiated power *W* and the cymomotive force *F* are related by the equation $F^2 = 377\,W$, where *F* is expressed in volts and *W* is expressed in watts per unit solid angle in the direction considered.

When the polarization of the electric field is elliptical, the c.m.f. may be shown as the magnitude and direction of the two main axes of the ellipse of polarization.

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* This Recommendation replaces Recommendation 108.

** See e.g. " Carlo Micheletta . Sulla determinazione della forza cimomotrice di emittitori con antenne a paraboloide " — Piccole Note-Recensioni e Notizie — I.S.P.T. 1, 1956, p. 13.

RECOMMENDATION 310 *

DEFINITIONS OF TERMS RELATING TO PROPAGATION IN THE TROPOSPHERE

The C.C.I.R., (Geneva, 1951 — Los Angeles, 1959)

CONSIDERING

that it is well known that the propagation of waves of frequencies greater than 30 Mc/s is greatly influenced by meteorological conditions in the troposphere;

UNANIMOUSLY RECOMMENDS

that the list of definitions annexed hereto be adopted for incorporation in the vocabulary;

VOCABULARY OF TERMS USED IN RADIO PROPAGATION THROUGH THE TROPOSPHERE

	Term	Definition
1.	*Troposphere*	The lower part of the earth's atmosphere extending upwards from the earth's surface, in which temperature decreases with height except in local layers of temperature inversion.
2.	*Tropopause*	The upper boundary of the troposphere, above which the temperature increases slightly with respect to height, or remains constant.
3.	*Temperature inversion*	In the troposphere: an increase in temperature with height.
4.	*Modified refractive index*	For a given height above sea level: the sum of the refractive index of the air at this height and the ratio of this height to the radius of the earth.
5.	*Refractive modulus*	One million times the amount by which the modified refractive index exceeds unity.
6.	*M-unit*	A unit in terms of which refractive modulus is expressed in accordance with the preceding definition.
7.	*M-curve*	A curve showing the relationship between refractive modulus and height above the earth's surface.
8.	*Standard refractive modulus gradient*	That uniform variation of refractive modulus with height above the earth's surface which is regarded as a standard for comparison. The gradient considered as normal has a value of 0·12 M-units per metre (3·6 M-units per hundred feet).
9.	*Standard radio atmosphere*	For tropospheric propagation: an atmosphere having the standard refractive modulus gradient.
10.	*Basic reference atmosphere*	An atmosphere defined by the relationship: $n(h) = 1 + \{289 \times 10^{-6} \exp(-0{\cdot}136h)\}$ where h is the height above sea-level in km. *Note.* — The refractive index in the first kilometre of the basic reference atmosphere is very nearly equal to that in an atmosphere corresponding to an earth of effective radius of 4/3 the real radius.

* This Recommendation replaces Recommendation 54.

	Term	Definition
11.	*Standard refraction*	The refraction which would occur in a standard radio atmosphere (see Fig. 1).
12.	*Super-refraction*	Refraction greater than standard refraction (see Fig. 1).
13.	*Sub-refraction*	Refraction less than standard refraction (see Fig. 1).
14.	*Standard propagation*	The propagation of radio waves over a smooth spherical earth of uniform electrical characteristics under conditions of standard refraction in the atmosphere.
15.	*Tangential wave path*	In radio-wave propagation over the earth: a path of propagation of direct wave, which is tangential to the surface of the earth. The tangential wave path is curved by atmospheric refraction.
16.	*Radio horizon*	The locus of points at which direct rays from the transmitter become tangential to the earth's surface.
17.	*Effective radius of the earth*	The radius of a hypothetical earth for which the distance to the radio horizon, assuming rectilinear propagation, is the same as that for the actual earth with an assumed uniform vertical gradient of refractive index. (For the standard atmosphere, the effective radius is 4/3 that of the real earth.)
18.	*Tropospheric-radio duct*	A stratum of the troposphere within which an abnormally large proportion of any radiation of sufficiently high frequency is confined and over part or all of which there exists a negative gradient of refractive modulus. The upper bounding surface is determined by a local minimum value of the refractive modulus. The lower bounding surface is either the surface of the earth or a surface parallel to the local stratification of refractive properties at which the refractive modulus has the same values as that at the local minimum value of the refractive modulus (see Fig. 2, 3 and 4).
19.	*Surface duct* *Ground-based duct*	A tropospheric-radio duct having the earth as its lower boundary and in which the modified refractive index is everywhere greater than the value at the upper boundary (see Fig. 2 and 3).
20.	*Elevated duct*	A tropospheric-radio duct of which the lower boundary is an elevated surface at which the modified refractive index has the same value as at the upper boundary (see Fig. 4).
21.	*Duct thickness* *Duct width*	The difference in height between the upper and lower boundaries of a tropospheric-radio duct.
22.	*Duct height*	The height above the surface of the earth of the lower boundary of an elevated duct (see Fig. 4).
23.	*Tropospheric mode*	Any one of the possible modes of propagation in the troposphere.
24.	*Trapped mode*	A mode of propagation in which the energy is substantially confined within a tropospheric-radio duct.
25.	*Mixing ratio*	The ratio of the mass (in grammes) of water vapour in a given volume of the atmosphere to the mass (in kilogrammes) of the dry air in the same volume.

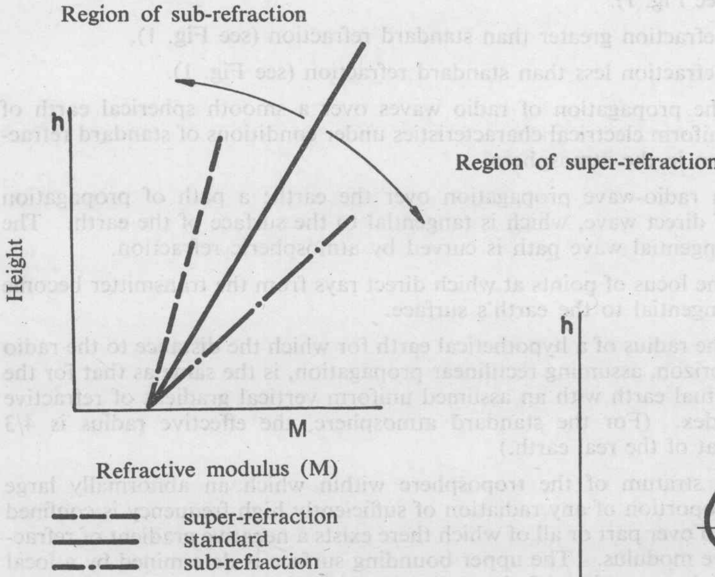

FIGURE 1

M-curves

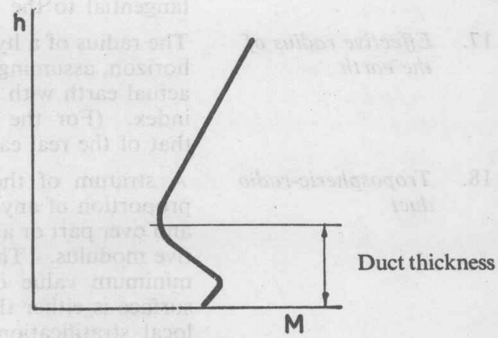

FIGURE 2

Surface duct

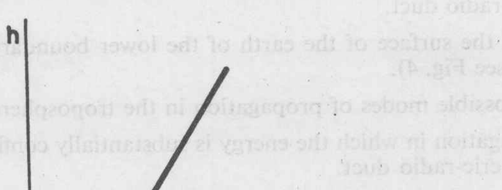

FIGURE 3

Surface duct

FIGURE 4

Elevated duct

RECOMMENDATION 311 *

PRESENTATION OF DATA IN STUDIES OF TROPOSPHERIC-WAVE PROPAGATION

The C.C.I.R., (London, 1953 — Warsaw, 1956 — Los Angeles, 1959)

CONSIDERING

(a) that there is an urgent need for guidance to be given to engineers in the planning of broadcasting television and fixed link services in the frequency band 30-4000 Mc/s;

(b) that it is important to determine how the field strengh in this frequency band depends on meteorological conditions and upon the nature of the terrain at locations both within and beyond the horizon;

(c) that to facilitate the comparison of results, it is desirable that Administrations and operating agencies should present field-strength data in a uniform manner;

(d) that it is not yet possible to establish a final method of presenting results and a system of statistical analysis best suited to the requirements expressed in § *(a)* and *(b)*;

UNANIMOUSLY RECOMMENDS

1. that the field strengths exceeded for 0 1%, 1%, 10%, 50%, 90%, 99% and 99·9% of the overall time should, whenever possible, be determined for all locations at which measurements are made;

2. that for broadcasting and television, the median values of field strength exceeded at 10%, 50% and 90% of the locations should be determined;

3. that it is desirable to amplify these overall statistics by a more detailed and precise analysis; for this purpose, the methods proposed in Annex I of the present Recommendation, or in Doc. 172 (France) of Warsaw, 1956, or in Doc. V/28 (France) of Geneva, 1958 might be taken as a basis;

4. that the statistical results of field-strength measurements should be displayed on probability paper. The field strength sould be plotted along the ordinate and expressed in db rel. 1μV/m, the values of field strength increasing, moving up the ordinate. The percentage of total valid recording time, or percentage of locations should be plotted along the abscissa, with a scale following the Gaussian probability law, percentages increasing from left to right. An example of a log-normal distribution plotted on probability paper is given in Annex II;

5. that all measured values of field strength should be normalized to correspond to those that would be obtained with a vertical half-wave dipole, or with a similar horizontal dipole placed broadside to the direction of the receiving point, the dipole in each case being at least several wavelengths above the ground and radiating 1 kW;

6. that, for broadcasting and television, and whenever possible, all measurements should be referred to a receiving antenna 10 m above the ground and this antenna should not be highly directional in the vertical plane.

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* This Recommendation replaces Recommendation 170.

ANNEX I

It should be noted that the recommendations given above refer particularly to the propagation of waves over long distances (especially in connection with interference problems in sound and television broadcasting) and also to propagation characteristics within the service areas of sound and television broadcasting stations. While the first interest lies in ascertaining those values of field strength exceeded for various percentages of the overall time at varying distances, for a more detailed analysis it might, however, be useful to analyze measurements within unit periods of 1 hour. This latter procedure would permit studies to be made of diurnal variations, while similarly seasonal variations could conveniently be studied by grouping the values obtained at specified hours of the day for a whole month and examining the change of field-strength distributions from month to month. Presentation of the results in this form would, moreover, permit later correlation of radio measurements with meteorological data.

For the study of propagation over fixed line-of-sight links in the VHF (metric), UHF (decimetric) or SHF (centimetric) bands, a more precise correlation between received field strength and prevailing atmospheric conditions might be required. For this and other reasons it is considered that results should be capable of being presented separately for each hour of the day of each month during which tests are being conducted. At the same time, overall distribution curves for periods of one month will be required to permit a study of seasonal variations; overall distribution curves for even longer periods will also, no doubt, be required by the planning engineer. It is generally convenient to refer results to the free space value for the distance and other conditions concerned.

Although it will usually be necessary to preserve, for reference, the original charts upon which the field-strength variations are recorded, it is essential that some much simpler and more conveniently accessible means of displaying the essential data be employed. One method is to plot the maximum, median and minimum field strengths for each hour on linear graph paper, the spread of results within the hour being shown by a vertical line. In addition, by determining the hourly median value or the value over some other percentage of the time, it is possible to obtain, for any given hour of the day, the statistical distribution of these values for a month (or any other desired period of time).

ANNEX II

The Gaussian probability scale is defined by

$$P(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty \exp\{-\xi^2/2\}\, d\xi$$

For abscissae $x = 0$, $x \to \infty$ and $x \to -\infty$, the corresponding values of the probability $P(x)$ are 50%, 0% and 100%.

An amplitude Gaussian distribution for a field strengh F measured in db (log-normal distribution) is given by:

$$P(F) = \frac{1}{\sigma\sqrt{2\pi}} \int_F^\infty \exp\left\{-(f-F_m)^2/2\sigma^2\right\} df$$

$P(F)$ is the probability (percentage of time or locations) that the field strength E expressed in db above 1 μV/m ($F = 20 \log E$) will exceed the level F. F_m is the median value of F, i.e. that which is exceeded for 50% of the time or locations. σ is the standard deviation, so that $P(F_m - \sigma) \approx 84\%$ and $P(F_m + \sigma) \approx 16\%$.

It is often of interest to know the field strength exceeded for 1% or 10% of the time; when the distribution is log-normal, the distribution curve is a straight line, and the corresponding deviations are given by 2·32 σ and 1·28 σ.