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# ITU-R

Radiocommunication Sector of ITU

**Recommendation ITU-R SM.1009-1**

**(10/1995)**

# Compatibility between the sound-broadcasting service in the band of about 87-108 MHz and the aeronautical services in the band 108-137 MHz

**SM Series**

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***Note**: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

*Electronic Publication*
Geneva, 2018

RECOMMENDATION ITU-R SM.1009-1*

# COMPATIBILITY BETWEEN THE SOUND-BROADCASTING SERVICE IN THE BAND OF ABOUT 87-108 MHz AND THE AERONAUTICAL SERVICES IN THE BAND 108-137 MHz

(1993-1995)

**Scope**

This Recommendation provides criteria, method and techniques for compatibility between the sound-broadcasting service in the band of about 87-108 MHz and the aeronautical services in the band 108-137 MHz.

**Keywords**
Compatibility, sound-broadcasting service, aeronautical service

The ITU Radiocommunication Assembly,

*considering*

a) that, in order to improve the efficiency of spectrum utilization, there is a need to refine the criteria used when assessing compatibility between the sound-broadcasting service in the band of about 87-108 MHz and the aeronautical services in the band 108-137 MHz;

b) that there is a need for a compatibility analysis method for identifying potential incompatibilities associated with a large broadcasting assignment plan;

c) that there is a need for a detailed, case-by-case compatibility analysis method to investigate potential incompatibility cases identified by a large scale analysis or for individual assessment of proposed broadcasting or aeronautical assignments;

d) that there is a need to continue the refinement of the compatibility criteria and assessment methods,

*recognizing*

that coordination has been effected since 1984 by other criteria and/or methods,

*recommends*

**1** that the criteria given in Annex 1 be used for compatibility calculations;

**2** that the method given in Annex 2 be used for predicting potential incompatibilities associated with a large broadcasting assignment plan;

**3** that the techniques in Annex 3 be used for detailed, case-by-case compatibility calculations concerning potential interference cases identified by the method given in Annex 2 or concerning individual assessment of proposed assignments to broadcasting or aeronautical stations;

**4** additionally, that results of practical verification of predicted compatibility situations as well as other relevant information may be used for coordination and to effect further refinement of the compatibility criteria, assessment method and techniques given in Annexes 1, 2 and 3 respectively.

*Note from the Director* – A list of selected documents that may be useful in studies of compatibility between the aeronautical radionavigation and radiocommunication services and the sound-broadcasting service is given below:

**1 ITU conference documents**

Regional Administrative Conference for FM Sound Broadcasting in the VHF Band (Region 1 and Certain Countries Concerned in Region 3). First Session (Geneva 1982): Report to the Second Session of the Conference (Geneva, 1982).

Final Acts of the Regional Administrative Conference for the Planning of VHF Sound Broadcasting (Region 1 and Part of Region 3) (Geneva, 1984).

**2 Ex-CCIR documents (Düsseldorf, 1990)**

Report 929-2 – Compatibility between the broadcasting service in the band of about 87-108 MHz and the aeronautical services in the band of 108-137 MHz.

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* Radiocommunication Study Group 1 made editorial amendments to this Recommendation in the years 2018 and 2019 in accordance with Resolution ITU-R 1.

Report 1198 – Compatibility between the broadcasting service in the band 87.5-108 MHz and aeronautical services in the band 108-137 MHz.

Report 927-2 – General considerations relative to harmful interference from the viewpoint of the aeronautical mobile services and the aeronautical radionavigation service.

NOTE 1 – Reports 929-2 and 1198 represent the culmination of work from:

– Interim Working Party 8/12 (Annapolis, 1983)

– Interim Working Party 10/8 (Paris, 1983)

– Joint Interim Working Party 8-10/1, First Meeting (Geneva, 1984)

– Joint Interim Working Party 8-10/1, Second Meeting (Rio de Janeiro, 1987)

– Joint Interim Working Party 8-10/1, Third Meeting (Helsinki, 1988)

and are contained in the following publication of the ex-CCIR (Düsseldorf, 1990):

– Compatibility between the broadcasting service in the band of about 87-108 MHz and aeronautical services in the band 108-137 MHz.

## 3 International Civil Aviation Organization (ICAO) documents

[ICAO, 1985] International standards, recommended practices and procedures for air navigation services: aeronautical telecommunications. Annex 10 to the Convention on International Civil Aviation, Vol. I. International Civil Aviation Organization, Montreal, Canada.

[ICAO, 1992] Handbook for evaluation of electromagnetic compatibility (EMC) between ILS and FM broadcasting stations using flight tests. International Civil Aviation Organization, Montreal, Canada.

## 4 Other documents

AUGSTMAN, E. and VOWLES, S. [1986] Frequency response characteristics of aircraft VOR/localizer antennas in the band 88-118 MHz. TP-7942E, Transport Canada, Ottawa, Ontario, Canada.

DONG, J.G. and SAWTELLE, E.M. [1977] Interference in communications and navigation avionics from commercial FM stations. FAA Report No. RD-78-35. Federal Aviation Administration, Washington, DC, USA.

[FAA, 1992] User's manual and technical reference for the airspace analysis mathematical model. Version 4.1. Federal Aviation Administration, Washington, DC, USA.

HARDING, S.J. [1989] Aeronautical receiver immunity to high level signals from FM broadcast transmitters. CAA Paper 89012. Civil Aviation Authority, London, UK.

HUNT, K., DOEVEN, J. and FINNIE, J. [September, 1993] LEGBAC: Church House to Malaga via Aviemore. *Telecomm. J.*, Vol. 60, No. IX.

[RTCA, 1981] FM broadcast interference related to airborne ILS, VOR and VHF communications. Document No. RTCA/DO-176. Radio Technical Commission for Aeronautics, Washington, DC, USA.

[RTCA, 1985] Minimum operational performance standards for airborne radio communications receiving equipment operating within the radio frequency range of 117.975-137.000 MHz. Document No. RTCA/DO-186. Radio Technical Commission for Aeronautics, Washington, DC, USA.

[RTCA, 1986a] Minimum operational performance standards for airborne ILS localizer receiving equipment operating within the radio frequency range of 108-112 MHz. Document No. RTCA/DO-195. Radio Technical Commission for Aeronautics, Washington, DC, USA.

[RTCA, 1986b] Minimum operational performance standards for airborne VOR receiving equipment operating within the frequency range of 108-117.95 MHz. Document No. RTCA/DO-196. Radio Technical Commission for Aeronautics, Washington, DC, USA.

ANNEX 1

# Interference mechanisms, system parameters and compatibility assessment criteria

CONTENTS



## 1 Background and introduction

Frequency modulation (FM) broadcasting service* interference to instrument landing system (ILS) localizer, VHF omnidirectional radio range (VOR) and VHF communications (COM) equipment** is a widely recognized problem among users of aviation facilities. In air/ground communication receivers, this interference problem ranges from distracting background audio to distorted and garbled reception of air traffic control signals. In airborne ILS localizer and VOR receivers, the interference problem ranges from distracting background audio to errors in course deviation and flag operation. The interference to these navigation receivers is thought to be the more serious problem, as an error in course deviation, especially during the critical approach and landing phase, is not as readily evident to the pilot as the disruption of communications.

Interference to aircraft receivers varies with the make and model of the navigation and communication receiver. There is an increasing probability of harmful interference due to the growing need for additional aeronautical and broadcasting frequency assignments.

This Annex describes:

– interference mechanisms;

– system parameters of the aeronautical radionavigation and radiocommunication systems affected;

– system parameters of the FM broadcasting stations;

– compatibility assessment criteria for Montreal receivers (see definitions in Annex 4);

– compatibility assessment criteria for ICAO, Annex 10, 1998 receivers derived from the measurement procedures of Recommendation ITU-R SM.1140.

## 2 Types of interference mechanisms

In general, from an ILS localizer and VOR receiver point of view, FM broadcasting transmission modulation can be regarded as noise. However, the frequencies 90 Hz and 150 Hz are specific, vulnerable frequencies for ILS localizer, and the frequencies 30 Hz and 9 960 Hz are specific, vulnerable frequencies for VOR because these frequencies provide critical guidance for the systems concerned and are therefore sensitive to interference.

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*Notes from the Director:*

* For a description of the characteristics of FM broadcasting stations, attention is drawn to Report ITU-R BS.1198.

** For a description of the ILS localizer, VOR and VHF communications systems, attention is drawn to Report ITU-R M.927.

## 2.1 Type A interference

### 2.1.1 Introduction

Type A interference is caused by unwanted emissions into the aeronautical band from one or more broadcasting transmitters.

### 2.1.2 Type A1 interference

A single transmitter may generate spurious emissions or several broadcasting transmitters may intermodulate to produce components in the aeronautical frequency bands; this is termed Type A1 interference.

### 2.1.3 Type A2 interference

A broadcasting signal may include non-negligible components in the aeronautical bands; this interference mechanism, which is termed Type A2 interference, will in practice arise only from broadcasting transmitters having frequencies near 108 MHz and will only interfere with ILS localizer/VOR services with frequencies near 108 MHz.

## 2.2 Type B interference

### 2.2.1 Introduction

Type B interference is that generated in an aeronautical receiver resulting from broadcasting transmissions on frequencies outside the aeronautical band.

### 2.2.2 Type B1 interference

Intermodulation may be generated in an aeronautical receiver as a result of the receiver being driven into non-linearity by broadcasting signals outside the aeronautical band; this is termed Type B1 interference. In order for this type of interference to occur, at least two broadcasting signals need to be present and they must have a frequency relationship which, in a non-linear process, can produce an intermodulation product within the wanted RF channel in use by the aeronautical receiver. One of the broadcasting signals must be of sufficient amplitude to drive the receiver into regions of non-linearity but interference may then be produced even though the other signal(s) may be of significantly lower amplitude.

Only third-order intermodulation products are considered; they take the form of:

$$f_{intermod} = 2 f_1 - f_2 \qquad \text{two-signal case or}$$

$$f_{intermod} = f_1 + f_2 - f_3 \qquad \text{three-signal case}$$

where:

$f_{intermod}$: intermodulation product frequency (MHz).

$f_1, f_2, f_3$: broadcasting frequencies (MHz) with $f_1 \geq f_2 > f_3$.

### 2.2.3 Type B2 interference

Desensitization may occur when the RF section of an aeronautical receiver is subjected to overload by one or more broadcasting transmissions; this is termed Type B2 interference.

# 3 Compatibility assessment parameters

## 3.1 Introduction

This section identifies the parameters of ILS localizer, VOR and COM aeronautical transmitters and receivers relevant for a compatibility assessment.

## 3.2 Characteristics of aeronautical systems

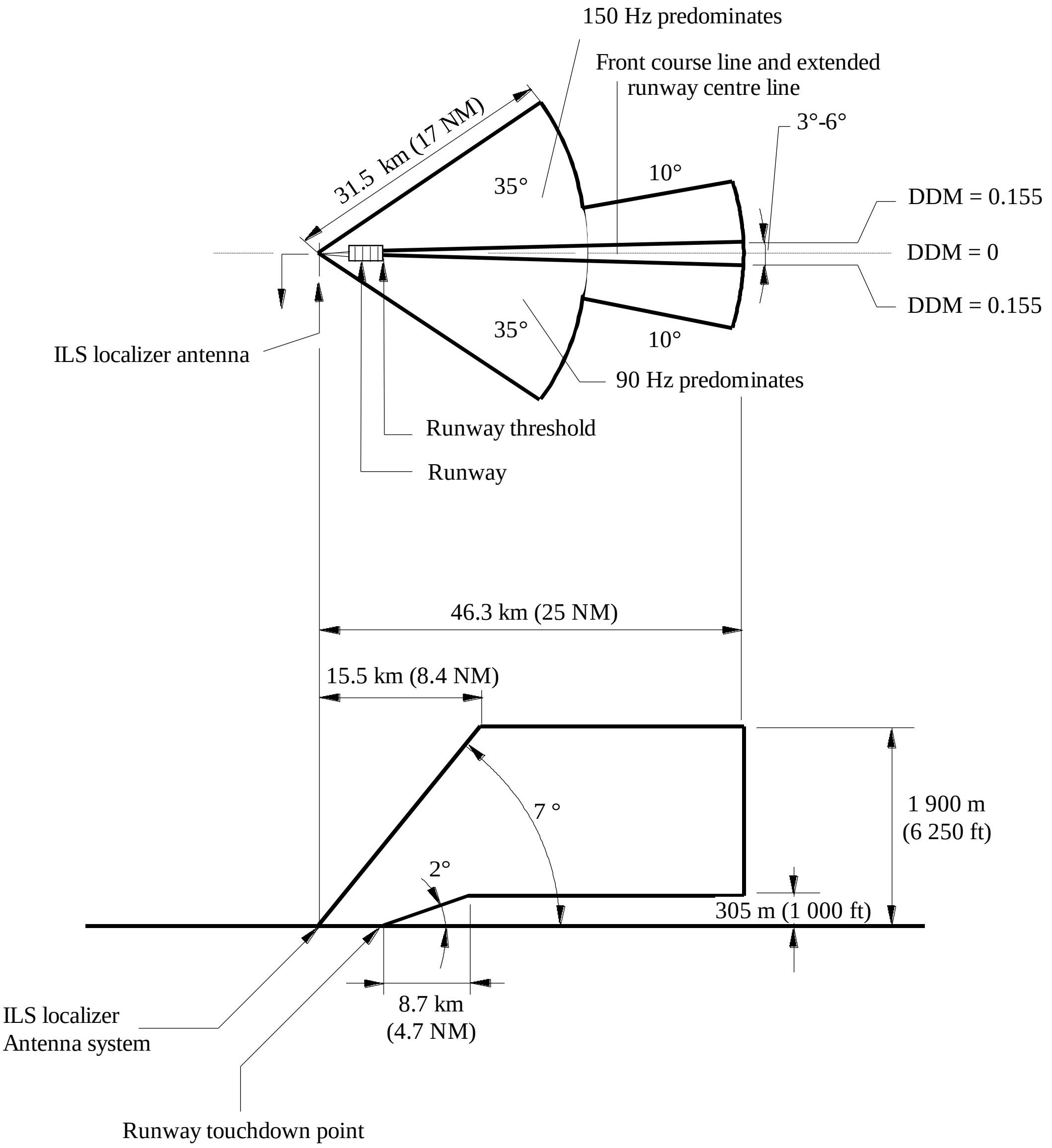
### 3.2.1 ILS localizer

#### 3.2.1.1 Designated operational coverage (see Note 1)

Figure 1 illustrates a typical designated operational coverage (DOC) for an ILS localizer front course based on ICAO Annex 10 (see Note 1). The DOC may also have back course coverage. Some administrations also use the ILS localizer as an auxiliary approach guidance system and the DOC may not be aligned with a runway.

NOTE 1 – See definitions in Annex 4.

FIGURE 1
**Typical ILS localizer front course DOC**




*Note 1* – All elevations shown are with respect to ILS localizer site elevation.
*Note 2* – Not drawn to scale.

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#### 3.2.1.2 Field strength

The minimum field strength to be protected throughout the ILS localizer front course DOC (see § 3.1.3.3 of Appendix 1) is 32 dB(μV/m) (40 μV/m). If service is provided in the ILS localizer back course coverage, the field strength to be protected is also 32 dB(μV/m). In certain areas of the ILS localizer DOC, ICAO Annex 10 (see Note 1) requires a higher field strength to be provided in order to increase the received signal-to-noise ratio, thereby increasing system integrity. This is the case within the ILS localizer front course sector (see Note 2) from a range of 18.5 km (10 NM) up to runway touchdown point (see Note 2) where signals of 39-46 dB(μV/m) are required depending upon the Facility Performance Category (I, II, III) of the ILS involved (see § 3.1.3.3 of Appendix 1).

NOTE 1 – The relevant part of ICAO Annex 10 is reproduced in Appendix 1.

NOTE 2 – See definitions in Annex 4.

#### 3.2.1.3 Frequencies

ILS localizer frequencies lie in the band 108-112 MHz. The 40 available channels occur as follows: 108.10, 108.15, 108.30, 108.35 MHz etc. to 111.70, 111.75, 111.90 and 111.95 MHz.

#### 3.2.1.4 Polarization

The ILS localizer signal is horizontally polarized.

### 3.2.2 VOR

#### 3.2.2.1 Designated operational coverage

The DOC of a VOR can vary from one installation to another; for example, a terminal VOR may have a 74 km (40 NM) radius, and an enroute VOR may have a 370 km (200 NM) radius. Details can be obtained from the appropriate national Aeronautical Information Publication (see definitions in Annex 4) (AIP).

#### 3.2.2.2 Field strength

The minimum field strength to be protected throughout the DOC (see § 3.3.4.2 of Appendix 1) is 39 dB(μV/m) (90 μV/m). The nominal values of the effective radiated power, e.r.p., to achieve this field strength are given in Fig. 2.

#### 3.2.2.3 Frequencies

In the band 108-112 MHz, VOR frequencies are located between ILS localizer frequencies and occur as follows: 108.05, 108.20, 108.25, 108.40, 108.45 MHz etc. to 111.60, 111.65, 111.80 and 111.85 MHz. VOR frequencies occupy channels spaced at 50 kHz intervals in the band 112-118 MHz and occur as follows: 112.00, 112.05 ... 117.95 MHz.

#### 3.2.2.4 Polarization

The VOR signal is horizontally polarized.

### 3.2.3 COM

#### 3.2.3.1 Designated operational coverage

The DOC of a COM facility can vary from one installation to another (from 9.3 km (5 NM) radius to 370 km (200 NM) radius). Details can be obtained from the Provider State (see definitions in Annex 4).

#### 3.2.3.2 Field strength

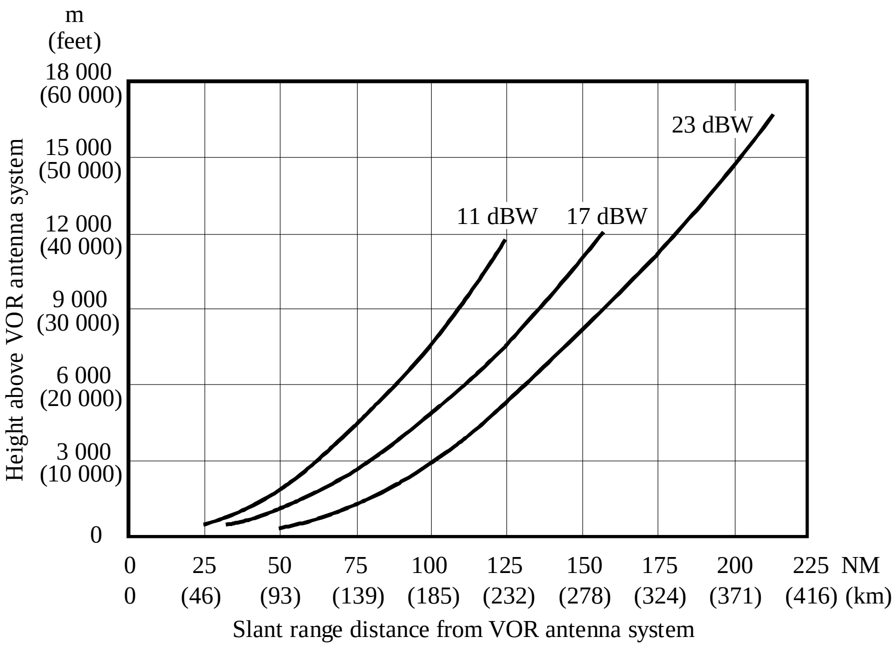
ICAO Annex 10 does not specify a minimum field strength provided by a ground-based COM transmitter, but in § 4.6.1.2 of Part I, it states that on a high percentage of occasions, the e.r.p. should be such as to provide a field strength of at least 38 dB(μV/m) (75 μV/m) within the DOC of the facility.

#### 3.2.3.3 Frequencies

COM frequencies occupy channels spaced at 25 kHz intervals in the band 118-137 MHz and occur as follows: 118 000, 118 025 ... 136 975 MHz.

FIGURE 2

**VOR coverage distance/height as a function of e.r.p.**




*Note 1* – Nominal VOR effective radiated power required to provide 39 dB(μV/m) field strength (–107 dB(W/m²) power density) at various slant ranges/heights with a typical antenna array located 4.9 m (16 ft) above ground. These curves are based on extensive experience of a number of facilities and indicate the nominal effective radiated power to assure the specified power density on a high percentage of occasions taking into account propagation and typical ground/aircraft installation characteristics.

*Source:* ICAO Annex 10, Attachment C to Part I, Fig. C-13.

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#### 3.2.3.4 Polarization

The COM signal is vertically polarized.

## 3.3 Characteristics of FM broadcasting stations

### 3.3.1 Maximum effective radiated power

The most accurate available value of maximum e.r.p. should be used for compatibility calculations.

### 3.3.2 Horizontal radiation pattern

The most accurate available information for horizontal radiation pattern (h.r.p.) should be used for compatibility calculations.

### 3.3.3 Vertical radiation pattern

The most accurate available information for vertical radiation pattern (v.r.p.) should be used for compatibility calculations.

### 3.3.4 Spurious emission suppression

In the North American experience, it has not generally been necessary to require the suppression of spurious emissions by more than 80 dB. Considering special circumstances within Region 1 and some areas of Region 3, the values given in Table 1, for spurious emission suppression in the aeronautical band 108-137 MHz, are recommended for the case of radiated intermodulation products from co-sited broadcasting transmitters.

TABLE 1

| Maximum e.r.p. (dBW) | Suppression relative to maximum e.r.p. (dB) |
|---|---|
| ≥ 48 | 85 |
| 30 | 76 |
| < 30 | 46 + maximum e.r.p. (dBW) |

NOTE 1 – Linear interpolation is used between maximum e.r.p. values of 30 and 48 dBW.

### 3.3.5 Frequencies

The bands of operation may be found in the Radio Regulations. In Region 1 and certain parts of Region 3, the band is 87.5-108 MHz, with channels every 100 kHz (87.6, 87.7 ... 107.9 MHz). In Region 2, the band is 88-108 MHz, with channels every 200 kHz (88.1, 88.3 ... 107.9 MHz).

### 3.3.6 Polarization

The polarization of an FM signal may be horizontal, vertical or mixed.

### 3.3.7 Free space field strength calculation for broadcasting signals

The free space field strength is to be determined according to the following formula:

$$E = 76.9 + P - 20 \log d + H + V \qquad (1)$$

where:

- $E$: field strength (dB(μV/m)) of the broadcasting signal
- $P$: maximum e.r.p. (dBW) of broadcasting station
- $d$: slant path distance (km) (see definition in Annex 4)
- $H$: h.r.p. correction (dB)
- $V$: v.r.p. correction (dB).

In the case of a broadcasting station with mixed polarization, the maximum e.r.p. to be used is the larger of the horizontal and vertical components. However, where both the horizontal and vertical components have equal values, the maximum e.r.p. to be used is obtained by adding 1 dB to the value of the horizontal component.

## 3.4 Receiver input power

Assuming an aircraft antenna radiation pattern with no directivity, the field strengths of the broadcasting signal and of the aeronautical signal are to be converted to power at the input to an aeronautical receiver according to the following formulas:

a) for a broadcasting signal in the band 87.5-108.0 MHz:

$$N = E - 118 - L_s - L(f) - L_a \qquad (2)$$

where:

- $N$: broadcasting signal level (dBm) at the input to the aeronautical receiver
- $E$: field strength (dB(μV/m)) of the broadcasting signal
- $L_s$: signal splitter loss of 3.5 dB
- $L(f)$: antenna system frequency-dependent loss at broadcasting frequency $f$ (MHz) of 1.2 dB per MHz below 108 MHz
- $L_a$: antenna system fixed loss of 9 dB.

b) for an aeronautical signal and a Type A1 signal in the band 108-118 MHz:

$$N_a = E_a - 118 - L_s - L_a \tag{3}$$

where:

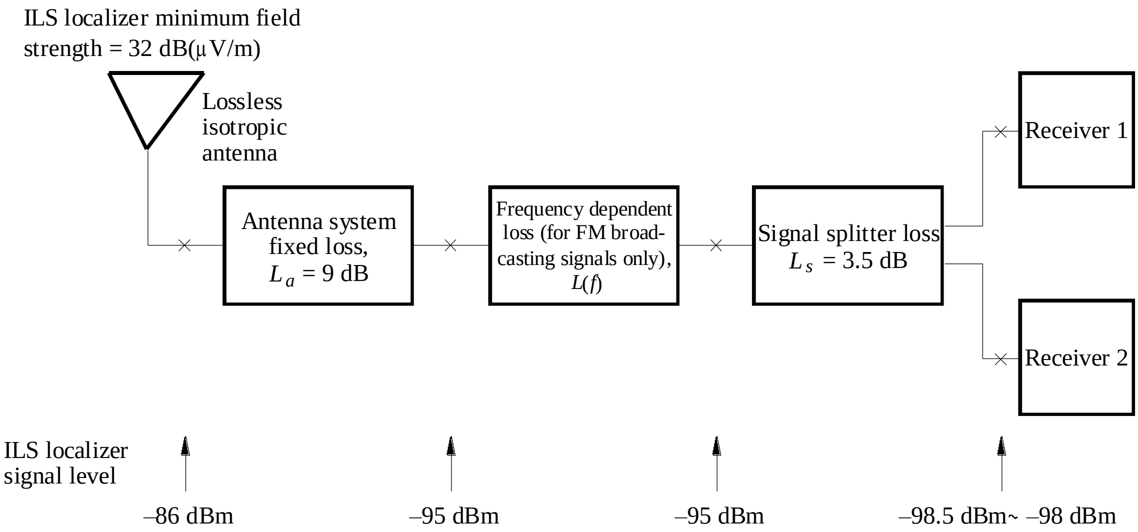
$N_a$ : signal level (dBm) at the input to the aeronautical receiver

$E_a$ : field strength (dB(μV/m)) of the aeronautical or Type A1 signal.

Figure 3 illustrates how the ILS localizer minimum field strength of 32 dB(μV/m) is converted to –98 dBm at the receiver input of a typical aircraft receiver installation using formula (3).

FIGURE 3

**Conversion of the ILS localizer minimum field strength to a signal level at the input to an aeronautical receiver**




*Note 1* – Typical aircraft installation includes a signal splitter to feed two aeronautical receivers.

*Note 2* – The frequency dependent loss *L*(*f*), is equal to 0 for aeronautical frequencies and therefore does not appear in formula (3).

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# 4 Compatibility assessment criteria

## 4.1 Standard interference thresholds

An interference threshold is the minimum power level of an interfering signal that causes an unacceptable degradation in receiver performance. In bench measurements and flight tests of ILS localizer and VOR receivers, it has been found that:

– the interference threshold based on a change in course deflection current (see definitions in Annex 4) is usually exceeded before the flag comes into view;

– a 1 to 3 dB increase in the interfering signal levels beyond the interference threshold levels will cause a gross change in course deflection current or cause the flag to appear.

Using simulated broadcasting signals, the interference thresholds in § 4.1.1 to 4.1.3 were used for the purpose of standardizing bench measurements for Type A and Type B interference and were chosen to be reasonable representations of typical operational situations.

#### 4.1.1 ILS localizer

The interference thresholds for a wanted signal with a difference in depth of modulation (see definitions in Annex 4) (DDM) of 0.093 are:

– a change in the course deflection current of 7.5 μA (see Note 1), or

– the appearance of the flag, whichever occurs first.

#### 4.1.2 VOR

The interference thresholds with a wanted signal present are:

– a change of the bearing indication by 0.5° which corresponds to 7.5 μA (see Note 1) course deflection current, or

– a change in the audio voltage level by 3 dB, or

– the appearance of the flag for more than 1 s.

NOTE 1 – For measurement of course deflection current, see § 4.2 of Annex 1 to Recommendation ITU-R IS.1140.

#### 4.1.3 COM

The interference thresholds for airborne COM receivers are as follows:

– with a wanted signal present, the interference threshold is a reduction to 6 dB in the (audio signal plus noise)-to-noise ratio $(S + N)/N$, or

– with no wanted signal present, the interference should not operate the squelch.

### 4.2 Interference assessment criteria – Montreal ILS localizer and VOR receivers (see definitions in Annex 4)

#### 4.2.1 Type A1 interference

Table 2 gives the values of the protection ratio to be used. Type A1 interference need not be considered for frequency differences greater than 200 kHz.

TABLE 2

| Frequency difference between wanted signal and spurious emission (kHz) | Protection ratio (dB) |
|---|---|
| 0 | 14 |
| 50 | 7 |
| 100 | –4 |
| 150 | –19 |
| 200 | –38 |

#### 4.2.2 Type A2 interference

Table 3 gives the values of the protection ratio to be used. Type A2 interference need not be considered for frequency differences greater than 300 kHz.

#### 4.2.3 Type B1 interference

##### 4.2.3.1 Compatibility assessment formulas

Taking account of tested ILS localizer and VOR receivers exhibiting poor immunity to Type B1 interference, the following formulas should be used to assess potential incompatibilities.

NOTE 1 – A potential incompatibility (see definitions in Annex 4) is identified when the relevant formula is satisfied.

a) *Two-signal case*: Montreal receiver

$$2\{N_1 - 28\log\{\max(1.0;\ f_A - f_1)\}\} + N_2 - 28\log\{\max(1.0;\ f_A - f_2)\} + K - L_c > 0 \quad (4)$$

b) *Three-signal case*: Montreal receiver

$$N_1 - 28\log\{\max(1.0;\ f_A - f_1)\} + N_2 - 28\log\{\max(1.0;\ f_A - f_2)\} + N_3 - 28\log\{\max(1.0;\ f_A - f_3)\} + K + 6 - L_c > 0 \quad (5)$$

where:

$N_1, N_2, N_3$: broadcasting signal levels (dBm) at the input to the aeronautical receiver for broadcasting frequencies $f_1$, $f_2$ and $f_3$ respectively

$f_A$: aeronautical frequency (MHz)

$f_1, f_2, f_3$: broadcasting frequencies (MHz) $f_1 \geq f_2 > f_3$

$K$ = 140 for ILS localizer and

$K$ = 133 for VOR

$L_c$: correction factor (dB) to account for changes in the ILS localizer or VOR signal levels (see § 4.2.3.3).

TABLE 3

| Frequency difference between wanted signal and broadcasting signal (kHz) | Protection ratio (dB) |
|---|---|
| 150 | –41 |
| 200 | –50 |
| 250 | –59 |
| 300 | –68 |

#### 4.2.3.2 Frequency offset correction

Before applying formulas (4) and (5), a correction from Table 4 is applied to each signal level as follows:

$$N\ (\text{corrected}) = N - \text{correction term}$$

Type B1 interference need not be considered for frequency differences greater than 200 kHz.

TABLE 4

| Frequency difference between wanted signal and intermodulation product (kHz) | Correction term (dB) |
|---|---|
| 0 | 0 |
| 50 | 2 |
| 100 | 8 |
| 150 | 16 |
| 200 | 26 |

### 4.2.3.3 Correction factor to account for changes in Type B1 interference immunity resulting from changes in wanted signal levels

The following correction factor may be applied for ILS localizer and VOR, two and three-signal cases:

$$L_c = N_A - N_{ref} \tag{6}$$

where:

$L_c$: correction factor (dB) to account for changes in the wanted signal level

$N_A$: wanted signal level (dBm) at the input to the aeronautical receiver

$N_{ref}$: reference level (dBm) of the wanted signal at the input to the aeronautical receiver for the Type B1 interference immunity formula

= –89 dBm for ILS localizer and

= –82 dBm for VOR.

### 4.2.3.4 Trigger and cut-off values (see definitions in Annex 4)

$$\text{Trigger value (dBm)} = \frac{L_c - K}{3} + 28 \log \{\max (1.0;\ f_A - f)\} \qquad \text{dBm} \tag{7}$$

$$\text{Cut-off value (dBm)} = -66 + 20 \log \frac{\max (0.4; 108.1 - f)}{0.4} \qquad \text{dBm} \tag{8}$$

where:

$L_c$: correction factor (dB) taking into account the change in wanted signal level (see § 4.2.3.3)

$K$ = 146 for ILS localizer and 139 for VOR 3-signal cases and

$K$ = 140 for ILS localizer and 133 for VOR 2-signal cases.

$f_A$: aeronautical frequency (MHz)

$f$: broadcasting frequency (MHz)

Experience has shown that the use of lower cut-off values merely associates additional intermodulation products with each trigger value, but at lower levels of potential interference.

### 4.2.4 Type B2 interference

For an assessment of Type B2 interference, the following empirical formula may be used to determine the maximum level of a broadcasting signal at the input to the airborne ILS localizer or VOR receiver to avoid potential interference:

$$N_{max} = -20 + 20 \log \frac{\max (0.4;\ f_A - f)}{0.4} \tag{9}$$

where:

$N_{max}$: maximum level (dBm) of the broadcasting signal at the input to the aeronautical receiver

$f$: broadcasting frequency (MHz)

$f_A$: aeronautical frequency (MHz).

For some combinations of frequency and wanted signal level, formula (9) assumes more stringent receiver immunity criteria than those of the ICAO Annex 10 1998 receiver as given in formula (13). To take into account of both Montreal and ICAO Annex 10 1998 receiver immunity characteristics, both formula (9) and formula (13) should be applied and the lower value of $N_{max}$ should be used.

No correction factor to account for improvement in immunity resulting from increases in wanted signal levels is applied in the above formula due to insufficient test data.

## 4.3 Interference assessment criteria – ICAO Annex 10 1998 ILS localizer and VOR receivers

### 4.3.1 Type A1 interference (see Note 1)

As for Montreal receivers, § 4.2.1.

### 4.3.2 Type A2 interference (see Note 1)

As for Montreal receivers, § 4.2.2.

NOTE 1 – Further A1 and A2 measurements need to be made before possible modifications to § 4.3.1 and 4.3.2 of this Recommendation can be considered.

### 4.3.3 Type B1 interference

#### 4.3.3.1 Compatibility assessment formulas

The following formulae should be used to assess potential incompatibilities.

a) *Two-signal case*

$$2\left\{N_1 - 20\log\frac{\max(0.4;108.1 - f_1)}{0.4}\right\} +$$

$$N_2 - 20\log\frac{\max(0.4;108.1 - f_2)}{0.4} + K - L_c + S > 0 \qquad (10)$$

where:

$N_1, N_2$: broadcasting signal levels (dBm) at the input to the aeronautical receiver for broadcasting frequencies $f_1$ and $f_2$ respectively

$f_1, f_2$: broadcasting frequencies (MHz) $f_1 > f_2$

$K$ = 78 for ILS localizer and VOR

$L_c$: correction factor (dB) to account for changes in wanted signal levels (see § 4.3.3.3)

$S$: 3 dB margin to take into account of the fact that the ICAO Annex 10 1998 receiver immunity criteria equations do not provide comprehensive compatibility assessment formulae.

b) *Three-signal case*

$$N_1 - 20\log\frac{\max(0.4;108.1 - f_1)}{0.4} +$$

$$N_2 - 20\log\frac{\max(0.4;108.1 - f_2)}{0.4} +$$

$$N_3 - 20\log\frac{\max(0.4;108.1 - f_3)}{0.4} + K + 6 - L_c + S > 0 \qquad (11)$$

where:

$f_1, f_2, f_3$: broadcasting frequencies (MHz) $f_1 \geq f_2 > f_3$

$N_1, N_2, N_3$: broadcasting signal levels (dBm) at the input to the aeronautical receiver for broadcasting frequencies $f_1$, $f_2$ and $f_3$ respectively

$K$ = 78 for ILS localizer and VOR

$L_c$: correction factor (dB) to account for changes in wanted signals, (see § 4.3.3.3)

$S$: 3 dB margin to take into account of the fact that the ICAO Annex 10 1998 receiver immunity criteria equations do not provide comprehensive compatibility assessment formulae.

#### 4.3.3.2 Frequency offset correction

Before applying formulae (10) and (11), a correction from Table 5 is applied to each signal as follows:

$$N\,(\text{corrected}) = N - \text{correction term}$$

Type B1 interference need not be considered for frequency differences greater than 150 kHz; in such cases, signal levels would be so high that type B2 interference would occur.

TABLE 5

| Frequency difference between wanted signal and intermodulation product (kHz) | Correction term (dB) |
|---|---|
| 0 | 0 |
| 50 | 2 |
| 100 | 5 |
| 150 | 11 |

#### 4.3.3.3 Correction factor to account for changes in immunity resulting from changes in wanted signal levels

The correction factor, $L_c$, described in § 4.2.3.3 for Montreal receivers but with $N_{ref}$ = –86 dBm for ILS localizer and –79 dBm for VOR, is to be used.

#### 4.3.3.4 Trigger and cut-off values (see definitions in Annex 4)

$$\text{Trigger value (dBm)} = \frac{L_c - K - S}{3} + 20 \log \frac{\max\,(0.4;\ 108.1 - f)}{0.4} \qquad \text{dBm} \qquad (12)$$

where:

$L_c$: correction factor (dB) (see § 4.3.3.3)

$K$ = 78 for ILS localizer and VOR for 2-signal cases and

$K$ = 84 for ILS localizer and VOR for 3-signal cases

$f$: broadcasting frequency (MHz)

$S$: 3 dB margin to take into account of the fact that the ICAO Annex 10 1998 receiver immunity criteria equations do not provide comprehensive compatibility assessment formulae.

The cut-off value is the same as for Montreal receivers described in equation (8).

### 4.3.4 Type B2 Interference

For an assessment of type B2 interference, the following empirical formula may be used to determine the maximum level of a broadcasting signal at the input to the airborne ILS localizer or VOR receiver to avoid potential interference:

$$N_{max} = \min\left(15;\ -10 + 20 \log \frac{\max\,(0.4;\ 108.1 - f)}{0.4} + L_c - S\right) \qquad (13)$$

where:

$N_{max}$: maximum level (dBm) of the broadcasting signal at the input to the aeronautical receiver

$f$: broadcasting frequency (MHz)

$S$: 3 dB margin to take into account of the fact that the ICAO Annex 10 1998 receiver immunity criteria equations do not provide comprehensive compatibility assessment formulae

$L_c$: correction factor (dB) to account for changes in the wanted signal level. $L_c = \max(0; 0.5(N_A - N_{ref}))$.

$N_A$: wanted signal level (dBm) at the input to the aeronautical receiver

$N_{ref}$: reference level (dBm) of the wanted signal at the input to the aeronautical receiver for the type B2 interference immunity formula

= –86 dBm for ILS localizer

= –79 dBm for VOR.

## 4.4 Interference assessment criteria – ICAO Annex 10 1998 COM receivers

Type A1 and Type B1 intermodulation interference to COM receivers cannot be caused to COM frequencies above 128.5 MHz. Type A2 interference cannot be caused to any COM service frequency. There were little data available on aircraft COM antenna characteristics which could be used to develop a formula to convert field strength to receiver input power.

### 4.4.1 Compatibility assessment formulas

ICAO has specified in its Annex 10, Part I (§ 4.7.3) that:

– after 1 January 1995, all new installations of COM receiving systems shall meet new interference immunity performance standards;

– after 1 January 1998, all COM receiving systems shall meet new interference immunity performance standards.

#### 4.4.1.1 Type B1 interference

ICAO Annex 10 states that the COM receiving system "shall provide satisfactory performance in the presence of two signal, third-order intermodulation products caused by VHF FM broadcast signals having levels at the receiver input of –5 dBm".

#### 4.4.1.2 Type B2 interference

ICAO Annex 10 states that the COM receiving system "shall not be desensitized in the presence of VHF FM broadcast signals having levels at the receiver input of –5 dBm".

APPENDIX 1

TO ANNEX 1

## ILS localizer/VOR coverage and minimum field strengths

*Extract from:* "International Standards, Recommended Practices and Procedures for Air Navigation Services: Aeronautical Telecommunications, Annex 10 to the Convention on International Civil Aviation, Volume I", International Civil Aviation Organization, Montreal, 1985.

The following extract pertains to the ILS localizer:

"3.1.3.3 *Coverage*

3.1.3.3.1 The localizer shall provide signals sufficient to allow satisfactory operation of a typical aircraft installation within the localizer and glide path coverage sectors. The localizer coverage sector shall extend from the centre of the localizer antenna system to distances of:

46.3 km (25 NM) within ± 10° from the front course line;

31.5 km (17 NM) between 10° and 35° from the front course line;

18.5 km (10 NM) outside of ± 35° if coverage is provided;

except that, where topographical features dictate or operational requirements permit, the limits may be reduced to 33.3 km (18 NM) within the ± 10° sector and 18.5 km (10 NM) within the remainder of the coverage when alternative navigational facilities provide satisfactory coverage within the intermediate approach area. The localizer signals shall be receivable at the distances specified at and above a height of 600 m (2 000 ft) above the elevation of the threshold, or 300 m (1 000 ft) above the elevation of the highest point within the intermediate and final approach areas, whichever is the higher. Such signals shall be receivable to the distances specified, up to a surface extending outward from the localizer antenna and inclined at 7° above the horizontal.

3.1.3.3.2 In all parts of the coverage volume specified in 3.1.3.3.1 above, other than as specified in 3.1.3.3.2.1, 3.1.3.3.2.2 and 3.1.3.3.2.3 below, the field strength shall be not less than 40 μV/m (–114 dBW/m$^2$).

*Note. – This minimum field strength is required to permit satisfactory operational usage of ILS localizer facilities.*

3.1.3.3.2.1 For Facility Performance Category I localizers, the minimum field strength on the ILS glide path and within the localizer course sector from a distance of 18.5 km (10 NM) to a height of 60 m (200 ft) above the horizontal plane containing the threshold shall be not less than 90 μV/m (−107 dBW/m$^2$).

3.1.3.3.2.2 For Facility Performance Category II localizers, the minimum field strength on the ILS glide path and within the localizer course sector shall be not less than 100 μV/m (–106 dBW/m$^2$) at a distance of 18.5 km (10 NM) increasing to not less than 200 μV/m (–100 dBW/m$^2$) at a height of 15 m (50 ft) above the horizontal plane containing the threshold.

3.1.3.3.2.3 For Facility Performance Category III localizers, the minimum field strength on the ILS glide path and within the localizer course sector shall be not less than 100 μV/m (–106 dBW/m$^2$) at a distance of 18.5 km (10 NM), increasing to not less than 200 μV/m (–100 dBW/m$^2$) at 6 m (20 ft) above the horizontal plane containing the threshold. From this point to a further point 4 m (12 ft) above the runway centre line, and 300 m (1 000 ft) from the threshold in the direction of the localizer, and thereafter at a height of 4 m (12 ft) along the length of the runway in the direction of the localizer, the field strength shall be not less than 100 μV/m (–106 dBW/m$^2$).

*Note. – The field strengths given in 3.1.3.3.2.2 and 3.1.3.3.2.3 above are necessary to provide the signal-to-noise ratio required for improved integrity.*

3.1.3.3.3 **Recommendation.** – *Above 7°, the signals should be reduced to as low a value as practicable.*

*Note 1. – The requirements in 3.1.3.3.1, 3.1.3.3.2.1, 3.1.3.3.2.2 and 3.1.3.3.2.3 above are based on the assumption that the aircraft is heading directly toward the facility.*

*Note 2. – Guidance material on significant airborne receiver parameters is given in 2.2.2 and 2.2.4 of Attachment C to Part I.*

3.1.3.3.4 When coverage is achieved by a localizer using two radio frequency carriers, one carrier providing a radiation field pattern in the front course sector and the other providing a radiation field pattern outside that sector, the ratio of the two carrier signal strengths in space within the front course sector to the coverage limits specified at 3.1.3.3.1 above shall not be less than 10 dB."

The following extract pertains to the VOR:

"3.3.3. – Polarization and pattern accuracy

3.3.3.1 The emission from the VOR shall be horizontally polarized. The vertically polarized component of the radiation shall be as small as possible.

*Note. – It is not possible at present to state quantitatively the maximum permissible magnitude of the vertically polarized component of the radiation from the VOR. (Information is provided in the* Manual on Testing of Radio Navigation Aids *(Doc 8071) as to flight checks that can be carried out to determine the effects of vertical polarization on the bearing accuracy.)*

3.3.3.2 The accuracy of the bearing information conveyed by the horizontally polarized radiation from the VOR at a distance of approximately 4 wavelengths for all elevation angles between 0 and 40°, measured from the centre of the VOR antenna system, shall be within ± 2°.

*3.3.4. – Coverage*

3.3.4.1 The VOR shall provide signals such as to permit satisfactory operation of a typical aircraft installation at the levels and distances required for operational reasons, and up to an elevation angle of 40°.

3.3.4.2 **Recommendation.** – *The field strength or power density in space of VOR signals required to permit satisfactory operation of a typical aircraft installation at the minimum service level at the maximum specified service radius should be 90 μV/m or –107 dBW/m*$^2$."

ANNEX 2

## General assessment method

CONTENTS

*Page*



## 1 Introduction

The purpose of this Annex is to provide an assessment method for the analysis of compatibility between stations of the aeronautical radionavigation services and stations in a large broadcasting assignment plan. The techniques given in Annex 3 may be used to carry out a more detailed analysis, or to verify the results obtained from an analysis.

## 1.1 Philosophy of the general assessment method

The central objective of the General Assessment Method (GAM) is to calculate all significant potential incompatibilities within an aeronautical volume at a number of defined calculation points or test points (see Note 1). For a particular set of broadcasting and aeronautical frequency combinations, the maximum potential incompatibility associated with a particular aeronautical service is identified in the form of a protection margin.

An extension of the compatibility assessment method contained in the Geneva Agreement, 1984, is needed because of subsequent refinement of the compatibility criteria and identification of the need for a more thorough assessment method. In addition, because of the need to identify and examine potential incompatibilities associated with a large assignment plan, it is necessary to develop an assessment method suitable for automated implementation in an efficient manner.

The GAM is based upon the need to protect the aeronautical radionavigation service at specified minimum separation distances (see Note 1) from broadcasting station antennas, depending on the aeronautical service (ILS or VOR) (see Note 1) and the particular use made of that service.

NOTE 1 – See definitions in Annex 4.

## 1.2 ILS localizer

When assessing compatibility with an ILS localizer the GAM is based on a number of fixed test points, supplemented by an additional test point for each broadcasting station within the Designated Operational Coverage (DOC) (see definitions in Annex 4) of the ILS.

## 1.3 VOR

The DOCs employed in the VOR service are large and consequently there is likely to be a large number of broadcasting stations located within each VOR DOC. The GAM assesses compatibility with VOR by generating a test point above each broadcasting station inside the DOC and taking account of broadcasting stations outside the DOC.

# 2 Location and height of ILS and VOR test points

## 2.1 ILS test points

### 2.1.1 Fixed test points

For each of the fixed test points shown in Fig. 4, the minimum height, distance from the localizer site and the bearing relative to the extended runway centre line are given in Table 6.

The fixed test points A, E, F, G and H have minimum heights (see also § 3.2.1) of 0, 0, 150, 300 and 450 m, respectively, above the ILS localizer site elevation. These values represent a glide path with a slope of 3°. All other fixed test points have minimum heights of 600 m.

### 2.1.2 Test points related to broadcasting stations

If the broadcasting station is within the shaded zone in Fig. 4:

– an additional test point is generated having the geographic coordinates of the broadcasting station and the same height as the broadcasting antenna.

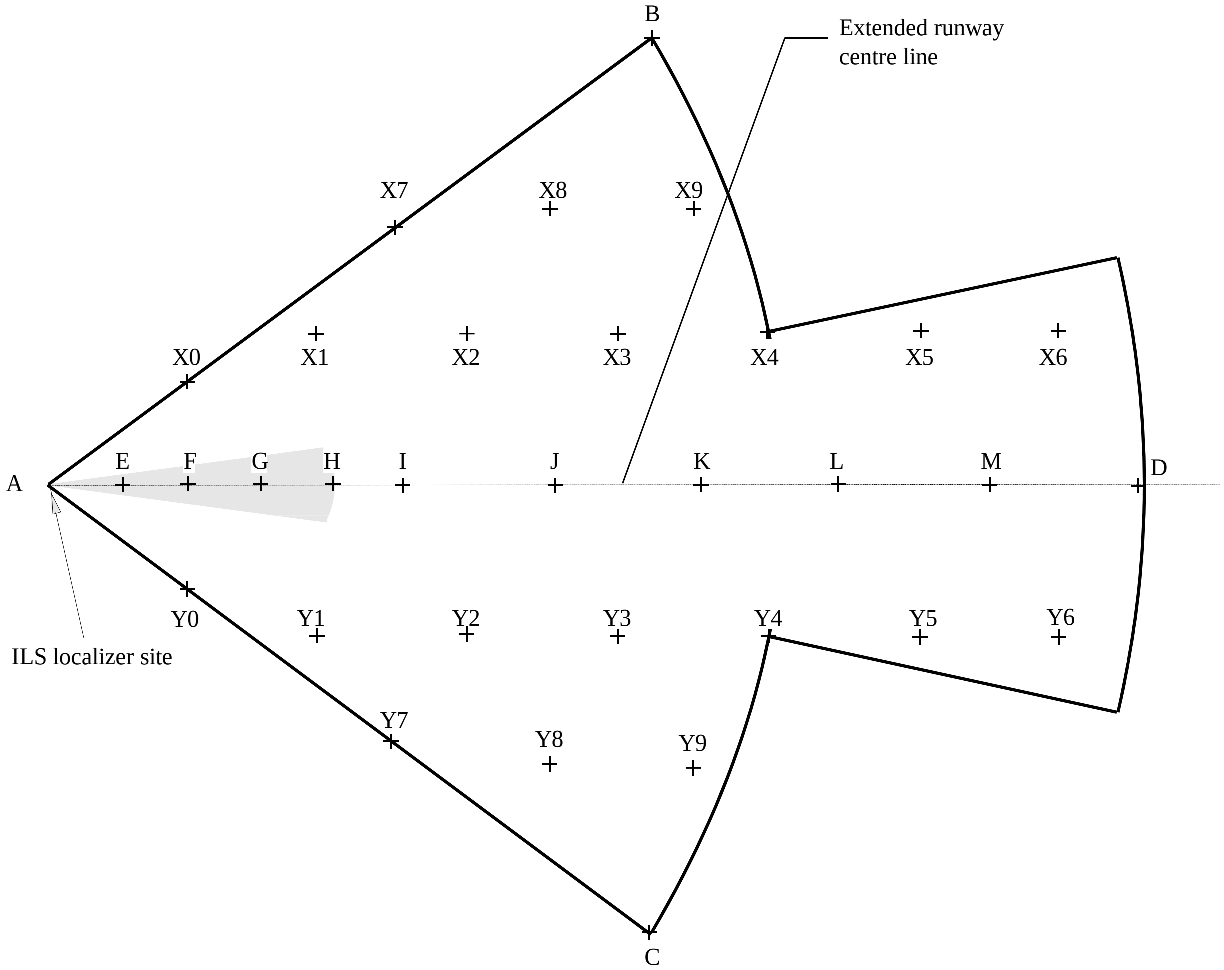
If the broadcasting station is within or below the ILS DOC but outside the shaded zone in Fig. 4, an additional test point is generated having the geographic coordinates of the broadcasting station. The minimum height of the test point is the greater of:

– 600 m above the ILS localizer site; or

– 150 m above the broadcasting antenna.

FIGURE 4

**Fixed test point locations within ILS DOC**




*Note 1* – The shaded zone extends 12 km from the ILS localizer site and is within ± 7.5° of the extended runway centre line.

D04

TABLE 6

| Points on or above the extended runway centre line | | | Points off the extended runway centre line (all at height of 600 m) | | |
|---|---|---|---|---|---|
| Identification | Distance (km) | Minimum height (m) | Identification | Distance (km) | Bearing relative to the runway centre line (degrees) |
| A | 0 | 0 | B, C | 31.5 | –35, 35 |
| E | 3 | 0 | X0, Y0 | 7.7 | –35, 35 |
| F | 6 | 150 | X1, Y1 | 12.9 | –25.5, 25.5 |
| G | 9 | 300 | X2, Y2 | 18.8 | –17.2, 17.2 |
| H | 12 | 450 | X3, Y3 | 24.9 | –12.9, 12.9 |
| I | 15 | 600 | X4, Y4 | 31.5 | –10, 10 |
| J | 21.25 | 600 | X5, Y5 | 37.3 | –8.6, 8.6 |
| K | 27.5 | 600 | X6, Y6 | 43.5 | –7.3, 7.3 |
| L | 33.75 | 600 | X7, Y7 | 18.5 | –35, 35 |
| M | 40 | 600 | X8, Y8 | 24.0 | –27.6, 27.6 |
| D | 46.3 | 600 | X9, Y9 | 29.6 | –22.1, 22.1 |

## 2.2 VOR test points

### 2.2.1 Test points related to broadcasting stations that are inside the DOC

A test point is located at the geographic coordinates of the broadcasting station, at a minimum height which is the greatest of:

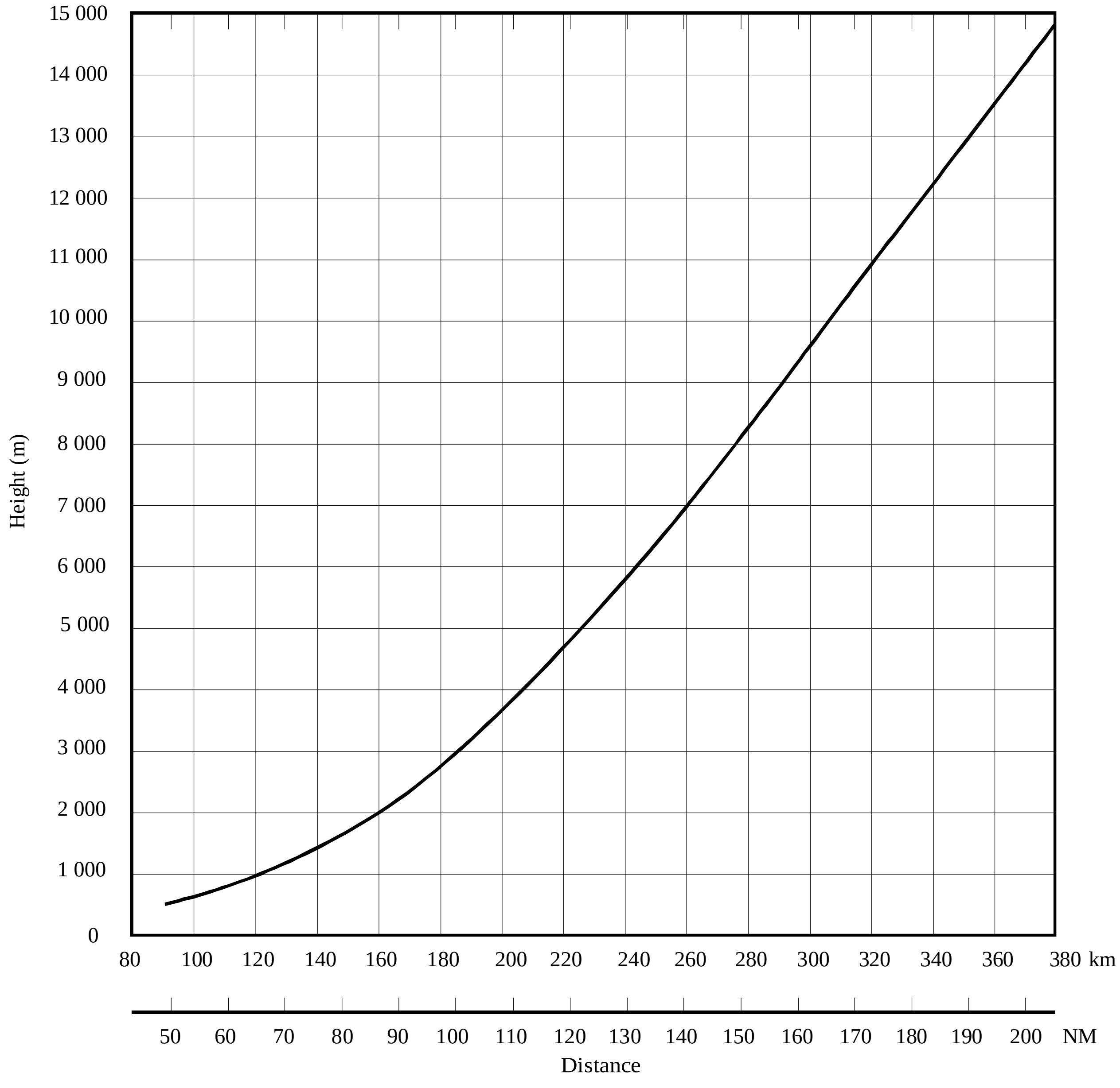
– 600 m above local terrain (approximated as 600 m above the site height of the broadcasting station), or

– 300 m above the antenna of the broadcasting station, or

– the height derived from Fig. 5 to which is added the height of the VOR site.

FIGURE 5

**Distance versus test point height above VOR site**




*Note 1* – This curve is derived from ICAO documentation (see § 3.2.2.2 of Annex 1).

#### 2.2.2 Test points related to broadcasting stations that are outside the DOC

Broadcasting stations which are outside the DOC but no more than 3 km from the boundary of the DOC are treated as in § 2.2.1. For stations more than 3 km outside the DOC, but within the distance limits specified in § 3.1.2, a test point is generated at the nearest point on the boundary of the DOC, and at a minimum height which is the greatest of:

– 600 m above mean sea level, or

– the broadcasting antenna height above mean sea level, or

– the height derived from Fig. 5 to which is added the height of the VOR site.

Test points on the boundary of the DOC which are separated by less than 250 m are regarded as co-located.

#### 2.2.3 Additional test points

Additional test points within the DOC may be specified to cover a particular use of a VOR, for instance where it is used as a landing aid, or where a service is required at an elevation angle of less than 0° (see also § 3.2.3.2).

## 3 Application of general assessment method

### 3.1 General

The compatibility criteria are contained in Annex 1.

#### 3.1.1 Test point selection

Test points are selected in accordance with the criteria set out in § 2.

#### 3.1.2 Broadcasting stations to be included in the analysis at a test point

Broadcasting stations are included in the analysis at a test point:

– if there is a line-of-sight path (see definitions in Annex 4) from the broadcasting antenna to the test point and if the calculated signal level is greater than the B1 cut-off value (§ 4.2.3.4 of Annex 1);

– if the free-space field strength (§ 3.3.7 of Annex 1) is at least the value which can cause Type A1 or A2 or B2 incompatibility (§ 4.2 and 4.3 of Annex 1) subject to a maximum separation distance of 125 km in the A1 and B2 cases.

#### 3.1.3 Compatibility calculations

In order to assess the compatibility of the set of broadcasting stations which meet the conditions of § 3.1.2 at any selected test point (see § 3.1.1), it is necessary to:

– calculate the free-space field strength (§ 3.3.7 of Annex 1) from each of the broadcasting stations at the test point taking account of the slant path distance (see definitions in Annex 4), the maximum e.r.p. and the antenna characteristics (see § 4);

– calculate the ILS or VOR signal level (see § 3.2.2.3 and 3.2.3.2);

– calculate the input power to an aeronautical receiver using § 3.4 of Annex 1.

Taking into account the frequency and type (ILS or VOR) of the aeronautical service and the information obtained above, the compatibility for each type of interference may be assessed as in § 3.1.3.1 to 3.1.3.4.

#### 3.1.3.1 Type A1 interference

The frequencies of the two and three component intermodulation products which can be generated by any sub-set of co-sited broadcasting stations are calculated. Any product for which the frequency falls within 200 kHz of the aeronautical frequency is examined further to determine if its field strength is sufficient to cause Type A1 interference, taking account of the criteria in § 4.2.1 of Annex 1.

To assess A1 compatibility with ICAO Annex 10 1998 aeronautical receivers, the criteria in § 4.3.1 of Annex 1 should be used.

#### 3.1.3.2 Type A2 interference

Each of the broadcasting stations (identified as in § 3.1.2) is examined to determine if its frequency falls within 300 kHz of the aeronautical frequency and, if so, if its field strength is sufficient to cause Type A2 interference, taking account of the criteria in § 4.2.2 of Annex 1.

To assess A2 compatibility with ICAO Annex 10 1998 aeronautical receivers, the criteria in § 4.3.2 of Annex 1 should be used.

#### 3.1.3.3 Type B1 interference

The frequencies of the two and three component intermodulation products which can be generated by any sub-set of broadcasting stations (identified as in § 3.1.2) which contains at least one component reaching the trigger value (see § 4.2.3.4 of Annex 1) and for which all components are above the cut-off value (see definitions in Annex 4) (see § 4.2.3.4 of Annex 1) at the input to the aeronautical receiver are calculated. Any product whose frequency falls within 200 kHz of the aeronautical frequency is examined further to determine if the sum (dBm) of the powers at the input to the aeronautical receiver (see § 3.4 of Annex 1) is sufficient to cause Type B1 interference, taking account of the criteria in § 4.2.3 of Annex 1.

To assess B1 compatibility with ICAO Annex 10 1998 aeronautical receivers, the criteria in § 4.3.3 of Annex 1 should be used.

#### 3.1.3.4 Type B2 interference

Each of the broadcasting stations (identified as in § 3.1.2) is examined to determine if its power at the input to the aeronautical receiver (see § 3.4 of Annex 1) (see Note 1) is sufficient to cause Type B2 interference, taking account of the criteria in § 4.2.4 of Annex 1.

To assess B2 compatibility with ICAO Annex 10 1998 aeronautical receivers, the criteria in § 4.3.4 of Annex 1 should be used.

NOTE 1 – The term "equivalent input power" is used to mean "the power at the input of an aeronautical receiver after taking into account any frequency dependent terms".

## 3.2 Special considerations regarding compatibility assessments

### 3.2.1 Test point heights greater than the minimum values

To ensure that all potential Type B1 interference situations are considered, additional calculations for greater test point heights should be carried out, subject to the test point height not exceeding:

– the maximum height of the DOC, or

– the maximum height at which the trigger value can be achieved.

A more detailed explanation of this matter and the reasons for its restriction to Type B1 interference are given in § 7 of Appendix 1.

### 3.2.2 ILS

#### 3.2.2.1 Fixed test points

The slant path distance between the broadcasting antenna and a test point is used in field-strength calculations. However, this is subject to the following minimum value:

– 150 m if the broadcasting station is within the shaded zone in Fig. 4, or

– 300 m if the broadcasting station is not within the shaded zone in Fig. 4.

#### 3.2.2.2 Test points related to broadcasting stations

If the broadcasting station is within the shaded zone in Fig. 4:

– additional calculations are made for a horizontal separation distance of 150 m, using the maximum value of the e.r.p. and the height specified in § 2.1.2.

If the broadcasting station is within or below the ILS DOC but outside the shaded zone in Fig. 4:

– additional calculations are made for a test point location above the broadcasting station for the height specified in § 2.1.2. The relevant maximum vertical radiation pattern correction derived from § 4.4 is applied.

#### 3.2.2.3 Calculation of ILS field strength

If sufficient information about the ILS installation is known, the two-ray method in § 3.2.2.3.1 may be used.

If the required information is not available, the ILS interpolation method given in § 3.2.2.3.2 may be used.

##### 3.2.2.3.1 Two-ray method

Appendix 3 provides the details of a method which may be used to obtain an accurate prediction of the ILS field strength. To use this method some detailed information about the ILS installation must be known and the required information is listed in Appendix 3. At test points A and E (see Table 6), the minimum field strength, 32 dB(μV/m) (see § 3.2.1.2 of Annex 1), is used.

##### 3.2.2.3.2 ILS interpolation method

The following linear interpolation method can be used for heights greater than 60 m above the ILS localizer site.

From the centre of the localizer antenna system to a distance (see Note 1) of 18.5 km, and for angles no more than ± 10° from the front course line, the field strength is 39 dB(μV/m).

NOTE 1 – Within § 3.2.2.3.2, the distances used are calculated in the horizontal plane through the ILS localizer site.

From the centre of the localizer antenna system to a distance of 31.5 km and for angles greater than 10° but no more than 35° each side of the front course line (see Fig. 1), the ILS field strength, $E_{ILS}$, is given by:

$$E_{ILS} = 39 - \frac{d}{4.5} \qquad \text{dB}(\mu\text{V/m}) \tag{14}$$

where:

$d$: distance (km) from the ILS localizer site to the test point.

From a distance of 18.5 km to a distance of 46.3 km, and for angles no more than ± 10° from the front course line, the ILS field strength, $E_{ILS}$, is given by:

$$E_{ILS} = 39 - \frac{d - 18.5}{4} \qquad \text{dB}(\mu\text{V/m}) \tag{15}$$

For heights below 60 m, the minimum field strength, 32 dB(μV/m), is used.

The values for ILS localizer field strength used in this interpolation method are the minimum values specified in ICAO Annex 10 (see also Appendix 1 to Annex 1) and since variations below these minima are not permitted, there is no requirement for a safety margin.

### 3.2.3 VOR

#### 3.2.3.1 Additional test points

The slant path distance between the antenna of the broadcasting station and any additional test point (see § 2.2.3) is used in field-strength calculations. However, this is subject to a minimum value of 300 m.

#### 3.2.3.2 Calculation of VOR field strength at test points

For test points with elevation angles greater than 0° and less than 2.5°, the following formula is applicable for installations where the VOR transmitting antenna is no more than 7 m above ground level:

$$E_{VOR} = E_{MIN} + \max\left(20 \log (\theta \, D_{MX} / D_{TP}); 0\right) \qquad (16)$$

where:

$E_{MIN}$: ICAO minimum field strength (39 dB(μV/m))

$D_{MX}$: specified range of VOR (km) in the direction of the test point

$D_{TP}$: slant path distance (km) from VOR transmitter site to test point

$\theta$: elevation angle (degrees) of the test point with respect to the VOR antenna, given by:

$$\theta = \tan^{-1}\left(\left[H_{TP} - H_{VOR} - (D_{TP} / 4.1)^2\right] / \left[1\,000 \, D_{TP}\right]\right) \qquad (17)$$

where:

$H_{TP}$: test point height (m) above sea level

$H_{VOR}$: VOR antenna height (m) above sea level.

For elevation angles which exceed the value of 2.5°, the field strength is calculated using the elevation angle of 2.5°.

For installations where the VOR transmitting antenna is more than 7 m above ground level, or where there is a requirement for a service at elevation angles of less than 0°, the minimum value of VOR field strength (39 dB(μV/m)) is to be used for all test points.

The method described above is an interpolation method based on a minimum field strength value and therefore there is no requirement for a safety margin.

### 3.2.4 Calculation of Type A1 potential interference

Spurious emissions, except radiated intermodulation products, should, as a general measure, be kept at such a low level that there will be no incompatibility to be considered further in the compatibility analysis. Hence A1 calculations are made only for the case of radiated intermodulation products from co-sited broadcasting stations.

Because the e.r.p. of the intermodulation product may not be known, the Type A1 interference margin is calculated indirectly by taking account of the unwanted field-strength value at a test point for each of the transmissions from co-sited broadcasting stations, together with the relevant A1 suppression value for each of these transmitters.

The Type A1 interference margin is calculated as:

$$IM = \max\left((E_i - S_i); ...; (E_N - S_N)\right) + PR - Ew \qquad (18)$$

where:

$IM$: A1 interference margin (dB)

$N$: number of intermodulation components ($N = 2$ or 3)

$E_i$: unwanted field strength (dB(μV/m)) of broadcasting transmission $i$ at the test point

$S_i$: A1 suppression (dB) of broadcasting transmitter $i$

$PR$: protection ratio (dB) appropriate for frequency difference between the intermodulation product and the aeronautical frequencies (see Table 2)

$Ew$: field strength (dB(μV/m)) of the aeronautical signal at the test point (at least 32 dB(μV/m) for ILS and 39 dB(μV/m) for VOR).

In a case where the A1 suppression value for a broadcasting transmitter is known, this value should be used when calculating compatibility.

#### 3.2.5 Calculation of Type B1 potential interference

To ensure that worst-case B1 results are obtained for broadcasting stations which are sited close to one another, any broadcasting station within 3 km of a test point is regarded as being beneath that test point (see also Appendix 1).

#### 3.2.6 Calculation of Type B2 potential interference

In the calculation of Type B2 potential interference, no allowance for the level of the aeronautical signal is made and thus the minimum values of 32 and 39 dB(μV/m) for ILS and VOR respectively are used.

#### 3.2.7 Multiple interference

In principle, the combined effect of multiple sources of potential interference to an aeronautical service at a given test point should be taken into account. However, within the GAM:

– the use of a free-space calculation method normally provides an over-estimate of any broadcasting field strength;

– the use of the calculation methods given in § 3.2.2.3 and 3.2.3.2, for ILS localizer and VOR, respectively, normally provides an under-estimate of any aeronautical field strength.

Therefore, it is not considered necessary to take multiple interference into account in the GAM.

However, in the case of A1 compatibility calculations, when the frequency difference between the wanted signal and the spurious emission is either 0 or 50 kHz, the protection ratio should be increased by 3 dB to provide a safety margin.

## 4 Broadcasting station antenna corrections

### 4.1 General

Account is taken of the directional properties of broadcasting station transmitting antennas when calculating field-strength values (§ 3.3.7 of Annex 1).

### 4.2 Polarization discrimination

No account is taken of any polarization discrimination between broadcasting and aeronautical radionavigation transmissions (except as indicated in § 3.3.7 of Annex 1).

### 4.3 Horizontal radiation pattern

For a broadcasting station which has a directional antenna, the horizontal radiation pattern (h.r.p.) data are specified at 10° intervals, starting from true north. The h.r.p. correction, $H$ (dB), is given by:

$$H = \text{(e.r.p. in the relevant direction)} - \text{(maximum e.r.p.)} \tag{19}$$

### 4.4 Vertical radiation pattern correction

Vertical radiation pattern (v.r.p.) corrections are applied only for elevation angles above the horizontal plane through the broadcasting antenna.

Broadcasting antennas vary from a simple antenna such as a dipole, as often used at low power stations, to the more complex multi-tiered antenna normally used at high power stations.

In a case where the actual antenna aperture is not known, Table 7 is used to relate the maximum e.r.p. to the vertical aperture and is based upon a statistical analysis of operational practice.

The v.r.p. corrections described in § 4.4.1 and 4.4.2 apply to both horizontally and vertically polarized transmissions and the limiting values quoted take account of the worst-case slant path.

TABLE 7

| Maximum e.r.p. (dBW) | Vertical aperture in wavelengths |
|---|---|
| e.r.p. $\geq$ 44 | 8 |
| 37 $\leq$ e.r.p. $<$ 44 | 4 |
| 30 $\leq$ e.r.p. $<$ 37 | 2 |
| e.r.p. $<$ 30 | 1 |

### 4.4.1 V.r.p. corrections for vertical apertures of two or more wavelengths

In order to model the envelope of the vertical radiation pattern of antennas with apertures of two or more wavelengths, the v.r.p. correction, *V* (dB), is calculated by using the following formula:

$$V = -20 \log (\pi A \sin \theta) \tag{20}$$

where:

$A$: vertical aperture (wavelengths)

$\theta$: elevation angle (relative to the horizontal).

It should be noted that for small elevation angles this expression can produce positive values for *V*. In such cases, *V* is set to 0 dB (i.e., no v.r.p. correction is applied).

For large elevation angles, *V* is limited to a value of –14 dB, that is, $0 \geq V \geq -14$ dB.

Where the actual maximum v.r.p. correction is known, this should be used as the limiting value in place of –14 dB.

### 4.4.2 V.r.p. corrections for vertical apertures of less than two wavelengths

When using low gain antennas (those with vertical apertures of less than two wavelengths) the values in Table 8 characterize the envelope of the v.r.p.

For intermediate angles linear interpolation is used.

TABLE 8

| Elevation angle (degrees) | v.r.p. correction (dB) |
|---|---|
| 0 | 0 |
| 10 | 0 |
| 20 | –1 |
| 30 | –2 |
| 40 | –4 |
| 50 | –6 |
| 60 | –8 |
| 70 | –8 |
| 80 | –8 |
| 90 | –8 |

#### 4.4.3 V.r.p. corrections for spurious emissions in the band 108-118 MHz

The v.r.p. corrections given in § 4.4.1 and 4.4.2 are also applied to spurious emissions in the band 108-118 MHz.

### 4.5 Combination of horizontal and vertical radiation patterns

The relevant values, in dB, of the h.r.p. and v.r.p. corrections are added arithmetically subject to a maximum combined correction of –20 dB, or the maximum v.r.p. correction, whichever is larger. At elevation angles above 45°, no h.r.p. corrections are made.

APPENDIX 1

TO ANNEX 2

## Location of test points with maximum interference potential

*An explanation of the GAM*

This Appendix is a clarification of the inter-relationship between test point location and local maxima of interference potential in relation to the GAM.

## 1 Aircraft at the same height as a broadcasting station antenna

Consider the situation of an aircraft flying near a broadcasting station. If the aircraft flies at the same height as the broadcasting antenna, the maximum value of broadcasting field strength perceived by the aircraft will be at the point of nearest approach. In the case of an omni directional broadcasting antenna, the points of maximum field strength lie on a circle centred on the antenna.

## 2 Aircraft at a greater height than a broadcasting station antenna

If the aircraft flies at a constant altitude on a radial line towards and over the site of a broadcasting antenna, the point of maximum field strength is vertically above the antenna (see Appendix 2 to Annex 2).

## 3 Relationship between vertical and horizontal separation distances

If the maximum value of v.r.p. correction for the broadcasting antenna is –14 dB, the maximum value of field strength achieved for a vertical separation of $y$ m is the same as that for a separation of $5y$ m in the horizontal plane through the broadcasting antenna (where the v.r.p. correction is 0 dB).

## 4 Location of maximum interference potential

For A1, A2 and B2 calculations, the vertical separation and horizontal separation concepts are equivalent because the broadcasting signals have a common source location. In the B1 case, the contributing sources are generally not co-sited and the location of the maximum interference potential may not be immediately obvious if the horizontal separation concept is used.

However, if the vertical separation concept is used, the point of maximum interference potential is above one or other of the broadcasting antennas (see Appendix 2 to Annex 2).

Thus, a unique pair (or trio) of points has been defined for a worst-case calculation without having to rely on a very large number of calculation points on some form of three-dimensional grid.

## 5 Test points for VOR

In the GAM, this direct approach is used for VOR compatibility calculations and is extended by means of additional test points situated at (or near) the DOC boundary to ensure that broadcasting stations outside the DOC are properly taken into account.

## 6 Test points for ILS

In contrast to the VOR situation, relatively few broadcasting stations are situated inside or below an ILS DOC. In consequence it is easier to demonstrate that compatibility has been fully evaluated by using a set of fixed test points to supplement test points generated above or near any broadcasting stations inside the DOC.

Test points inside the shaded zone in Fig. 4 are chosen to permit assessment of compatibility from ground level upwards and the test point heights chosen represent a glide path with a slope of 3°.

## 7 Effect of increased test point height

Calculations of 2 or 3 component Type B1 potential interference give worst-case results at the minimum test point height for any given sub-set of broadcasting stations which are within line-of-sight of the test point. However, at greater test point heights it is possible for additional broadcasting stations to become line-of-sight to the test point and further calculations are needed to determine if these stations can contribute to a Type B1 potential interference. The maximum value of any potential interference occurs at the minimum height for which all relevant broadcasting stations are within line-of-sight of the test point. The greatest height which needs to be considered is the lower of:

– the maximum height of the DOC, or

– the maximum height at which the signal level from a broadcasting station achieves the trigger value.

APPENDIX 2

TO ANNEX 2

# Considerations regarding maximum field strength and interference potential

## 1 Maximum field strength

Consider an aircraft flying on a path at constant altitude along a radial towards a broadcasting station with the aircraft height greater than that of the broadcasting antenna (see Fig. 6).

In the following:

$P$: e.r.p. (dBW)

$h$: height difference (km)

$d$: slant path distance (km)

$\theta$: elevation angle, relative to the horizontal at the broadcasting antenna

$V$: v.r.p. correction (dB).

At any point T, the field strength $E$ (dB(μV/m)) (Note 1) is given by (see § 3.3.7 of Annex 1):

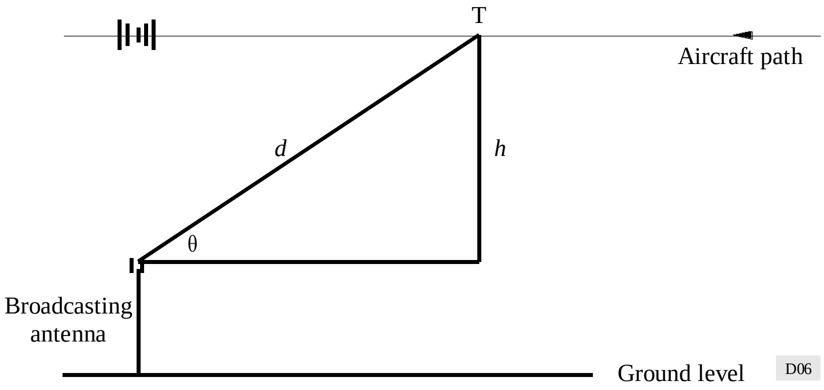
$$E = 76.9 + P - 20 \log d + V \tag{21}$$

NOTE 1 – For simplicity, it is assumed that there is no h.r.p. correction.

The v.r.p. correction is modelled as –20 log ($\pi$ $A$ sin $\theta$), where $A$ is the vertical aperture of the antenna, in wavelengths, subject to a maximum value of correction for high values of $\theta$.

FIGURE 6

**Aircraft path above a broadcasting antenna**




**1.1** At low values of $\theta$ (where $V$ is between 0 and its maximum value),

$$E = 76.9 + P - 20 \log d - 20 \log (\pi A \sin \theta) \qquad (22)$$

but $d = h / \sin \theta$

therefore:

$$\textbf{Error!} = 76.9 + P - 20 \log (h \pi A) \qquad (23)$$

Thus the field-strength value is constant.

**1.2** At larger values of $\theta$ (where $V$ has reached its maximum value), that is near the broadcasting station (the zone shown shaded in Fig. 6), the v.r.p. correction remains constant at its maximum value. Thus:

$$E = 76.9 + P - 20 \log d + \text{constant} \qquad (24)$$

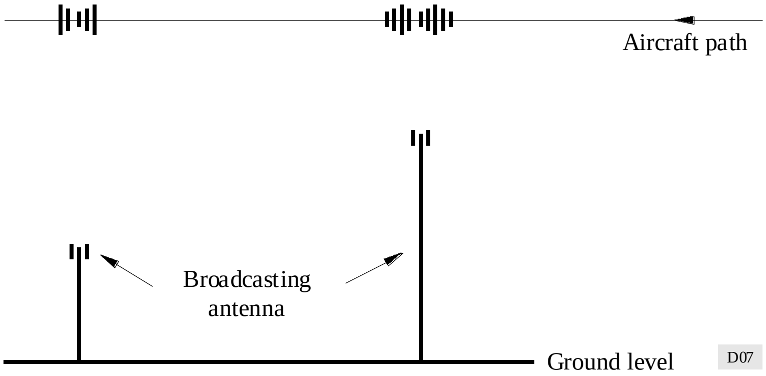
The maximum value of field strength is achieved when $d$ reaches its minimum value (= $h$), directly above the broadcasting antenna.

## 2 Maximum Type B1 interference potential

Consider an aircraft flying on a path at a constant altitude above the line joining two broadcasting antennas (see Fig. 7).

FIGURE 7

**Aircraft path above two broadcasting antennas**



Outside the shaded areas, the field-strength values are constant (as described in § 1.1), their sum is constant and therefore the Type B1 interference potential is also constant.

Inside each shaded area, the field-strength value from the nearer transmitter increases to a local maximum directly above its antenna (as described in § 1.2).

In the GAM, both local maxima are examined thus permitting the worst case to be identified.

Similar reasoning applies to the three station case.

APPENDIX 3

TO ANNEX 2

## Prediction of ILS field strength using two-ray geometry

This model uses two-ray geometry over a smooth spherical earth. It is a requirement of this method that the ground in the vicinity of the reflection point is a reasonable approximation to a smooth earth.

For an ILS localizer signal, the area in which the reflection takes place will be on (or very near to) the airport itself and in this area the ground is likely to be substantially flat and thus a good approximation to the required conditions.

The elements needed to make the calculation are:

– maximum e.r.p. of the ILS localizer installation;

– slant path distance between the ILS localizer antenna and the test point;

– horizontal radiation pattern of the ILS localizer antenna;

– bearing of the test point;

– height of the ILS localizer antenna above ground level (a.g.l.);

– height of the ILS localizer site above mean sea level (a.m.s.l.);

– height of the test point a.m.s.l.

Because the maximum elevation angle which needs to be considered within any ILS DOC is 7° (see Fig. 1), there is no need to include the vertical radiation pattern of the ILS localizer antenna in the calculation.

In the case of a path of less than a few hundred kilometres, it is a reasonable approximation to assume that the Earth may be represented as a parabola with heights measured on the *y*-axis and distances on the *x*-axis (see Fig. 8).

Under these circumstances, the difference in path length, Δ (m), between the direct path and that involving a reflection is given by:

$$\Delta = \frac{2\,h_1\left[h_2 - h_p - (D/4.1)^2\right]}{1000\,D} \qquad \text{m} \qquad (25)$$

where:

$D$: horizontal distance (km) from the ILS localizer site to the test point

$h_1$: ILS transmitting antenna height (m) above the reflecting plane

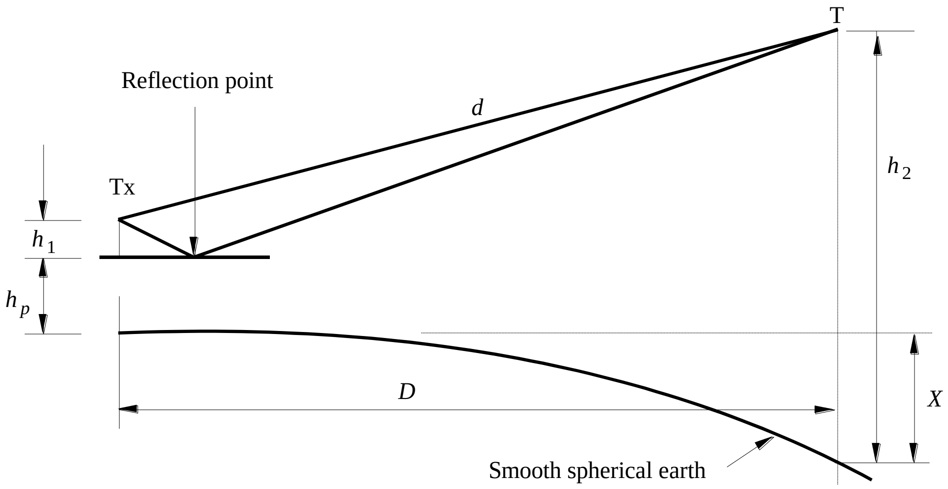
$h_2$: test point height (m) a.m.s.l.

$h_p$: height of the reflection plane (m) a.m.s.l. (equal to the ILS localizer site height)

and reference should be made to Note 1 on Fig. 8.

FIGURE 8

**Two-ray geometry**




*Note 1* – The effect of the Earth's curvature in the region between the transmitter site and the reflection point is neglected in this approximation.

Tx: ILS localizer transmitting antenna
T: test point
*d*: slant path distance (km)
*X*: curved earth height difference (m), (identified for information only); $X = (D/4.1)^2$

D08

At the reflection angles involved, the Earth has a reflection coefficient very close to –1 and the correction factor, *C*, due to the summation of the two signal components is given by:

$$C = 10 \log \left(2 - 2 \cos (2\pi \Delta / \lambda)\right) \qquad (26)$$

where:

$\lambda$: wavelength (m), of the ILS signal.

The reflection zone is close to the transmitter site and if the latter is a few hundred metres from the end of the runway then the reflection zone will be between these two points. Care must be taken when determining the height of the ILS transmitting antenna above the reflection zone in the case where the ground is sloping. This means that an accurate ground profile is required in order to obtain accurate field strength results. For greatest accuracy, the reflection plane should be drawn through the ground slope in the reflection zone with the heights above the reflection plane recalculated appropriately.

The predicted field strength, *E* (dB(μV/m)), is given by:

$$E = 76.9 + P - 20 \log d + C + H \qquad (27)$$

where:

$P$: e.r.p. (dBW) of the ILS localizer installation

$d$: slant path distance (km)

$C$: correction (dB) given in equation (26)

$H$: h.r.p correction for the ILS localizer transmitting antenna in the direction of the test point.

An allowance of 8 dB is to be made to provide a safety margin, but the field strength value calculated as in § 3.2.2.3.2 is taken as a lower limit.

The field strength, $E_{ILS}$ (dB(μV/m)), to be used in compatibility calculations is thus:

$$E_{ILS} = \max (E - 8; \text{value from § 3.2.2.3.2}) \qquad (28)$$

ANNEX 3

# Detailed compatibility assessment and practical verification

CONTENTS

*Page*



## 1 Introduction

The General Assessment Method (GAM) predicts more potential incompatibilities to the aeronautical radionavigation service than may occur in practice. However, the results of correlation tests show that when measured data are used in a compatibility analysis, the calculated results match closely with practical experience. Thus, the use of measured data will improve the accuracy of a compatibility analysis.

As an extension to the GAM, a detailed, case-by-case analysis may be conducted using parameters derived from models with increased degrees of accuracy. These models may be used individually or in combination. They approach practical experience when the calculated values of individual parameters approximate more closely to measured values. The advantage of this modelling approach is that it provides opportunities for an efficient compatibility analysis and that it can provide accurate results, thus avoiding the need for extensive flight measurements and their associated practical difficulties.

## 2 Matters requiring special attention

### 2.1 Prediction of broadcasting field strengths

In the GAM the prediction of broadcasting field strengths is based on free-space propagation. However, measurements have shown that free-space propagation predictions may lead to a significant overestimation in a case where both the transmitting and receiving antennas are at low heights (for example, less than 150 m) above the ground.

In general, it is not possible to perform calculations which are more realistic than those based on free-space propagation because sufficient information is not readily available about the propagation path between the broadcasting station antenna and the test point. In particular, information about the ground profile along this path is required. However, where this information is available, for example from a terrain data bank, then more realistic field strength calculations may be made. For the reasons given earlier, it is to be expected that the field strength values calculated by a more detailed method, in particular for propagation paths with a restricted ground clearance, will be significantly lower than the values given using free-space propagation only. Under those circumstances, more detailed field strength calculation methods will result in a significant reduction in potential incompatibility.

## 2.2 Test point considerations

When undertaking a detailed compatibility analysis for any test point at which the GAM has indicated a potential incompatibility, care should be taken to check the validity of the test point in relation to the aeronautical service volume. Because the GAM generates test points automatically, it is possible that some test points will coincide with locations where, in accordance with published aeronautical documentation:

– aircraft are not able to fly because of natural or man-made obstructions;

– aircraft are not permitted to fly because of specific flight restrictions;

– pilots are advised not to use the aeronautical navigation facility because it is known to give unreliable results in a particular area.

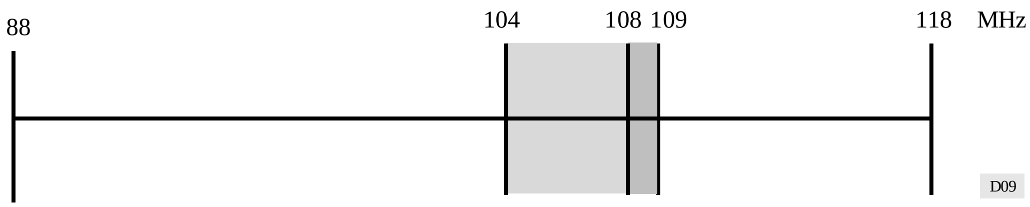
In addition, there can be circumstances where the test points generated by the GAM lie below and therefore outside the service volume of a VOR. This is particularly likely to occur with lower power VOR installations.

## 2.3 Considerations for coordinated stations

A very large number of aeronautical and broadcasting stations have been coordinated between administrations using compatibility criteria other than those contained in Annex 1. In particular, in Region 1 and certain countries in Region 3, the Geneva 1984 criteria have been widely used for many years. Calculations made using the GAM with the B1 interference criteria for the Montreal receiver given in Annex 1 will show less potential interference than calculations made using the Geneva 1984 criteria in most cases; however, there will be cases where more potential interference will be calculated. The frequency ranges for aeronautical and broadcasting stations where more potential interference may be calculated are shown shaded in Fig. 9. Because some worst-case assumptions are an inherent part of the GAM, it is to be expected that in a large majority of the cases where the GAM indicates more potential interference, a more detailed compatibility assessment, taking account of the proposals in this Annex, will show that in practice there will be no reduction in compatibility. In particular, the use of realistic aeronautical and broadcasting field strengths, rather than minimum or free-space values, respectively, will provide a significant reduction in calculated potential interference.

FIGURE 9

**Spectrum chart for VHF/FM and ILS/VOR bands**




The frequency range within which the Montreal receiver may show more potential B1 interference than the GE84 receiver is shown shaded.

There may be cases where the more detailed analysis is not able to restore the compatibility to the values previously calculated. If the incompatibilities are confirmed, for example by flight tests, the relevant administration(s) must take the necessary steps to ensure compatibility.

## 2.4 Consideration of operating stations

Because the GAM is intended to calculate all significant potential incompatibilities within an aeronautical service volume, a number of worst-case assumptions were included. There is thus likely to be an over-estimation of potential interference and it may be found that the GAM indicates potential interference in situations where the relevant aeronautical and broadcasting stations are all operating and no interference problem appears to exist in practice. Such situations should be examined as they may provide useful information which will lead to an improvement of the assessment method.

## 3 Multiple interference

In a case where measured values, or reasonably accurate predictions of the wanted and unwanted field strengths are available, account must be taken of multiple intermodulation products, for each interference mode. This may be done by using the power sum of the individual interference margins, IM, at a given test point.

The total interference margin, *IM* (dB), is given by:

$$IM = 10 \log \left( \sum_{i=1}^{N} 10^{(IM_i / 10)} \right) \tag{29}$$

where:

$N$: number of individual interference margins

$IM_i$: value of *i*th interference margin.

## 4 Detailed compatibility assessment

Tests have shown that as predicted values for data are replaced by measured values, the results of compatibility calculations approach closer to those found in practice. When all data values in the analysis are replaced by measured values, the results of compatibility calculations compare closely with the results from correlation flight tests.

Thus in a detailed, case-by-case compatibility assessment, the most accurate data values available should be used. In particular, the accuracy of compatibility calculations will be improved by:

– replacing the predicted horizontal radiation pattern for a broadcasting antenna with the pattern measured for the antenna as installed;

– replacing the predicted vertical radiation pattern for a broadcasting antenna (see Annex 2, § 4) with the pattern measured for the antenna as installed;

– in the case of ILS, calculate the wanted signal level by the two-ray method of § 3.2.2.3.1 rather than by the interpolation method of § 3.2.2.3.2;

– replacing the predicted horizontal radiation pattern for the ILS localizer transmitting antenna with the measured pattern for the antenna as installed.

Further improvements to the accuracy of the compatibility calculations will be obtained by:

– replacing predicted levels of broadcasting signals with values measured during flight trials;

– replacing predicted levels of aeronautical signals with values measured during flight trials.

In the latter case, it has been found possible to measure ILS field strengths along the centre line of the runway and make use of a predicted or measured horizontal radiation pattern for the ILS localizer antenna to obtain accurate values for field strengths at locations off the extended runway centre line. This avoids the need to make extensive measurements throughout the ILS DOC.

## 5 Practical verification process

Verification of the results of compatibility assessment calculations may be obtained by:

– measuring the levels of broadcasting signals at the input to an aeronautical receiver;

– measuring the level of an aeronautical signal at the input to its receiver;

– using an aeronautical receiver with characteristics which have been measured by bench tests, taking into account an adequate range of broadcasting and aeronautical signal levels and frequencies and taking into account the difference between these measured characteristics and those used in the theoretical calculations;

– using an aircraft receiving antenna with a radiation pattern and frequency response which have been measured and taking into account the difference between these measured characteristics and those used in the theoretical calculations.

It is particularly important to use an aircraft receiving antenna with measured characteristics if it is desired to make an accurate comparison between predicted field strength values for broadcasting stations and the levels of their signals at the input to an aeronautical receiver.

## 6 Summary

Improved accuracy may be obtained from a compatibility assessment calculation by using more accurate data, for example:

– measured broadcasting antenna horizontal radiation patterns;

– measured broadcasting antenna vertical radiation patterns;

– an improved prediction of the ILS field strength;

– a measured ILS localizer transmitting antenna horizontal radiation pattern.

Verification of a compatibility assessment calculation may be obtained by using:

– measured levels of broadcasting signals;

– measured levels of aeronautical signals;

– an aeronautical receiver with measured characteristics;

– an aircraft receiving antenna with measured radiation pattern and frequency response characteristics.

ANNEX 4

# Definitions

## Aeronautical Information Publication (AIP)

A document published by a Provider State describing, among other things, the characteristics and DOC of aeronautical facilities.

## Antenna corrections

These are the reductions in effective radiated power (e.r.p.) on specified azimuthal bearings and elevation angles relative to the value of e.r.p. in the direction of maximum radiation. They are normally specified as horizontal and vertical corrections in dB.

## COM

A two-way (air-ground) radiocommunication system operating in the band 118-137 MHz.

## Course deflection current

The output of the receiver which is fed to the pilot's indicator and to the autopilot. For the ILS localizer receiver, it provides left/right guidance proportional to the DDM of the 90 Hz and 150 Hz signals for a given angular displacement from runway centre line. For a VOR receiver, it provides left/right guidance proportional to the phase difference of two 30 Hz signals.

## Course line

It is the projection onto the horizontal plane of the path that an aircraft would fly while following an ILS localizer receiver indicator showing zero course deflection (i.e. DDM = 0). For normal ILS approaches, the course line should be identical to the extended runway centre line (see Fig. 1).

## Course sector

A sector in the horizontal plane originating from the ILS localizer antenna, containing the course line and limited by the full scale fly-left and full scale fly-right deflection of the ILS localizer receiver indicator. Full scale indicator deflection is equivalent to ± 150 μA course deflection current (DDM = 0.155).

## Cut-off value

The minimum power level of a broadcasting signal at the input to an aeronautical receiver to which this signal is considered to form a potential source of Type B1 interference.

## Designated Operational Coverage (DOC)

The volume inside which the aeronautical service operational requirements are met; this is the coverage volume promulgated in aeronautical documents.

## Difference in Depth of Modulation (DDM)

The depth of modulation is the ratio of the amplitude of the modulation of the 90 Hz or 150 Hz signal to the carrier amplitude. The DDM is the modulation depth of the stronger signal minus the modulation depth of the weaker signal.

## Distance and distance calculation

Where two locations are separated by more than 100 km, then the distance between them is calculated as the shorter great-circle ground distance. For distances less than 100 km, the height of the broadcasting transmitter antenna and the height of the test point are taken into account and if there is a line-of-sight path between them, the slant path distance is calculated.

## Effective Earth radius

An effective Earth radius of 4/3 times the true value is used for distance calculations.

## Elevation angle

The angle relative to the horizontal between two locations (positive above horizontal), using the effective Earth radius value defined above (see Fig. 6).

## Flag

A visual warning device which is displayed in the pilot's indicator associated with an ILS localizer or VOR receiver, indicating when the receiver is inoperative, not operating satisfactorily or when the signal level or the quality of the received signal falls below acceptable values.

## Front course sector

The course sector which encompasses the runway. The width of the front course sector is adjusted between 3° and 6° (normally 5°) so that the distance between a full scale fly-left deflection and a full scale fly-right deflection of an ILS localizer receiver indicator would equate to a width of approximately 210 m at the runway threshold (see Fig. 1).

## Future immunity aeronautical receivers

Receivers which at least meet the immunity to Type B interference as specified in ICAO Annex 10. As of 1 January 1998, all receivers in use shall be considered to have this degree of immunity. These receivers are also referred to as 1998 ICAO Annex 10 receivers.

## Glide path

The descent profile for a runway, normally 3°, provided by an ILS glide path transmitter and antenna system operating in the band 329.3-335.0 MHz.

## ICAO Annex 10

"International Standards, Recommended Practices and Procedures for Air Navigation Services: Aeronautical Telecommunications, Annex 10 to the Convention on International Civil Aviation, Volume I", International Civil Aviation Organization, Montreal, 1985.

## Instrument Landing System (ILS)

A radionavigation system specified in ICAO Annex 10 and agreed internationally as the current standard precision approach and landing aid for aircraft.

## ILS localizer

The component of an ILS which provides guidance in the horizontal plane. The transmitter with its associated antenna system produces a composite field pattern amplitude modulated with 90 Hz and 150 Hz. The radiation field pattern is such that when an observer faces the localizer from the approach end of the runway, the depth of modulation of the radio frequency carrier due to the 150 Hz tone predominates on the right-hand side and that due to the 90 Hz tone predominates on the left-hand side. The DDM is zero on the centre line of the runway and the extended runway centre line.

## Line-of-sight

Unobstructed path between two locations using the effective Earth radius defined above.

## Minimum separation distances

Minimum horizontal and vertical separation distances defining a zone around a broadcasting antenna within which aircraft would not normally fly.

## Montreal aeronautical receivers

An ILS localizer or VOR receiver whose characteristics are defined by the equations specified in § 4.2 of Annex 1. (These characteristics were agreed at the 1992 meeting of Task Group 12/1 in Montreal.) The term encompasses receivers previously termed "current immunity" and "poor immunity".

## Potential incompatibility

A potential incompatibility is considered to occur when the agreed protection criteria are not met at a test point.

## Provider state

The authority responsible for the provision of aeronautical services for a country or other specified area.

## Runway threshold

The beginning of that portion of the runway usable for landing.

## Runway touchdown point

A point on a runway defining the start of the surface where the aircraft wheels may make contact with the ground, normally inset from the runway threshold.

## Slant path distance

The shortest distance between two points above the Earth's surface (e.g., between a broadcasting antenna and a test point).

## Test point

A point for which a compatibility calculation is made. It is completely described by the parameters of geographical position and height.

## Trigger value

The minimum value of a FM broadcasting signal which, when applied to the input of an aeronautical receiver, is capable of initiating the generation of a third order intermodulation product of sufficient power to represent potential interference.

## VHF Omnidirectional Radio Range (VOR)

A short range (up to approximately 370 km or 200 nautical miles) aid to navigation which provides aircraft with a continuous and automatic presentation of bearing information from a known ground location.