



Report ITU-R M.2147
(05/2009)

**Assessment of potential interference
between FM broadcasting stations
operating in the band around 87-108 MHz
and aeronautical VDL Mode 4 systems
in the band 112-117.975 MHz
operating in the AM(R)S**

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***Note:** This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

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REPORT ITU-R M.2147

Assessment of potential interference between FM broadcasting stations operating in the band around 87-108 MHz and aeronautical VDL Mode 4 systems in the band 112-117.975 MHz operating in the AM(R)S*

(2009)

1 Introduction

1.1 At the ITU World Radiocommunication Conference 2007 (WRC-07) amendments to the ITU Radio Regulations included revised provisions for the use of the band 108-117.975 MHz. The Radio Regulations as adopted at this conference stipulate:

“5.197A Additional allocation: the band 108-117.975 MHz is also allocated on a primary basis to the aeronautical mobile (R) service, limited to systems operating in accordance with recognized international aeronautical standards. Such use shall be in accordance with Resolution **413 (Rev.WRC-07)**. The use of the band 108-112 MHz by the aeronautical mobile (R) service shall be limited to systems composed of ground-based transmitters and associated receivers that provide navigational information in support of air navigation functions in accordance with recognized international aeronautical standards. (WRC-07)”

1.1.1 Although prior to WRC-07 all systems in the aeronautical mobile (R) service could use the band 108-112 MHz, detailed criteria that would in particular address the potential of interference from the AM(R)S into FM broadcasting receivers, had only been implemented for the ICAO-standard ground based augmentation system (GBAS) and as such would need to be developed. In addition, ICAO had expressed its concerns about airborne AM(R)S transmitters using the band 108-112 MHz because of the potential interference into the ILS-Localizer. With the view to avoid unnecessary compatibility issues between such AM(R)S and FM broadcasting, the band available for airborne AM(R)S transmitters was reduced to 112-117.975 MHz, thus creating a “guardband” of 4 MHz between the two services.

1.2 In ITU-R criteria have been established on the compatibility between FM broadcasting stations operating in the band around 87-108 MHz and aeronautical radionavigation systems (the instrument landing system (ILS), the VHF omnidirectional radio range (VOR) and the ICAO ground-based augmentation system (GBAS)) operating in the band 108-117.975 MHz. These criteria are contained in Recommendations ITU-R SM.1009-1 (ILS and VOR) and ITU-R M.1841¹ (GBAS).

1.3 Plans have been established to start using the band 112-117.975 MHz for VDL Mode 4 operating under the AM(R)S allocation. ICAO Standards and Recommended Practices have been approved in 2001. This Report addresses compatibility issues between FM broadcasting stations and the VDL Mode 4 system. This Report follows closely the principles described in Recommendation ITU-R M.1841 because the FM immunity criteria that have been developed for VDL Mode 4 are identical to those for GBAS. Definitions, references and methodologies used in this Report are as contained in Recommendation ITU-R M.1841.

* This Report should be brought to the attention of Radiocommunication Study Group 6.

¹ 2007 version of Recommendation ITU-R M.1841 is used as a reference for purpose of this Report.

1.4 Resolution 413 (Rev.WRC-07) stipulates, *inter alia*, that AM(R)S systems operating in the band 108-117.975 MHz shall “.... not cause harmful interference to stations operating in the bands allocated to the broadcasting service in the band 87-108 MHz ...”. Furthermore, the ITU-R was invited to study any compatibility issues between the broadcasting service and the AM(R)S that may arise from the introduction of AM(R)S systems in the band 112-117.975 MHz.

1.5 The analysis below examines the interference mechanisms for type A1, A2, B1 and B2 interference, as detailed in Recommendation ITU-R M.1841.

2 Assessment of potential interference from FM broadcasting stations operating in the band around 87 to 108 MHz into aeronautical VDL Mode 4 systems in the band 112-117.975 MHz

2.1 Type A1 interference

2.1.1 Type A1 interference is caused by spurious emissions or intermodulation products caused by several FM broadcasting transmitters (normally operating from the same FM broadcasting transmitter site. These emissions fall within the passband of the aeronautical receivers and cannot be suppressed by these receivers.

2.1.2 For FM broadcasting transmitters, the spurious emission suppression from co-sited broadcasting transmitters in the aeronautical band 108-117.975 MHz assumed in the compatibility assessment as per Recommendation ITU-R M.1841 is as in Table 1:

TABLE 1
Spurious emission suppression

Maximum e.r.p. (dBW) for FM broadcasting transmitters	Suppression relative to maximum e.r.p. (dB)
≥ 48	85
30	76
≤ 30	46 + max. e.r.p. (dBW)

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

NOTE 2 – Implementation of FM broadcasting stations is expected to meet at least these values; these values are indicative.

2.1.3 The protection ratio that may be used to assess type A1 interference for VDL Mode 4 receivers is as in Table 2:

TABLE 2
Protection ratio that may be used to assess type A1 interference

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

NOTE 1 – These protection ratios for VDL Mode 4 are the same as for ILS, VOR and GBAS as referenced in Recommendations ITU-R SM.1009-1 and ITU-R M.1841.

2.1.4 Calculation of interference margin for type A1 interference (from co-sited broadcasting stations).

2.1.4.1 Paragraph 3.2.5 of Recommendation ITU-R M.1841 (equation (13)) shows that the type A1 interference margin should be calculated as:

$$IM = \max((E_i - S_i); \dots; (E_N - S_N)) + PR - E_w$$

where:

- IM*: A1 interference margin (IM = 0 implies no interference)
- N*: number of intermodulation components ($N = 2$ or 3)
- E_i*: field strength (dB(μV/m)) of the FM broadcasting transmission *i*
- S_i*: Type A1 suppression (dB) of broadcasting transmitter *i* (see Table 1)
- PR*: protection ratio as per Table 2 (in the analysis below only the co-channel case whereby the intermodulation product coincides with the desired aeronautical frequency was used; this was considered to present the worst case)
- E_w*: field strength (dB(μV/m)) of the aeronautical signal (at least 37.5 dB(μV/m) for VDL Mode 4).

2.1.4.2 *E_i* can be calculated as follows (equation (1) in Recommendation ITU-R M.1841):

$$E_i = 76.9 + P - 20 \log d$$

where:

- E_i*: field strength (dB(μV/m)) of the (unwanted) FM broadcasting transmission *i*
- P*: maximum e.r.p. (dBW) of the broadcasting station
- d*: distance between the broadcasting station and the aeronautical receiver (km).

NOTE 1 – In the following calculations no correction for vertical or horizontal radiation polarization has been considered; maximum coupling of the broadcasting signal with the aeronautical antenna has been assumed.

2.1.4.3 Equation (13) of Recommendation ITU-R M.1841 can be rewritten as follows:

$$IM = (76.9 + P - 20 \log d - S) + PR - E_w$$

2.1.4.3.1 In the case where:

the radiated power of the FM broadcasting transmitter $P = 100$ kW

type A1 suppression $S = 85$ dB

the spurious emission or intermodulation product coincides with the aeronautical frequency in use ($PR = 14$ dB) and

E_w is 37.5 dB(μ V/m),

the interference margin of 0 dB will be reached at a distance of 8.3 km.

2.1.4.3.2 This is too large and in cases where the situation of a transmitter site generated intermodulation product falls on a VDL Mode 4 frequency in operational use, additional suppression is necessary. As an example, for the situation described in § 2.4.3.1 above, a total suppression of the intermodulation product with 103.4 dB would reduce the interference distance from the transmitter site to 1 km. In comparison, under the same circumstances, the following spurious suppression would be needed for:

ILS ($E_w = 32$ dB(μ V/m)) 108.9 dB

VOR ($E_w = 39$ dB(μ V/m)) 101.9 dB

GBAS ($E_w = 46.6$ dB(μ V/m)) 94.3 dB.

This implies that the magnitude of A1 spurious suppression would be in the same order of magnitude as is required for VOR systems.

It should be noted that the necessary type A1 suppression to protect VDL Mode 4 is not required as a general measure. It would only apply to those cases where no alternative for a VDL Mode 4 frequency assignment in an area close to the FM broadcasting transmitter is possible. As such, the occurrence of type A1 interference is considered a local implementation matter.

2.1.4.3.3 Mitigating factors that can be considered include the consideration of the vertical antenna diagram of the broadcasting transmitter and the efficiency of the FM broadcasting antenna to radiate signals above 112 MHz. It should also be considered that this type of interference only can occur in cases where two broadcasting antennas (or transmitters) are co-located and the radiated signal of one transmitter can be coupled into the other antenna (or when one FM-broadcasting antenna is used for two transmitters).

2.1.4.3.4 As a result, it was concluded that Type A1 interference is a local issue that can be solved by technical means, including frequency assignment planning, as an implementation measure. For the protection of VDL Mode 4 receivers on board an aircraft therefore no specific ITU material (such as an ITU-R Recommendation) needs to be developed. However, the possibility of Type A1 interference needs to be brought to the attention of the aviation and the broadcasting community.

2.2 Type A2 interference

2.2.1 Type A2 interference is caused by non-negligible components of the FM signal in aeronautical bands. This type of interference will in practice only occur from broadcasting transmitters using frequencies near 108 MHz and will only interfere with aeronautical mobile services operating on frequencies near 108 MHz.

2.2.2 For VDL mode 4, when operating above 112 MHz, type A2 interference is not expected.

2.3 Type B1 interference

2.3.1 Type B1 interference is interference caused by third order intermodulation products that are generated inside an aeronautical receiver resulting from (high powered) broadcasting transmissions outside the aeronautical frequency band. (See also Recommendation ITU-R M.1841, § 2.2.2.) These intermodulation products can involve two or three broadcasting frequencies.

2.3.2 For the assessment of type B1 interference (two frequencies, $f_{intermod} = 2f_1 - f_2$).

The following formula can be used (equation (4) in Recommendation ITU-R M.1841):

$$2 \left\{ N_1 - 20 \log \left(\frac{\max(0.4; 108.1 - f_1)}{0.4} \right) \right\} + N_2 - 20 \log \left(\frac{\max(0.4; 108.1 - f_2)}{0.4} \right) + K - L_c + S > 0$$

2.3.3 From formulas (1) and (2) in Recommendation ITU-R M.1841 the value for N (which is the signal level (dBm) at the input of the aeronautical receiver can be calculated as follows:

$$N = 76.9 + P - 20 \log d - 118 - L_s - L(f) - L_a$$

In these formulas:

- N (N_1 or N_2): broadcasting signal level (dBm) at the input of the aeronautical receiver
- P : maximum e.r.p. (dBW) of the broadcasting station
- d : distance from the broadcasting station to the aeronautical receiver
- 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
- $K = 78$
- L_c : correction factor (dB) to account for changes in wanted signal level
- $S = 3$ dB.

Formula above can be rewritten when $L_s = 3.5$ dB and $L_a = 9$ dB as:

$$N = P - 20 \log d - 53.6 - L(f)$$

when $P = 100$ kW (or 50 (dBW)):

$$N = -3.6 - 20 \log d - L(f)$$

2.3.3.1 In the following calculations, no account has been taken for differences in polarization of the broadcasting and aeronautical signals and the correction factor L_c is assumed to be 0 (no correction in case the actual wanted signal is higher than the minimum assumed in the formula (13) of Recommendation ITU-R M.1841).

2.3.3.2 Calculation of minimum separation distance from a broadcasting station with the following characteristics:

$$f_1 = 107.9 \text{ MHz}$$

$$f_2 = 103.8 \text{ MHz}$$

$$P_1 = P_2 = 100 \text{ kW (50 dBW)}.$$

Antennas are co-located; the combination of f_1 and f_2 is the worst case capable of generating an intermodulation product on the aeronautical frequency 112 MHz.

2.3.3.2.1 With these characteristics the minimum separation distance between the FM broadcasting transmitter station and the VDL Mode 4 receiver, necessary to meet the compatibility requirements, is 5.5 km.

2.3.4 This separation distance is considered to be too large. However, as indicated in § 1.1 above, AM(R)S (except those for the transmission of navigational information by ground-based transmitters (such as GBAS)) systems cannot use the band 108-112 MHz. Therefore it would require, *inter alia*, the front end of the VDL Mode 4 receiver to reject RF signals below 112 MHz. (The receiver should be designed to receive signals in the band 112-137 MHz instead of 118-137 MHz.)

2.3.4.1 With this change, formula (13) of Recommendation ITU-R M.1841 should include as reference frequency in the frequency dependent element 112 MHz instead of 108.1 MHz and can be rewritten as follows:

$$2 \left\{ N_1 - 20 \log \left(\frac{112 - f_1}{0.4} \right) \right\} + N_2 - 20 \log \left(\frac{112 - f_2}{0.4} \right) + K - L_c + S > 0$$

With this change, the separation distance between VDL Mode 4 receivers and FM broadcasting transmitters (co-located, each transmitter radiating 100 kW, the separation distance from the FM transmitter site and the VDL Mode 4 receiver would be reduced to about 550 m. For two FM broadcasting stations with an e.r.p. of 300 kW, this distance would increase to about 960 m.

As this has been considered as the worst case, interference from FM broadcasting stations into VDL Mode 4 receivers with RF pass band filtering for VDL Mode 4 signals not below 112 MHz, type B1 interference has been considered to not cause a threat that would cause harmful interference to the reception of VDL Mode 4 signals.

2.4 Type B2 interference

2.4.1 Type B2 interference is characterized as desensitization of the RF section of an aeronautical receiver when it is subject to overloading by one or more high powered broadcasting transmissions. Annex 10, Volume III, Part I, § 6.9.5.6.2.2 provides criteria for the VDL receiver. It has been observed that currently different criteria apply for the use of VDL Mode 4 frequencies below 112 MHz and above 112 MHz.

2.4.2 In accordance with formula (10) of Recommendation ITU-R M.1841, for VDL frequencies from 112-117.975 MHz, the maximum level of a broadcasting signal at the input of a VDL Mode 4 receiver can be established as follows:

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