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COMPATIBILITY ANALYSIS OF RADIO ASTRONOMY IN THE FREQUENCY RANGE 608 - 614 MHZ WITH DVB-T

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COMPATIBILITY ANALYSIS OF RADIO ASTRONOMY IN THE FREQUENCY RANGE 608 - 614 MHz WITH DVB-T

1 INTRODUCTION

In the frequency range 608 - 614 MHz (in TV channel 38) there is a secondary allocation to the Radio Astronomy Service (RAS) used for observations in a number of European countries[1]. The use of this band for RAS is also addressed in footnote 5.149 of the ITU RR[2].

Taking into account the regulatory status of the secondary RAS allocation vs the primary Broadcasting Service (BS) allocation in this band, methods of compatibility assessments with the primary DVB-T may be provided for information.

2 PROTECTION CRITERIA

The recommended protection criteria to be used for radio astronomical measurements are given in Rec. ITU-R RA.769-2. For this study the following levels for Single dish and Very Long Baseline Interferometry (VLBI)) RAS sites from Rec. ITU-R RA. 769-2 were used:

Observation mode	**Protection levels**
• Single dish:	-253 dB(W/m^{2}Hz) assuming an integration time of 2000 s;
• VLBI:	-212 dB(W/m^{2}Hz) assuming an integration time of 10 μs.

For interferometery observation, the protection criterion is derived using the method given in Recommendation ITU-R RA.769-2, the parameters given in this recommendation and assuming an integration time of 1 second, this gives:

-236 dB(W/m^{2}Hz) assuming an integration time of 1 s.

The protection criterion depends on the observation mode, which must be defined for each RAS site.

The maximum allowed (interfering) power flux density depends on the bandwidth.

2.1 Maximum interfering power flux density

In the case of DVB-T, the total bandwidth of 6 MHz (68 dBHz) of the RAS band is subjected to interference. In this case the levels of maximum power flux density to be protected are:

- Single dish: -185 dB(W/m^2)
- Interferometery: -168 dB(W/m^2) and
- VLBI: -144 dB(W/m^2)

2.2 Maximum interfering field strength

The maximum power flux densities in the band 608-614 MHz can be converted to the following values of maximum interfering field strength at the RAS site.

- Single dish : -39 dBμV/m
- Interferometery: -22 dBμV/m and
- VLBI: +2 dBμV/m

The above values refer only to the case of one interferer at a time.

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[1] **5.306** *Additional allocation:* in Region 1, except in the African Broadcasting Area (see Nos. **5.10** to **5.13**), and in Region 3, the band 608-614 MHz is also allocated to the radio astronomy service on a secondary basis.

[2] According to **5.149**, "administrations are urged to take all practicable steps to protect the radio astronomy service operating in the band 608-614 MHz from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 4.5 and 4.6 and Article 29)."

3 CO-CHANNEL INTERFERENCE

3.1 Relative interfering power level

DVB-T transmitter spectrum masks are defined in the CEPT Chester Agreement. In this study the critical case mask is used (the mask for the non-critical cases is provided in Annex 1). The breakpoints may be then defined as follows:

Relative frequency MHz	Relative level dB
-12.0	-87.2
-6.0	-62.2
-4.2	-50.2
-3.9	0
+3.9	0
+4.2	-50.2
+6.0	-62.2
+12.0	-87.2

For the reference transmission power level of 0 dBW (ERP) in the UHF channel 38, the interfering power in the RAS band 608-614 MHz is then equal to -1.2dBW (ERP).

The relative interfering power levels are 1.2 dB below nominal transmission levels.

3.2 Maximum allowable DVB-T field strengths in channel 38

For any DVB-T transmitter operating in UHF TV channel 38 the maximum allowed nominal field strengths at the RAS receiving sites are as follows:

- Single dish: -39 + 1.2 = -37.8 dBμV/m
- Interferometery: -22 + 1.2 = -20.8 dBμV/m and
- VLBI: +2 + 1.2 = 3.2 dBμV/m.

4 ADJACENT CHANNEL INTERFERENCE

4.1 Relative interfering power level

Using the DVB-T transmitter mask described in section 3.1, the interfering power in adjacent channels can be determined by integration using a 4 kHz integration step (ref. ITU-R Rec. SM.1541-1/Annex 1/Appendix 1).

For the reference radiated power level of 0 dBW (ERP) in one of the adjacent channels 37 or 39 (it is assumed that the DVB-T transmissions are operating without frequency offset), the interfering power P_i in the RAS band 608-614 MHz is equal to:

- P_i (interference from channel 37) = - 70.8 dBW (ERP)
- P_i (interference from channel 39) = - 41.0 dBW (ERP)

4.2 Maximum allowable DVB-T field strengths in channels 37 and 39

For a DVB-T transmitter operating in TV **channel 37** maximum allowed nominal interfering field strength at the RAS site are equal to:

- Single dish: -39 + 70.8 = 31.8 dBμV/m
- Interferometery: -22 + 70.8 = 48.8 dBμV/m and
- VLBI: +2 + 70.8 = 72.8 dBμV/m

for DVB-T transmitter operating in TV **channel 39** maximum allowed nominal interfering field strength at the RAS site are equal to:

- Single dish: -39 + 41 = 2 dBμV/m
- Interferometery: -22 + 41 = 19 dBμV/m and
- VLBI: +2 + 41 = 43 dBμV/m

5 SEPARATION DISTANCES

The minimum separation distances to be respected can be derived using the propagation curves presented in the Recommendation ITU-R P.1546. These distances have been estimated under the assumption that the value of the harmful interference threshold is exceeded for not more than 10% of the time due to variable propagation conditions. In addition the following assumptions were made:

- DVB-T radiated power = 1 kW (ERP)
- Transmitting antenna height = 150 m.
- Receiving antenna height = 50 m

Using these antenna height parameters, the height of the ground cover surrounding the receiving antenna as being equal 10 m, and a Fresnel clearance path length for 611 MHz of 55 km, a (field-strength) correction for receiving antenna height of 14.3 dB is calculated. This correction needs to be subtracted from the maximum allowed nominal field strength at the radio astronomy receiving site.

The following separation distances have been calculated using Recommendation P.1546 (611MHz, land path, 10% of the time, 50% locations).

- co-channel situation

nominal transmitting frequency = UHF TV channel 38

- Single dish to DVB-T transmitter: = 797 km
- Interferometery to DVB-T transmitter: = 606 km
- VLBI to DVB-T transmitter: = 340 km

- adjacent channel situation

nominal transmitting frequency = UHF TV channel 37 or 39

for **channel 37**:

- Single dish to DVB-T transmitter: = 124 km
- Interferometery to DVB-T transmitter: = 60 km
- VLBI to DVB-T transmitter: = 23 km

for **channel 39**:

- Single dish to DVB-T transmitter: = 351 km
- Interferometery to DVB-T transmitter: = 208 km
- VLBI to DVB-T transmitter: = 75 km

For the second adjacent TV channels (36, 40) the minimum separation distances can be calculated, but the values of those distances will be significantly smaller than for the first adjacent channels and can be used only for national purposes. For international co-ordination the interference from the DVB-T transmitters operating in TV channels 37, 38, 39 should be taken into account only.

For **other transmission powers and antenna heights and mixed paths** the separation distances can be found using **Rec. ITU-R P.1546**.

6 PROTECTION RATIOS FOR RADIO ASTRONOMY INTERFERED WITH BY DVB-T

For compatibility assessment between RAS and DVB-T the protection ratios for different frequency separations are provided. The protection curve can be derived based on maximum interfering field strengths described in 2.2 and on DVB-T transmitters' spectrum masks.

The protection ratios given below assume the use of the critical DVB-T transmitter spectrum mask. In cases where a less critical mask is in use, it would be necessary to derive new protection ratio values taking account of the differences between critical and non-critical masks (Annex 1 provides protection ratio for the non-critical cases). This only applies to DVB-T transmitters operating in channels other than 38, in particular those operating in TV channels 37 and 39.

For the calculations, the following parameters should be used:

- Centre frequency of RAS: 611 MHz (centre of band 608-614 MHz)
- Receiving antenna discrimination RD: 0 dB (for all azimuths)
- Percentage of time that the protection requirements for RAS are exceeded due to variable propagation conditions: 10%

Field strength to be protected and assumed values for receiving antenna heights:

Radio Astronomy service type	Service identifier	Field strength to be protected	Assumed receiving antenna height (m)
Single dish	XA	-39 dBμV/m	50
Interferometery	XB	-22 dBμV/m	50
VLBI	XC	+2 dBμV/m	50

Protection ratios:

Δf (MHz)	+/-9	+/-8	+/-7	+/-6	+/-5	+/-4	+/-3	+/-2	+/-1	0
PR (dB)	-71	-66	-41	-9	-6	-4	-3	-2	-1	-1

7 DETAILED COMPUTERISED COMPATIBILITY ANALYSIS

For detailed calculations the following parameters must be specified for each RAS site:

- Service identifier as described in Chester 1997 Multilateral Coordination Agreement (XA, XB or XC)
- Latitude and longitude of Radio Observatory,
- Site height above ground level.

Information about European RAS stations operating in the band 608-614 MHz is available on the CRAF's (Committee for Radio Astronomy Frequencies) website (www.astron.nl/craf).

The compatibility analysis for every planned DVB-T station in TV channels 37, 38, 39 should be done taking into account the maximum interfering field strengths, the protection ratios table and location of the RAS observatory sites operating in the band 608-614 MHz. The interfering field strength of DVB-T should be calculated according to the Rec. ITU-R P.1546 for 50% of location and 10% of time.

8 CONCLUSIONS

The separation distances between RAS observatories operating over TV channel 38 and DVB-T transmitters, operating in TV channels 37, 38, and 39, mainly depend on the type of RAS observations, and on the radiated power of the DVB-T transmitters.

In this report, the separation distances between the three types of RAS observations and DVB-T transmitters operating in TV channels 37, 38, and 39 were calculated for a certain set of parameters as an example. For other transmitter powers, antenna heights and mixed propagation paths the separation distances can be calculated using the method and values of field strength to be protected as shown in this report.

ANNEX 1

PROTECTION RATIOS FOR RAS INTERFERED WITH BY DVB-T'S NON-CRITICAL CASE

A.1. Introduction

Section 6 of the Report provides Protection Ratios (PR) for the sensitive cases. Those PR assume the use of the critical DVB-T transmitter spectrum mask. However, the non-critical case may also be notified by administrations. This annex gives the protection ratios to be applied for the case of non-critical DVB-T spectrum mask.

A.2. Symmetrical spectrum masks for DVB-T

Two symmetrical spectrum masks for DVB-T have been included in the Chester 97 Agreement and will be then used in the planning process of the RRC-06. The break points of the masks for an 8 MHz DVB-T signal for the non-critical cases are shown in Table A.1.

8 MHz channels	
	Non-critical cases
Relative frequency (MHz)	**Relative level (dB)**
–12	–77.2
–6	–52.2
–4.2	–40.2
–3.9	–0
+3.9	–0
+4.2	–40.2
+6	–52.2
+12	–77.2

Table A.1: Break points of the non-critical mask for an 8 MHz DVB-T signal

A.3. Protection ratios for RAS interfered with DVB-T – non critical case

For compatibility assessment between RAS and DVB-T the PR for different frequency offsets are provided. The protection curve can be derived based on maximum interfering field strengths and on DVB-T transmitters' spectrum masks, using a 4 kHz integration step. In the case of use of the non-critical DVB-T spectrum mask the following protection ratio values should be used:

Δf (MHz)	+/-9	+/-8	+/-7	+/-6	+/-5	+/-4	+/-3	+/-2	+/-1	0
PR (dB)	-61	-56	-37	-9	-6	-4	-3	-2	-1	-1

Those values have been calculating taking into account the same assumptions as for the calculations using the critical DVB-T spectrum mask. Separation distances may then be derived using the same methodology and assumptions as those used in section 5.