Cross-border interference between broadcasting and mobile services

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Abstract – *This paper briefly introduces the cross-border interference issues between DVB-T broadcasting and mobile UMTS services, as a consequence of the WRC-07 which co-allocated the band 790-862 MHz (channels 61 to 69) to mobile services from June 2015. The basic criteria of broadcast network planning for DVB-T reception and the required interference protection from mobile UMTS services operating in the same frequency band as DVB-T are described in this paper. The aim of this paper is to show the interference conditions and coordination procedures in the case of using the frequency band 790-862 MHz for mobile services before the above mentioned June 2015.*

Keywords – *interference between broadcasting and mobile, cross-border coordination*

1. INTRODUCTION

DVB-T (Digital Video Broadcasting – Terrestrial) [1] is a widespread digital video broadcasting system that is currently in use in most of the European countries. The transition from analogue to digital video broadcasting has already finished in some of the more developed countries in Europe, and will end in the rest of Europe by the year 2015.

The frequency bands that are allocated for the DVB-T system in Europe are: band III in VHF and bands IV and V in UHF. For the time being it is possible to use 49 channels in UHF frequency band, from channel 21 to channel 69. However, on the WRC-07 (World Radiocommunication Conference 2007) [2] the band 790 – 862 MHz (which corresponds to channels 61 to 69) was co-allocated to mobile services (except aeronautical mobile), on a primary basis from June 2015 in ITU Region 1 with an identification of the band IMT (International Mobile Telecommunications). There is a great interest from a number of mobile operators and mobile equipment manufacturers to use this part of the frequency spectrum before 2015 as propagation conditions are far better because of the use of the lower frequency band and consequently the costs for building mobile networks would be lower.

A number of countries in Europe use the channels above channel 60 for DVB-T broadcasting during the transition period from analogue to digital television broadcasting mainly because this part of the spectrum was previously unused in these countries. However, some of the countries would like to implement IMT services (mainly UMTS services) in the frequency band 790 – 862 MHz before June 2015, which opens a whole new interference scenario between DVB-T broadcasting and mobile UMTS services operating in the same frequency band. This situation is especially challenging in the case of two bordering countries, of which one uses DVB-T in their allotment/assignment adjacent to the border, and the other plans to use the same frequency band for mobile services. It is important to coordinate such cases on a bilateral or multilateral level.

2. DVB-T NETWORK PLANNING AND CROSS BORDER COORDINATION PRINCIPLES

The DVB-T standard [1] is currently in use in Croatia alongside analogue television transmission, as Croatia is currently in the transition from analogue to digital television broadcasting, which is expected to end by the year 2011. The analogue and digital television networks in Croatia have been carefully planned, as to insure a non-interfering and simultaneous operation of both of these networks.

2.1. Basic parameters of DVB-T networks

One of the main principles of broadcast network planning is to ensure that the maximal interference reduction is obtained when a specific channel/frequency is assigned to a transmitter [3], and it is achieved via these two conditions:

- Territory coverage should be maximized using a single frequency transmission;
- Harmful interference should be minimized outside the service area, as to achieve the conditions for channel re-usage as close as possible.

The first condition is defined as minimal electrical field strength which is necessary to achieve the proper quality of service for the signal decoding on the reception location:

Minimal usage field – $F_{k,min}$ dB(μV/m). (1)

The values of the minimal usage field - $F_{k,min}$ for the DVB-T system are specified in the ITU-R recommendation BT.1368-3 [4].

For achieving the second condition the minimal signal-to-interference ratio *C/I* (Carrier-to-Interference) is used. This minimal *C/I* ratio is also called protection ratio (PR) and it is necessary for achieving the reception of the signal and proper decoding procedures. If the harmful interference level is above the wanted signal level on the receiver input, the reception will not be possible.

In the DVB-T system one of the most important issues in the planning process is the fast degradation of the picture quality. Fast degradation of the picture quality appears as a consequence of a too low signal level. Consequently, the field strength calculations should be made with a high percentage of covered locations (between 70% and 99% location probability) [5].

The digital television broadcasting system uses the COFDM modulation technique [6]. Several parameters of the COFDM can be set accordingly to network requirements and these are: carrier modulation, code rate and guard interval. A combination of modulation, code rate and guard interval is called the DVB-T system variant.

The choice of the system variant depends on the DVB-T network planning process. Each of the system variants defines it own minimal usage field strengths, protection ratios and maximum data rates. The possibility to choose different interference resistance of a DVB-T system variant and corresponding maximum data rate makes it possible to plan the DVB-T network for different reception modes. Table 1 shows the most common DVB-T planning configurations with regards to reception mode, modulation, code rate and location probability.

Table 1. Common DVB-T planning configurations

Reception mode	Modulation	Code rate	Location probability
Fixed	64-QAM	2/3	95%
	64-QAM	3/4	95%
Portable outdoor	16-QAM	2/3	95%
	64-QAM	2/3	95%
Mobile	QPSK	2/3	99%
	16-QAM	1/2	99%
Portable indoor	16-QAM	2/3	70%
	16-QAM	2/3	95%

To simplify the network planning process Reference Planning Configurations (RPC's) are defined in the GE06 Final acts [7]. They represent the most often planning configurations. Table 2 shows the three different Reference Planning Configurations, their corresponding minimal usage field - $F_{k,min}$ and reception conditions.

Table 2. Reference Planning Configurations

Planning Configuration	$F_{k,min}$ dB(μV/m) at 10 m	Reception condition
RPC-1	56	Fixed
RPC-2	78	Portable outdoor, mobile
RPC-3	88	Portable indoor

2.2. Coordination trigger field strength

In the bilateral or multilateral coordination process there are several technical parameters that are used for the interference calculations. One of them is the trigger field strength value at the border of the affected countries. Transmitters that do not exceed the trigger value at the border may be operated without further coordination or assessment procedures. The coordination trigger field strength values for the protection of the broadcasting service, as well for the protection of the mobile service are defined by the GE06 agreement [7] and are shown in table 3. The trigger values have been normalized with 8 MHz, which corresponds to the segment of one TV channel. The NA and NB are the System type codes (STC) for the mobile service, where NA represents a land mobile system, and NB represents a generic mobile system.

Table 3. Coordination trigger field strength

Coordination trigger field strength for the protection of the broadcasting service at 10 m	
Protection of the analogue TV	22 dBμV/m/8 MHz at the border
Protection of the digital TV	25 dBμV/m/8 MHz at the border
Coordination trigger field strength for the protection of the mobile service at 10 m	
Protection of the mobile stations	49,2 dBμV/m/8 MHz (NB)
Protection of the base stations	11,6 dBμV/m/8 MHz (NA) 8,2 dBμV/m/8 MHz (NB)

2.3. Protection of the broadcasting service

For the protection of the broadcasting service, more precise interference field strength - F_{int}

determination method can be used. The formula which is used in this method is defined in the GE06 Final acts [7]:

$$F_{int} = F_{med} + f_{corr} - PR - CF \qquad (2)$$

In this formula F_{med} (equivalent to $F_{k,min}$) represents the minimum median field strength of the relevant broadcasting system (for example 56 dBµV/m for RPC 1), f_{corr} represents the frequency correction [7], PR is the relevant protection ratio [8] and CF represents the relevant combined location correction factor [7].

An example of interference field strength trigger values for the UMTS system as interferer into a DVB-T system at an operating frequency of 826 MHz, 10 m height and 1% of time are shown in table 4.

Table 4. Interference field strength trigger values for UMTS as interferer into DVB-T at 826 MHz

Planning configuration	F_{med} dBµ V/m	f_{corr} dB	PR dB	CF dB	F_{int} dBµ V/m
RPC-1	56	2.1	19.1	12.8	26.2
RPC-2	78	3.1	21.4	12.8	46.9
RPC-3	88	3.1	24.4	15.7	51.0

As shown in table 4, the trigger value of the interference field strength ranges from 26.2 dBµV/m for RPC-1 to 51 dBµV/m in the case of the RPC3 configuration. The RPC-1 interference field strength value is the worst case and it determines the coordination trigger field strength for DVB-T.

2.4. Protection of the mobile service

There are three cases in the interference calculations for the protection of the mobile service:

- Mobile service is using a designated downlink;
- Mobile service is using a designated uplink;
- Mobile service is using a shared uplink and downlink.

In the case of the mobile service using a designated downlink, the coordination field strength trigger value is 49,2 dBµV/m in 8 MHz at 10 m for NA and NB systems considered in the GE06 Agreement [7]. There is a possibility for the effected administrations to agree on interference values much higher than the GE06 coordination trigger value, but the result of the coordination process depends heavily on the broadcasting reception mode.

In the case of the mobile service using a designated uplink, the interference scenario is particularly difficult since high power high tower broadcasting transmitters may be co-channel with highly sensitive base station receivers. The interference trigger field strength for base stations is about 10 dBµV/m in 8 MHz at 10 m. In such a situation, interference may be unavoidable at the border if a frequency is used for broadcasting to cover an allotment adjacent to the border, with a resulting interference trigger level which may be exceeded far from the borders.

3. SIMULATION RESULTS

Fig. 1 shows the sum of interference field strength levels of the Hungarian DVB-T transmitters on channel 65 (826 MHz) in their ZALSOM allotment which is bordering the north-west part of Croatia. The shown thresholds of 49.2 dBµV/m (in black) and 11.6 dBµV/m (in brown) represent the trigger values for the protection of the mobile service.

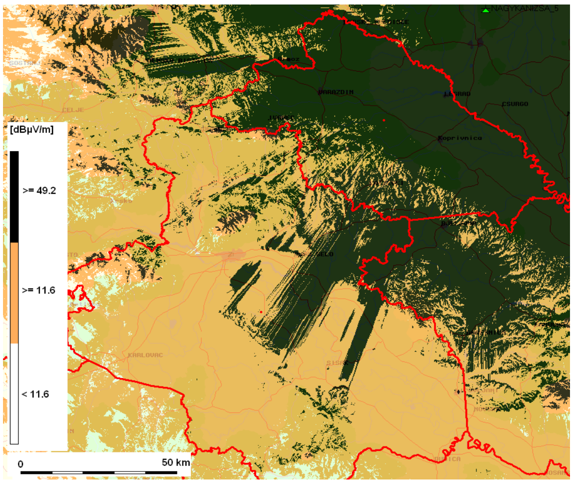

Fig. 1. Interference sum of Hungarian DVB-T transmitters on channel 65 (L=50, T=1)

Two cases have been simulated in order to research the possibility to implement a mobile UMTS system on channels 61 to 69 before June 2015 in Croatia. For each case there were five test points set on which the corresponding field strength values of the UMTS mobile system - F_{UMTS} and the broadcasting DVB-T system - F_{DVB-T} were compared. The values are shown in table 5.

Table 5. Test point field strength values

Test point	Longitude	Latitude	F_{UMTS} dBµV/m	F_{DVB-T} dBµV/m
T01	016E4119	46N2605	37.4	59.6
T02	016E4627	46N2303	42.4	87.0
T03	016E5213	46N2105	48.4	87.0
T04	016E5636	46N1452	56.4	75.1
T05	017E0914	46N1019	43.4	82.2
T06	015E5915	45N4931	70.4	35.5
T07	016E0253	45N4955	64.4	34.5
T08	016E0137	45N4847	60.4	36.1
T09	015E5912	45N4741	61.4	38.2
T10	016E0010	45N5030	66.4	26.7

The first case simulates the worst case scenario, where the base stations in the mobile service are operating on the same channel as DVB-T transmitters used to cover areas adjacent to the border. It is shown in Fig. 2.

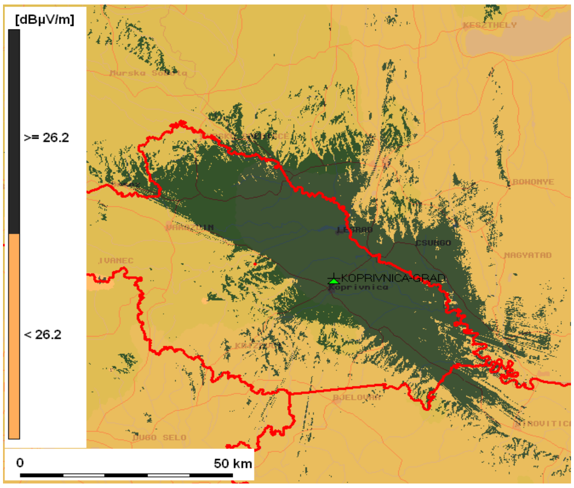

Fig. 2. Interference field level of Croatian UMTS base station in Koprivnica on channel 65 (L=50, T=1)

The simulated mobile UMTS base station shown in Fig. 2 is situated in the city of Koprivnica. The black colour represents the interference field strength values that are over 26.2 dBμV/m, which is the trigger field strength for the RPC-1 DVB-T planning configuration. In table 5 test points T01 to T05 correspond to this case, and they have been placed alongside the border with Hungary. The field strength values of the DVB-T system are far greater then those of the UMTS system, therefore the mobile UMTS system would suffer severe interference, and it would not be possible to implement it before June 2015.

A more realistic implementation scenario of a mobile UMTS system operating on channel 65 in the city of Zagreb is shown in Fig. 3.

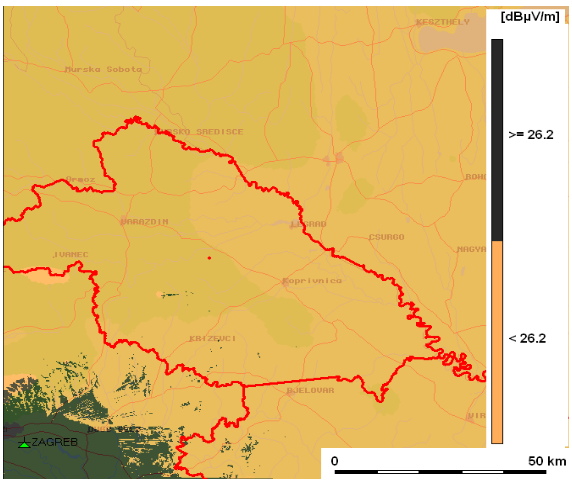

Fig. 3. Interference field level of Croatian UMTS base station in Zagreb on channel 65 (L=50, T=1)

Fig. 3 represents the interference field strength of a mobile UMTS base station situated in the city of Zagreb, which is approximately 80 kilometres away from the Hungarian border. Test points T06 to T10 in table 5 correspond to this case, and they have been placed inside the city of Zagreb. In this case it would be possible to implement the mobile UMTS system, as its corresponding interfering field strength does not exceed the trigger value of 26.2 dBμV/m at the border with Hungary. The interference field strength sum levels of the Hungarian DVB-T transmitters in the area of Zagreb are substantially lower and they would not interfere with the mobile UMTS station operating in Zagreb.

4. CONCLUSION

This paper shows two interference scenarios of the UMTS mobile system interfering into a DVB-T broadcasting system. The realistic scenario could be achieved at a distance closer then 80 kilometres from the border, by ensuring that at a reasonable distance beyond the border the interfering field strength from the DVB-T networks are as low as possible. Such interference reductions should be coordinated in detail among the affected administrations. Additional assessment of the influence of the new generation mobile systems (for example LTE) on the broadcasting DVB-T system should be taken.

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