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DRM DAYTIME MW TESTS FOR FREQUENCIES BELOW 1 MHz

Abstract

This report presents the study on the coverage extension of the DRM system developed after an extensive measurement campaign in the coverage area of an experimental transmitter installed in Milan (Italy). The study analyses the extension of the coverage based on a set of static measurements done during the year 2006. The conclusions given in this report focus on minimum field strength and minimum SNR thresholds and the evaluation of available ITU-R Recommendations in order to verify the predicted field strength coverage by a DRM transmitter.

Italy requests preparation of a Report on the results.

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1 Scope

During the last years, several studies have been carried out all over the world in order to evaluate the Digital Radio Mondiale (DRM) performance in medium wave bands for frequencies above 1 MHz.

In Italy, due to coming in force of a particular law on electromagnetic field strength, in which the derived limits differs a lot from the values reported in Recommendation ITU-R BS.1698, several analogue MW transmitters have been switched off. Such situation gave us the opportunity to start with digital DRM tests by the utilization of the site (antennas, combiner and final amplifier) left free from analogue transmission.

The first transmission site used for the field trial was located near Milan. We decided to provide initial field test on frequencies below 1 MHz. The chosen frequency was the same used in the past for RADIODUE network on 693 kHz.

2 Objectives

The main objectives of this study have been: the evaluation of the coverage of Digital Radio Mondiale (DRM) system using the medium wave band below 1 MHz and the determination of the maximum power compatible with Italian electromagnetic field restrictions. This objective has been based on an extensive far field measurement campaign, that was planned and carried out in the northern part of Italy, and near field evaluation.

The secondary objectives of this study have been the reception capability comparison between professional and commercial receivers, taking into account the figures indicated in Appendix 1 to Annex 1 to Recommendation ITU-R BS.1615.

These general objectives have been divided into several “operational” targets:

– determination of the receiving antennas for mobile and static reception, compatible with the figures indicated in Appendix 1 to Annex 1 to Recommendation ITU-R BS.1615;

– set up of transmitting configurations, measurement systems and acquisition data;

– evaluation of the maximum transmission power permitted by both transmitter features and compliance with the national law on electromagnetic field strength;

– evaluation of relation between field strength and signal to noise ratio (SNR) in different reception environments, based on actual field measurements;

– analysis of the influence of the environment on static reception coverage;

– study of the field strength distribution over the coverage area, in order to compare the measured values with the output of the currently used prediction method. The reference method should be the Recommendation ITU-R P.368-7;

– study of the mobile reception within the expected coverage area and identification of critical disturbances;

– identification, inside coverage area, of appropriate locations where to install fixed recording systems in order to evaluate long time sunrise and sunset effects on the coverage area and quality of reception.

3 Experimental transmitting system

The DRM signal has been broadcasted by RAIWAY's transmitting station situated in Siziano. RAIWAY is the company owned by RAI (Radio Televisione Italiana) in charge to manage the transmitting network. Siziano is located 20 kilometres far from Milan, in the south direction, and it is the main Italian site currently used to broadcast RAI's regular analogue MW signals. A summary of the features of this transmitting site can be found in Table 1 and Figure 1.

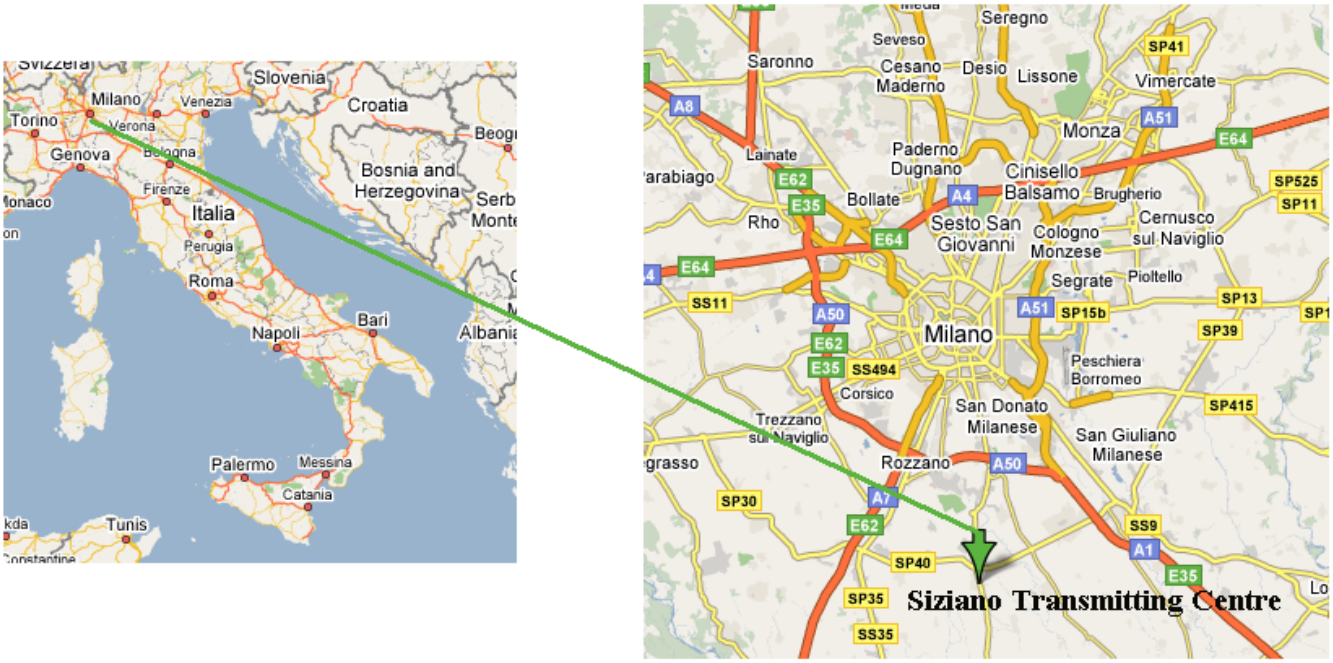
TABLE 1

Transmitting centre characteristics

Transmission centre	Siziano (Milan)
Broadcaster	RAI – Radio Televisione Italiana
Transmission centre coordinates	9º 10' E ; 45º 20' N
Frequency	693 kHz
Bandwidth	9 kHz
Radiating system	Vertical Dipole (148 mt. Heigh)
Transmission scheduling	24 hours per day

FIGURE 1

Transmitting centre location

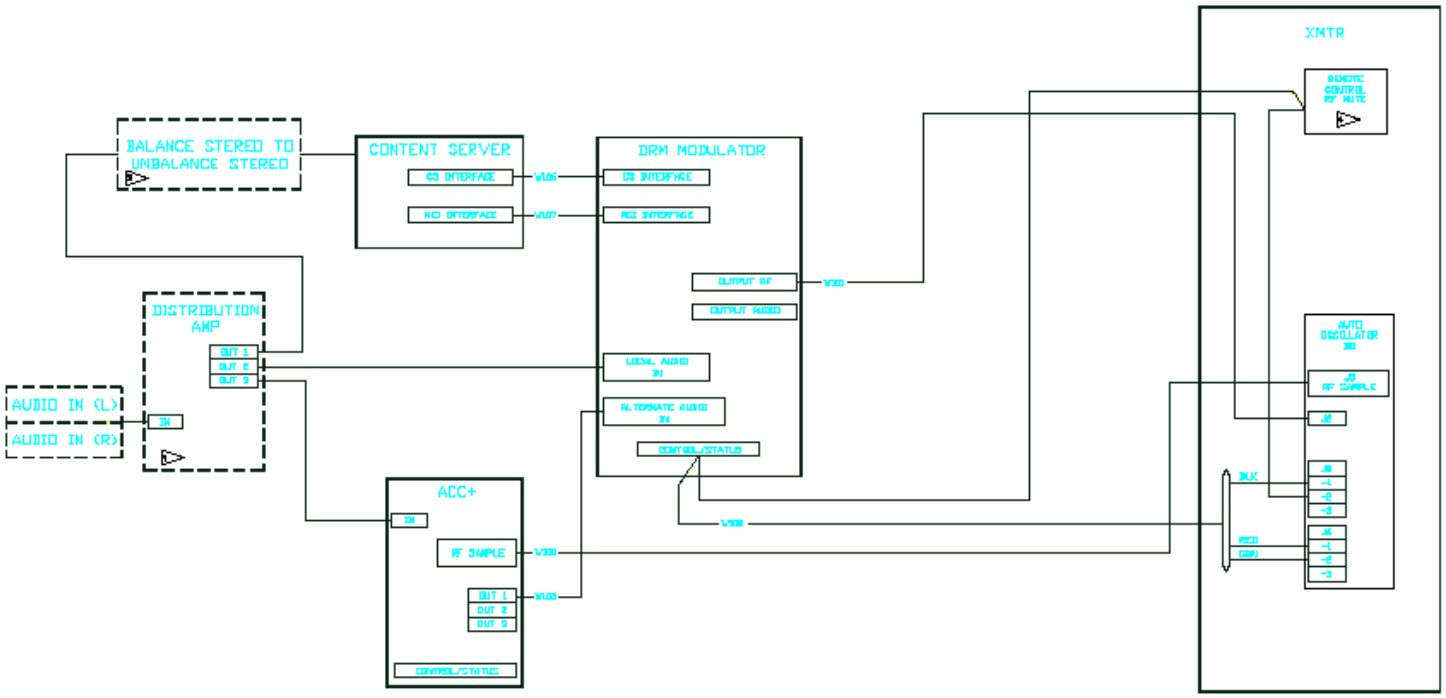


The radiating infrastructure is based on a vertical monopole, used in combination for analogue MW and digital DRM transmission, with a maximum gain of 0.8 dB on short vertical monopole. The installed transmitter is a modified Harris Corporation DX50 model. The equipment, already installed, has been adjusted to fulfil the Recommendation ITU-R BS.1615 radiated spectrum mask requirements. The DRM output power is 34 kW whereas the combined MW output power is 200 kW.

The DRM standard provides several configurable transmission parameters that allow many different DRM transmission modes with adjustable robustness against noise, multipath and interference. A summary of the features of this transmitting system can be found in Figure 2. The adopted Content Server is able to provide only one audio programme.

FIGURE 2

Transmitting system



In order to evaluate the whole daytime coverage area with a parametric stereo modulation, the mode in Table 2a (with a Bit Rate in Table 2b) was chosen for the first test.

TABLE 2a

Transmission modes - SNR

Modulation scheme	**Protection level No.**	**Average code rate**	**Robustness mode/spectrum occupancy type**			
			A/2 (9 kHz)	**B/3 (10 kHz)**	**C/3 (10 kHz)**	**D/3 (10 kHz)**
16-QAM	0	0.5	8.6	9.3	9.6	10.2
	1	0.62	10.7	11.3	11.6	12.1
64-QAM	**0**	**0.5**	**14.1**	14.7	15.1	15.9
	1	0.6	15.3	15.9	16.3	17.2
	2	0.71	17.1	17.7	18.1	19.1
	3	0.78	18.7	19.3	19.7	21.4

TABLE 2b

BitRate

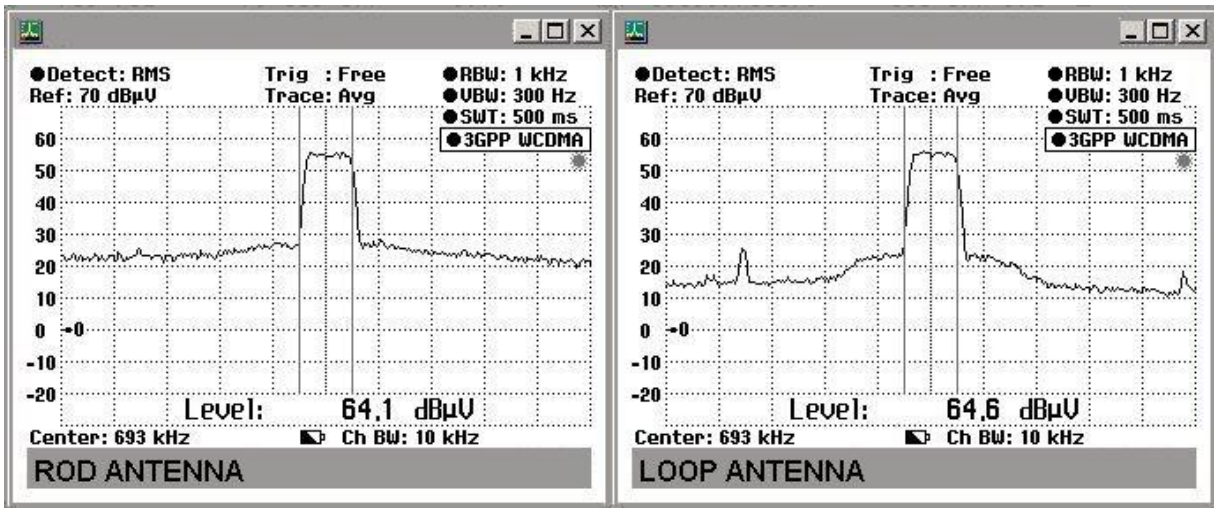
Table 4.2			Nominal Signal Bandwidth (kHz)					
Mode	MSC Modulation (nQAM)	Robustness level [1]	4.5	5.0	9.0	10.0	18.0	20.0
			Approx. available bit rate kb/s (equal error protection, standard mapping)					
A	64	Max.	9.4	10.6	19.7	22.1	40.9	45.8
		Min.	14.7	16.7	30.9	34.8	64.3	72.0
	16	Max.	6.3	7.1	13.1	14.8	27.3	30.6
		Min.	7.8	8.9	16.4	18.5	34.1	38.2
B	64	Max.	7.2	8.3	15.3	17.5	31.8	35.8
		Min.	11.3	13.0	24.1	27.5	50.0	56.1
	16	Max.	4.8	5.5	10.2	11.7	21.2	23.8
		Min.	6.0	6.9	12.8	14.6	26.5	29.8

4 Measurement system and methodology

4.1 Measurement system

The long time MW measurement experience of RAI Monitoring Centre suggested that the Rod antenna is not suitable for on vehicle measurements nor for fixed measurements (Figure 3).

FIGURE 3



The reason is related to the antenna factor and to the electrical discharge. In particular antenna factor for rod antenna is changing with environment. For that reason, a special double loop antenna for mobile field strength measurements was developed.

In the past, RAI made the evaluation of the coverage area of all its MW transmitters by measurements provided with equipped vehicle using omni directional loop antennas designed and built in its own laboratories (Figure 4). It has been only designed for field strength measurements and not for any kind of listening (in analogue MW transmission the border of the coverage area is given by 60 dBµV/m).

FIGURE 4

Unfortunately the noise figure of double loop, like for any kind of rod antenna, (see Table 3, representing the measurements made at the same point with different antenna types) didn't permit to match the figures indicated in Appendix 1 to Annex 1 to Recommendation ITU-R BS.1615 (Table 4).

TABLE 3

Comparison between antenna types

Antenna type	**Field Strength (dBµV/m)**	**SNR (dB)**	**Audio decoding**	**Antenna factor (dB)**
Loop	58,1	30,9	ok	20
Double Loop	58,8	4,0	Not ok	12
Rod	58,0	19,0	ok	15

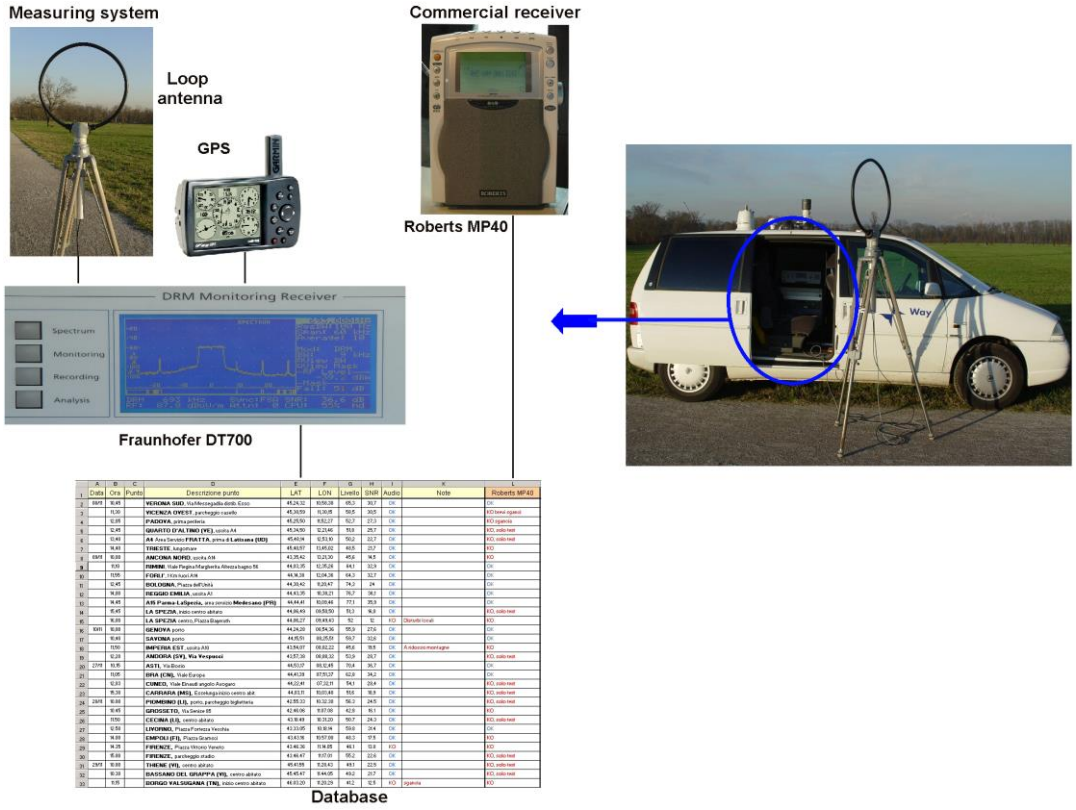
TABLE 4

<table>
<tr><th colspan="3"></th><th colspan="2">Double sideband (DSB) (AM)</th><th colspan="2">Digital</th></tr>
<tr><td colspan="3">1 Required receiving quality</td><td colspan="2">Audio frequency S/N:
26 dB with 30%
(–10.5 dB) modulation
(Rec. ITU-R BS.703)</td><td colspan="2">BER = 1 × 10^{–4}</td></tr>
<tr><td colspan="3">2 Required C/N for the above quality (dB)</td><td colspan="2">26 + 10.5 = 36.5</td><td colspan="2">x</td></tr>
<tr><td colspan="3">3 Receiver IF bandwidth (kHz)</td><td colspan="2">8</td><td colspan="2">10
(1 dB higher receiver intrinsic noise than DSB)</td></tr>
<tr><td rowspan="3">4 Receiver sensitivity for the above C/N (dB(µV/m))</td><td>LF</td><td>66</td><td rowspan="3">Required in Recommen-dation ITU-R BS.703</td><td>30.5 + x</td><td rowspan="3">(x dB above the receiver intrinsic noise)</td></tr>
<tr><td>MF</td><td>60</td><td>24.5 + x</td></tr>
<tr><td>HF</td><td>40</td><td>4.5 + x</td></tr>
<tr><td rowspan="3">5 Receiver intrinsic noise related to field strength, for the above sensitivity (dB(µV/m))</td><td>LF</td><td>29.5</td><td rowspan="3">(36.5 dB (C/N) below the sensitivity)</td><td>30.5</td><td rowspan="3">(1 dB higher than DSB)</td></tr>
<tr><td>MF</td><td>23.5</td><td>24.5</td></tr>
<tr><td>HF</td><td>3.5(1)</td><td>4.5</td></tr>
</table>

So, we started to develop an improved double loop antenna. In the meantime, only static measurement has been provided both inside the main towns and along the route connecting the towns itself. Each town was described with a number of points varying between 5 and 12.

The measurement vehicle was equipped as shown in Figure 5:

FIGURE 5
Measurement system



The acquisition system was composed of the fully characterized loop active antenna R&S HFH2-Z2 mounted on a tripod. The DRM monitoring receiver was composed by a Fraunhofer DT700 connected to a GPS position reference and a computer software to acquire and to store the following parameters:

– Location coordinates
– Time
– Signal strength at the input receiver in dBµV
– SNR
– Sync, FAC, SDC and Audio

Signal strength is converted into field strength by using the antenna factor.

4.2 Measurement methodology

The measurement campaign included only static measurements at both fixed locations inside towns and fixed points along routes connecting towns. In both cases, the routes and locations were selected according to environmental criteria in order to obtain results applicable to urban, suburban and rural coverage planning.

5 Measurement campaign

Starting from Milan, measurements were provided along 6 main directions:

– North direction, from Milan to central Alps;

– East direction, from Milan to Trieste, up to Slovenian border;
– South-East direction, from Milan to Ancona;
– South direction, from Milan to Liguria and to a part of Tuscany coast (Florence included);
– South-West direction from Milan to Cuneo, up to French border;
– West direction, from Milan to Turin and West Alps;

In some directions a comparison, in terms of audio decoding, has been performed between professional and commercial receivers.

A sample of data acquired in measurement points are reported in the following Table 5:

TABLE 5

Day	Time	Measurement point	LAT	LON	dBµV/m	SNR	Audio DT700	Audio Roberts MP40
08/11	10,45	**VERONA SUD**	45,24,32	10,58,38	65,3	30,7	OK	OK
	11,30	**VICENZA OVEST**	45,30,59	11,30,15	58,5	30,5	OK	NOT OK
	12,05	**PADOVA**, prima periferia	45,25,50	11,52,27	52,7	27,3	OK	NOT OK
	14,40	**TRIESTE**, lungomare	45,40,57	13,45,02	48,5	21,7	OK	NOT OK
09/11	10,00	**ANCONA NORD**, uscita A14	43,35,42	13,21,30	45,6	14,5	OK	NOT OK
	11,10	**RIMINI**, Regina Margherita	44,03,35	12,35,26	64,1	32,9	OK	OK
	11,55	**FORLI'**, 1 Km fuori A14	44,14,38	12,04,36	64,3	32,7	OK	OK
	12,45	**BOLOGNA**, Piazza dell'Unità	44,30,42	11,20,47	74,3	24	OK	OK
	14,00	**REGGIO EMILIA**, uscita A1	44,43,35	10,38,21	76,7	36,1	OK	OK
	15,45	**LA SPEZIA**, inizio centro abitato	44,06,49	09,50,50	51,3	16,8	OK	NOT OK, text only
10/11	10,00	**GENOVA** porto	44,24,28	08,54,36	55,9	27,6	OK	OK
	10,40	**SAVONA** porto	44,15,51	08,25,51	59,7	32,6	OK	OK
	11,50	**IMPERIA EST**, uscita A10	43,54,07	08,02,22	45,6	19,5	OK	NOT OK
	12,20	**ANDORA (SV), Via Vespucci**	43,57,38	08,08,32	53,9	28,7	OK	NOT OK, text only
27/11	10,15	**ASTI,** Via Bosio	44,53,17	08,12,45	70,4	36,7	OK	OK
	11,05	**BRA (CN),** Viale Europa	44,41,39	07,51,37	62,8	34,2	OK	OK
	12,03	**CUNEO,** Viale Einaudi	44,22,41	07,32,11	54,1	28,4	OK	NOT OK, text only
	15,30	**CARRARA (MS),**	44,03,11	10,03,48	51,6	18,9	OK	NOT OK, text only
28/11	10.00	**PIOMBINO (LI)**	42.55.33	10.32.30	56.3	24.5	OK	NOT OK, text only
	10.45	**GROSSETO,** Via Senise 85	42.46.06	11.07.08	42.8	16.1	OK	NOT OK
	12.50	**LIVORNO,** Piazza Fortezza	43.33.05	10.18.14	59.8	31.4	OK	OK
	14.00	**EMPOLI (FI),** Piazza Gramsci	43.43.16	10.57.00	48.3	17.5	OK	NOT OK
	15.00	**FIRENZE,** parcheggio stadio	43.46.47	11.17.01	55.2	22.6	OK	NOT OK, text only
29/11	10.00	**THIENE (VI),** centro abitato	45.41.55	11.28.43	49.1	22.5	OK	NOT OK, text only
	10.30	**BASSANO DEL GRAPPA (VI)**	45.45.47	11.44.05	49.2	21.7	OK	NOT OK, text only
	13.10	**ROVERETO NORD** Rotari	45.54.05	11.02.01	48.8	23.4	OK	NOT OK

The following map shows the measurement points on the border of the coverage area (Map 1):

MAP 1


SVIZZERA
DOMODOSSOLA
Liv. 49.6 dBµV
SNR 16.7
ZENNA
Liv. 43.6 dBµV
SNR 19.3
BORMIO
Liv. 39.9 dBµV
SNR 13.5
ROVERETO
Liv. 48.8 dBµV
SNR 23.4
MP40 NO
LATISANA
Liv. 50.2 dBµV
SNR 22.7
MP40 NO
CERESOLE R.
Liv. 46.1 dBµV
SNR 21.0
BRESCIA
Liv. 62.3 dBµV
SNR 33.5
MP40 OK
VICENZA
Liv. 58.5 dBµV
SNR 30.5
MP40 OK
QUARTO D'A.
Liv. 51.8 dBµV
SNR 25.7
MP40 NO
TRIESTE
Liv. 48.5 dBµV
SNR 21.7
MP40 NO
VERONA
Liv. 65.3 dBµV
SNR 30.7
MP40 OK
PADOVA
Liv. 52.7 dBµV
SNR 27.3
MP40 NO
MEDESANO
Liv. 77.1 dBµV
SNR 35.9
MP40 OK
REGGIO E.
Liv. 76.7 dBµV
SNR 36.1
MP40 OK
BRA
Liv. 62.8 dBµV
SNR 34.2
MP40 OK
SESTRIERE
Liv. 50.5 dBµV
SNR 25.3
GENOVA
Liv. 55.9 dBµV
SNR 27.6
MP40 OK
LA SPEZIA
Liv. 51.3 dBµV
SNR 16.8
MP40 NO
BOLOGNA
Liv. 74.3 dBµV
SNR 24
MP40 OK
FORLI'
Liv. 64.3 dBµV
SNR 32.7
MP40 OK
CUNEO
Liv. 54.1 dBµV
SNR 28.4
MP40 OK
SAVONA
Liv. 59.7 dBµV
SNR 32.6
MP40 OK
MASSA CAR.
Liv. 51.6 dBµV
SNR 18.9
MP40 NO
RIMINI
Liv. 64.1 dBµV
SNR 32.9
MP40 OK
ANDORA
Liv. 53.9 dBµV
SNR 28.7
MP40 NO
IMPERIA
Liv. 45.6 dBµV
SNR 19.5
MP40 NO
FIRENZE
Liv. 55.2 dBµV
SNR 22.6
MP40 NO
LIVORNO
Liv. 59.8 dBµV
SNR 31.4
MP40 OK
EMPOLI
Liv. 48.3 dBµV
SNR 17.5
MP40 NO
ANCONA
Liv. 45.6 dBµV
SNR 14.5
MP40 NO
CECINA
Liv. 50.7 dBµV
SNR 24.3
MP40 NO
PIOMBINO
Liv. 56.3 dBµV
SNR 24.5
MP40 NO
GROSSETO
Liv. 42.8 dBµV
SNR 16.1
MP40 NO
Vedi tabella

5.1 Global results

On the bases of acquired data we can reach the following determination:

The whole north-west part of Italy is completely covered with a signal strength with a level greater then the minimum one indicated in Recommendation ITU-R BS.1698 for the adopted configuration transmission parameters (38,6 dBµV/m). Moreover minimum SNR of 14,1 dB was exceeded in each measurement point, also in deep valleys. The extension of coverage area can be identified with national border (Sestriere, Ceresole Reale, Domodossola and Bormio). On the east direction the DRM signal is available up to Trieste on which seacoast the field strength is 48,5 dBµV/m with a SNR of 21,7 dB. Due to particular orographical and bad terrain conductivity the Brennero valley was covered only before the town of Trento which resulted not covered. In south-east direction DRM is available up to just before Ancona. In south direction DRM reaches all Liguria coast, and a part of Tuscany coast up to Grosseto town. The cities of Genova, Savona, La Spezia and Livorno are also covered.

On the tags of above Map 1, are reported the location where the commercial receiver was able/not able to decode DRM signal.

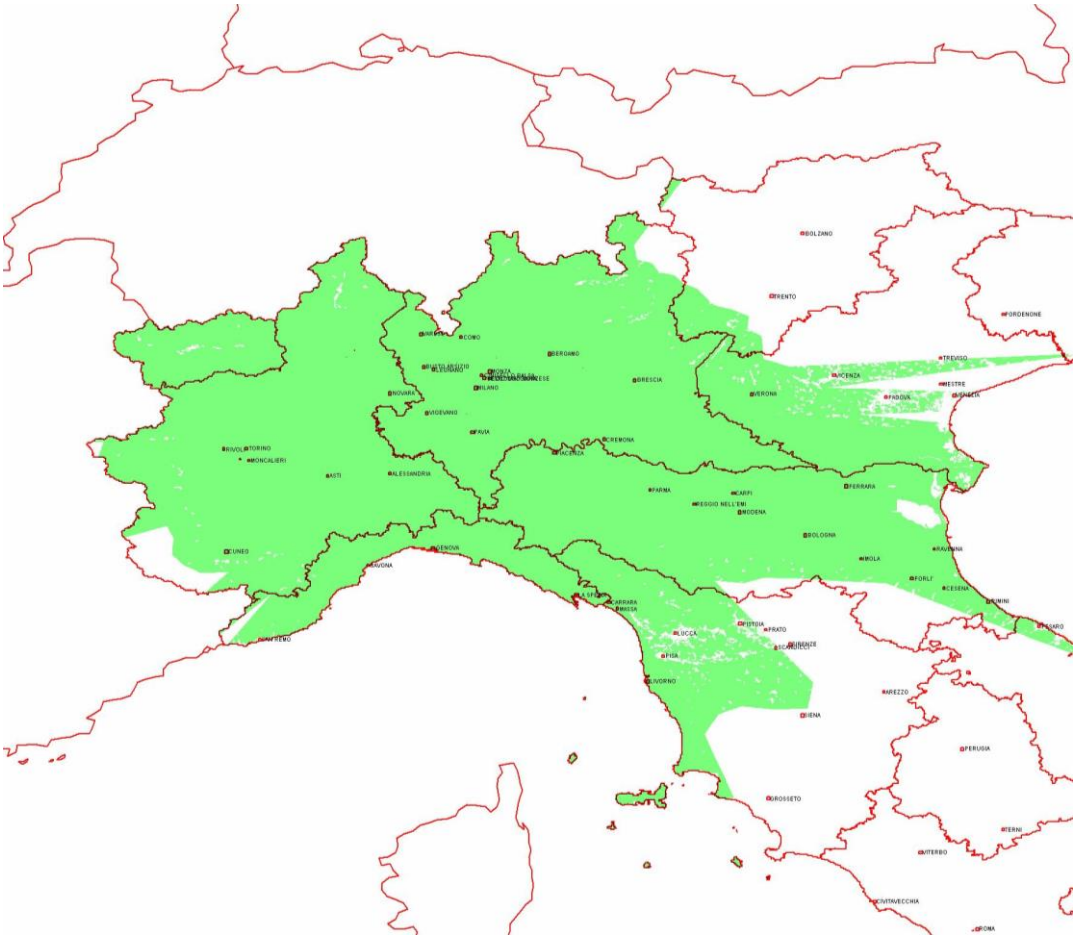
The whole coverage results are also reported on the following Map 2, where the smallest areas are concerning the part of coverage area in which both commercial and professional receivers were able to decode DRM signal. The largest part of the area is concerning the part of coverage area in which only professional receiver was able to decode DRM signal.

MAP 2

Measured coverage area

Following is reported the predicted area (Map 3):

MAP 3
Predicted coverage area



The service area shown on Map 3 is computed on the base of 45 dBµV/m for towns below 1,000 living persons and of 53 dBµV/m for towns with more than 1,000 living persons.

At the moment, about 150 static measurement points were verified.

Some data analysis was done in order to identify locations where reception was not available because of local particular situations:

– in the centre town of Turin, 125 Km far from the transmitter, in 1 of 12 measurement points the performance of DRM signal has been damaged by an electric feeder for public transport. In that point was recorded a SNR of 13,4 dB with a signal strength of 52,1 dBµV/m and no audio decoding;

– northern from Milan, at the beginning of Valtellina valley (93 km far from the transmitter) some orographical situations and bad terrain conductivity cause low signal strength (35,7 dBµV/m) and SNR (8,5 dB). Travelling along the valley route the signal and SNR come back to increase up to Bormio city, 170 km far from the transmitter.

During day time no important broadcasting interference situations were recorded in the whole predicted and measured coverage area.

As can be easily noted, measured and predicted area match quite well.

5.2 Future steps

At the moment RaiWay is installing automatic systems in some of its regional departments on the border of covering area in order to make a continuative monitoring. The task is to verify the quality of the service during all daytime, to verify the night time situation and to make a comparison between different transmission modes.

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