Radiocommunication Study Groups

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Vatican City State, Italy

FIELD TRIAL IN ROME ON THE POSSIBLE USE OF THE DRM+ SYSTEM IN VHF BAND II TO MIGRATE THE FM SOUND BROADCASTING SERVICE TO DIGITAL TECHNOLOGY

In December 2011 Vatican Radio carried out some broadcasting tests of DRM+[1] in the VHF Band II at 103.8 MHz. The aim of the tests was to verify the performance of DRM+ in a difficult interference scenario such as the FM VHF band II in Rome and to check the compatibility of the digital technology with existing antenna arrays having complex RF coupling systems such as the one located in the Vatican.

The frequency used was assigned to the Vatican in the GE84 Agreement and was chosen for two main reasons: it is not used during a few timeslots in the morning and it suffers from some strong interferences coming from stations operating at 103.7 MHz and 104.00 MHz located close to Rome (some of those interfering stations in some points within the 103.8 MHz FM service area do not comply with the protection ratios specified in Recommendation ITU-R BS.412.9[2]).

The tests were carried out taking into account the normal programs schedule. During the tests the digital transmitter was connected to the antenna feeder via a changeover, leaving the analogue transmitter in stand-by. The antenna array is a complex system: four FM transmitters at different power levels share the same antenna with elliptical polarization and omni-directional horizontal radiation pattern.

This contribution details the results of the test and some relevant considerations.

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1 Defined as System G in Recommendation ITU-R BS.1114.

2 For further information see Figure 1 of Recommendation ITU-R BS.412-9.

1 Description of the installation

A low power transmitter was installed in the transmitting building entitled to Pope Leone XIII [N41°54’13.83” E12°27’0.11”] located in the Vatican City (Fig. 1). The position has been identified as CVA in all the maps in this document.

FIGURE 1

FM station in the Vatican

FIGURE 2

DRM+ Transmitter

The DRM+ transmitter was composed by a linear power amplifier NAUTEL model VS1 300W RMS with the corresponding exciter and a digital modulator RFmondial model LV6M (Fig. 2). The modulator was fed with a DRM+ multiplex generated by a Fraunhofer DRM Content Server R5 operating in the Transmitting Centre of Santa Maria di Galeria located about 20 km outside Rome. The DRM+ multiplex was sent to the transmitter via a private Ethernet network link. The test was carried out at 200 W RMS complying with the DRM+ transmitter spectrum mask.

FIGURE 3

Particular of one transmitting element

The power, frequency, channel bandwidth and multiplex characteristics are given in the tables below:

TABLE 1

DRM Channel description; content server configuration

Frequency	103.8 MHz
Power	200 W RMS
Antenna	10 bays
Antenna hor. beam	Omni
Polarization	Elliptical
Gain (vert. comp.)	8.18 dBd
Gain (hor. Comp.)	7.44 dBd
Power split. (V/H)	0.70/0.30
Channel bandwidth	100 kHz

TABLE 2

Configured services on the DRM Multiplex

DRM channel BW	100 kHz
MUX ref. ID	Test DRM+
Timeslot. (UTC)	800-1 200
Robustness	MODE E
Channel BW	100 kHz
MSC	4QAM
Protection level	EEP PL=0 [0.25]
SDC	4QAM
Max net bit rate	37 200 bps
Unused bit rate	0bps

TABLE 3

Service identification	Vatican DRM+
Audio codec	AAC[3]
Audio mode	Full Stereo
SBR	ON
Sampling rate	24 kHz
Audio bitrate	36 880 bps
AFS	NO
Text message	320 bps

3 AAC, Advanced Audio Coding

The antenna was manufactured by “SIRA ANTENNE” in the nineties. Each bay is composed of four 2x3 elements crossed YAGI installed on the external sides of the square-section mast.
A complex RF routing system composed of combiners, filter cavities and directional couplers permits proper insulation among all the transmitters and adequate power splitting for polarization diversity.

Four different FM transmitters are normally operating on 93.3 MHz, 96.3 MHz, 103.8 MHz and 105 MHz at different power levels. The antenna feeding system permitted to disconnect the analogue transmitter operating at 103.8 MHz and connect the digital one. The analogue transmitter was switched off during the tests. The tuning of the RF routing system was not modified to optimize the signal transfer from the transmitter to the antenna.

FIGURE 4

Antenna control panel

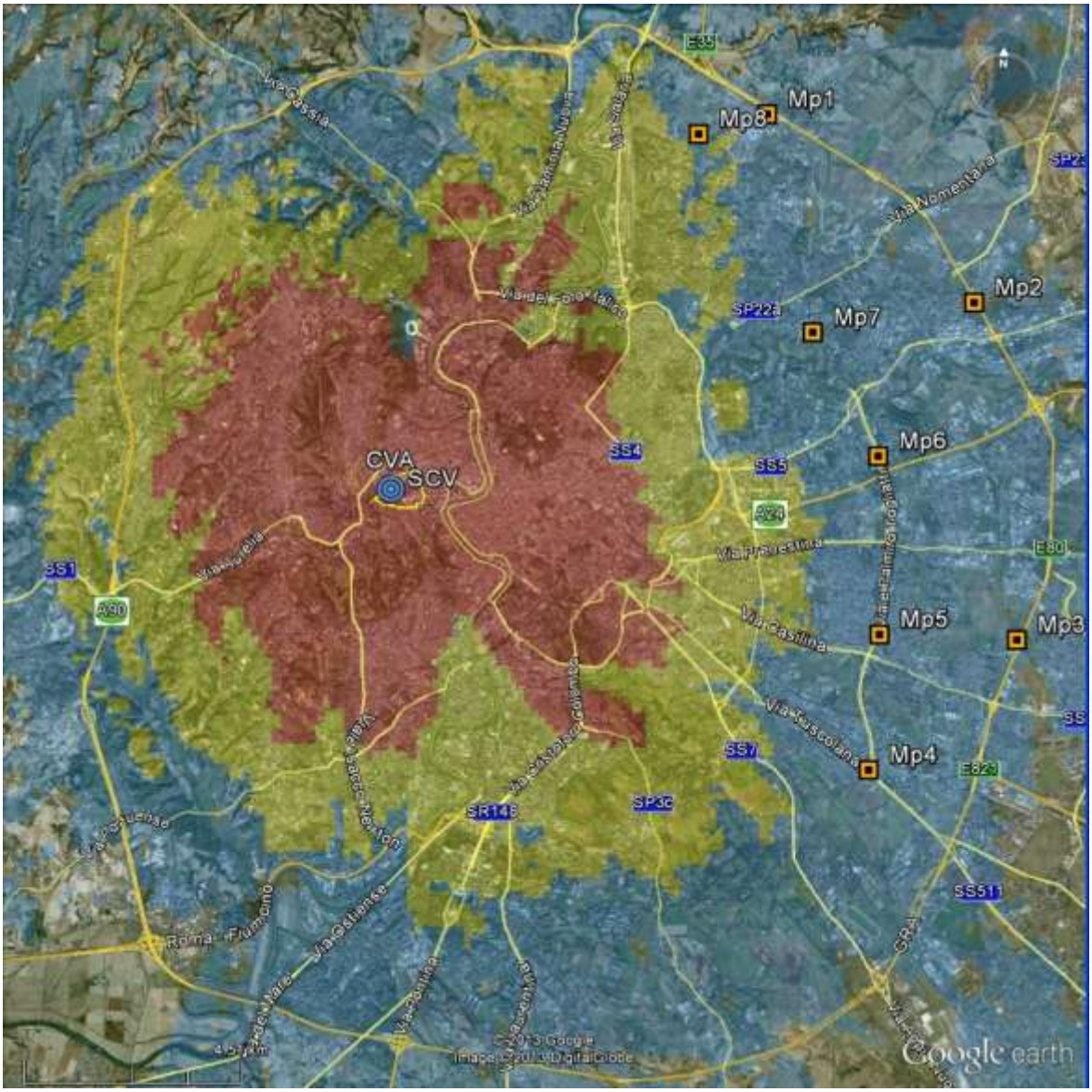
2 The existing FM service

The 103.8 MHz analogue FM service is currently operated at 9 kW; Map 1 shows the prediction of the field strength vertical component 10m above the ground. Due to the congestion of the FM band in Rome the effective service area for portable reception could be considered unconditioned only in the area identified in yellow or red; in other areas (in cyan) the coverage depends on the particular reception condition (indoor/outdoor, fixed/mobile/portable), in those areas the listening experience is quite poor due to splats coming from interfering stations operating from transmitting locations higher than the Vatican. The interference scenario has been monitored in 8 different points indicated as Mp1…Mp8 on the map below. The closer interferer is a station operating with a low power transmitter at 103.7 MHz from Vermicino, located 20 km from the Vatican in the SE

direction. Another interferer operating at low power on 103.9 MHz is located over Tivoli (in the E direction) and another one operating at high power at 104 MHz is located in the SE direction, having Rome as target service area.

MAP 1

The current analogue FM service



Colour legend of Map 1:

EM > 90 dBµV/m	EM > 82 dBµV/m	EM > 74 dBµV/m

Table 4 shows the signal strength ratios measured in the monitoring points considered:

TABLE 4

	103.8 MHz	**103.5 MHz**	**103.7 MHz**	**104.0 MHz**
	dBµV	**Int.-Ref. dB**	**Int.-Ref. dB**	**Int.-Ref. dB**
Mp1	55.8	3.5	–9.5	6.4
Mp2	58	15.2	–12.2	11.9
Mp3	63	15.3	–2.8	11.3
Mp4	59.8	14.6	–11.2	7.1
Mp5	53.8	–5.3	–10.3	0.9
Mp6	56.6	–4.1	–0.7	–8.8
Mp6	61.7	–1.2	–14.8	1
Mp8	63.9	–2	–16.1	–7.4

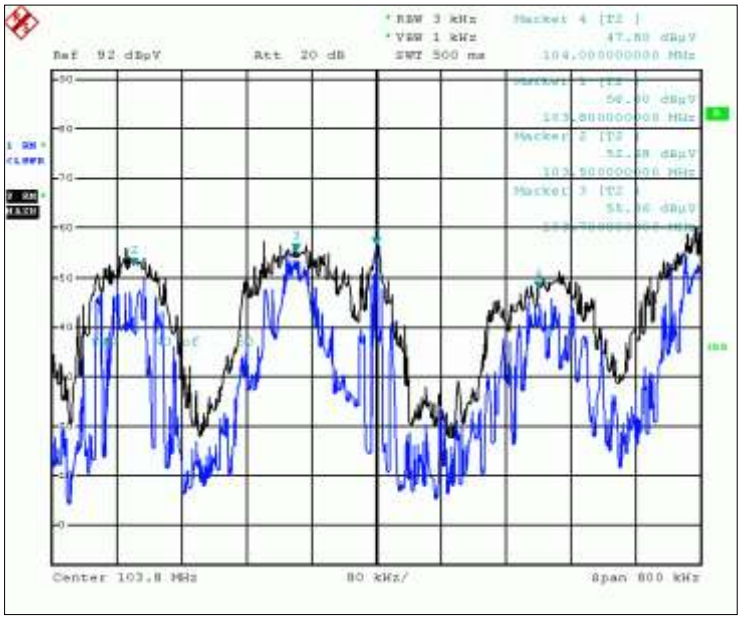
The first column shows the RF voltages measured at the receiver in dBµV of the reference signal at 103.8 MHz. The other columns display the difference between the interfering signal and the reference one.

The relative protection ratio as given in Recommendation ITU-R BS.412.-9 is satisfied only in few points[4]. Figure 5 displays, as example, the interference scenario measured in Mp6.

[4] See Figure 1 of Recommendation ITU-R BS.412-9, case stereophonic broadcasting steady interference.

FIGURE 5

Spectrum plot taken in Mp6



3 The tests and the results

The measurements were performed by Vatican Radio using the following equipment:

RFMondial DRM+ Test Receiver connected to GPS.

Log File containing all necessary data such as geographical, electromagnetic and audio errors, with one record for each DRM Frame.

Kathrein stilo antenna (model 510351), physical length 79 cm measured according to the manual.

Rhode Schwarz ESPI Test Receiver.

Fiat “Scudo” minivan with antennas, DC power system and on-board inverter.

An ad hoc ground plane was realized on the car roof.

The “Centro Nazionale Controllo Emissioni Radioelettriche Roma” department of Italian “Ministero dello Sviluppo Economico”, attended one day session of measurements.

FIGURE 6

Measurement vehicle

The monitoring sessions examined the mobile reception of the 103.8 MHz signal on different paths likely to represent the reception of the signal in the main target area. The results are detailed below.

Map 2 shows audio reception along three different paths representative of Rome:

a) the main centre;

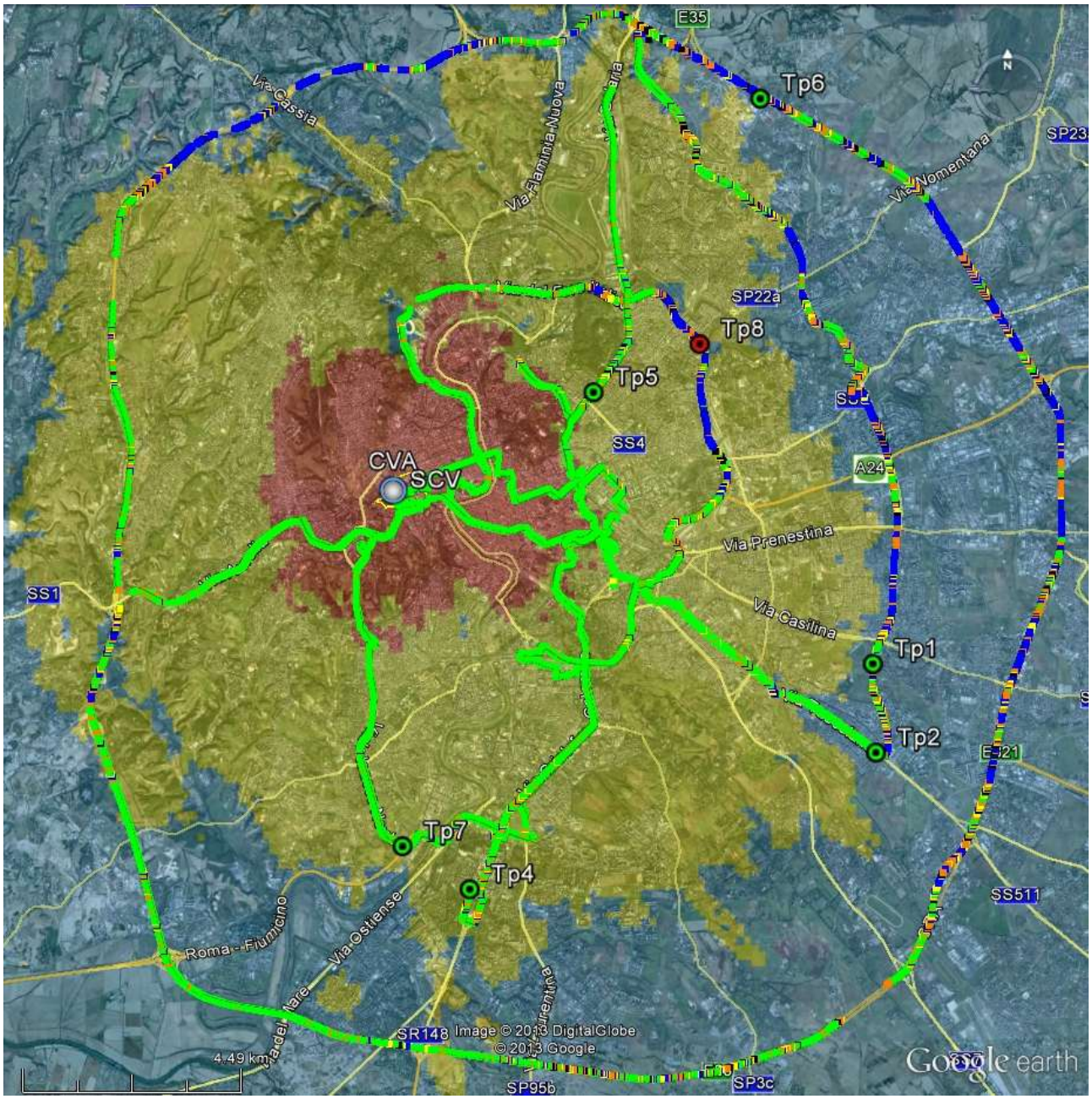
b) a ring surrounding the main centre;

c) the "GRA" motorway (motorway A90/E80) encompassing the main urban area (about 10 km radius).

According to Recommendation ITU-R BS.1660-6 the minimum median field strength for 4QAM modulation scheme R=1/3 is 40.7 dBμV/m for portable outdoor reception and 42.3 dBμV/m for mobile reception.

MAP 2

Measured DRM+ reception along three different paths representative of Rome

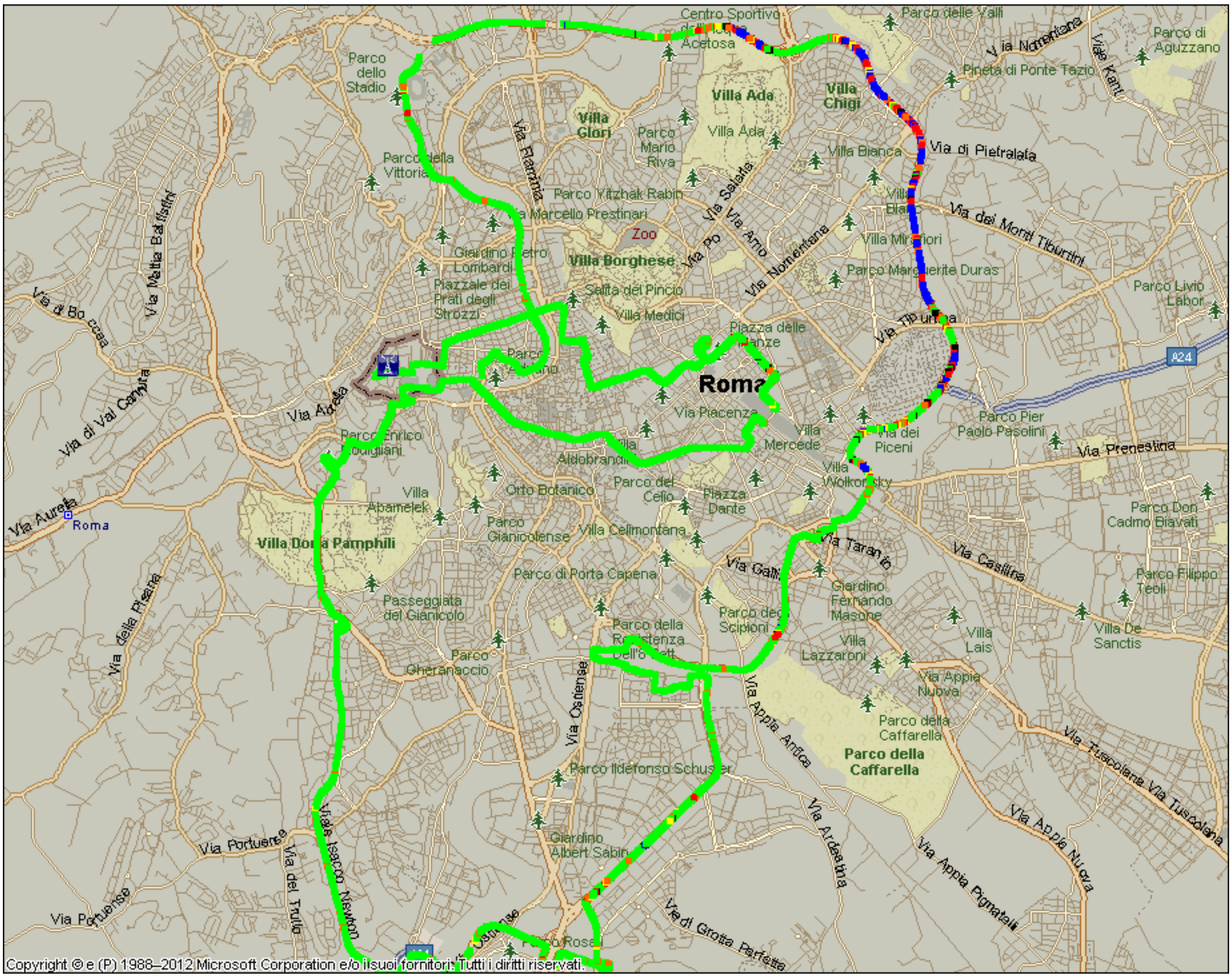


<table>
<tr><td colspan="6">Thresholds related to the DRM decoding process (paths):</td></tr>
<tr><td>■ Receiver status undefined[5]</td><td>■ No Sync</td><td>■ Sync ok</td><td>■ FAC ok</td><td>■ SDC ok</td><td>■ Audio OK</td></tr>
<tr><td colspan="6">Thresholds for predicted field strength at 10m (overlaid):</td></tr>
<tr><td colspan="2">■ EM > 84 dBμV/m</td><td colspan="2">■ EM > 64 dBμV/m</td><td colspan="2">■ EM > 44 dBμV/m</td></tr>
</table>

Map 3 shows the measured DRM+ reception in two paths representing the main centre of Rome. The legend of colours with respect of the DRM+ decoding process is the same as the one of map 2.

MAP 3

Measured DRM+ reception in two paths representing the main centre of Rome



[5] This status is representative of a transition condition of the receiver. In this situation is not possible to determine *a priori* if audio was decoded or not. In all statistical analysis of the audio decoding process in this situation audio has been considered as NOT decoded.

It has been possible to decode the audio signal in 98.3% of location belonging to the internal ring and 87.8% locations of the external one. These percentiles also include locations inside that should be theoretically excluded from the statistics.

It should be noted that in the north east of the external path of Map 3 there are many points marked in blue; the issue has been investigated and two reasons have been identified:

– The path passes through of a long tunnel with only some small parts open to free sky, in those points there was no propagation.

– That area is quite depressed with difficult propagation conditions.

Map 4 shows the elevation profile in one direction and Figure 7 the EM free space prediction in the point corresponding to the red cross on Map 4.

MAP4

Particular of the external path with terrain elevation profile over the red line

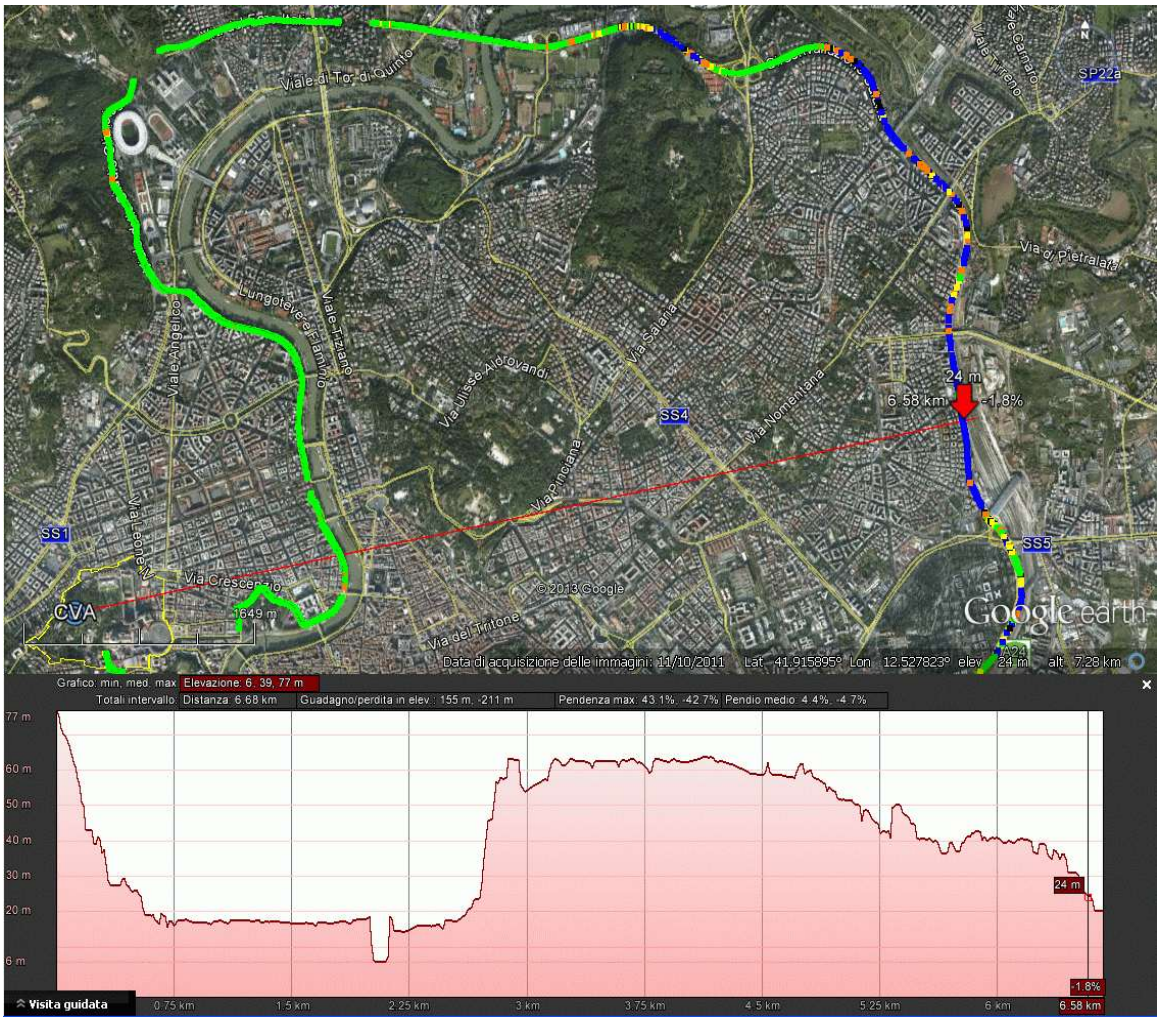
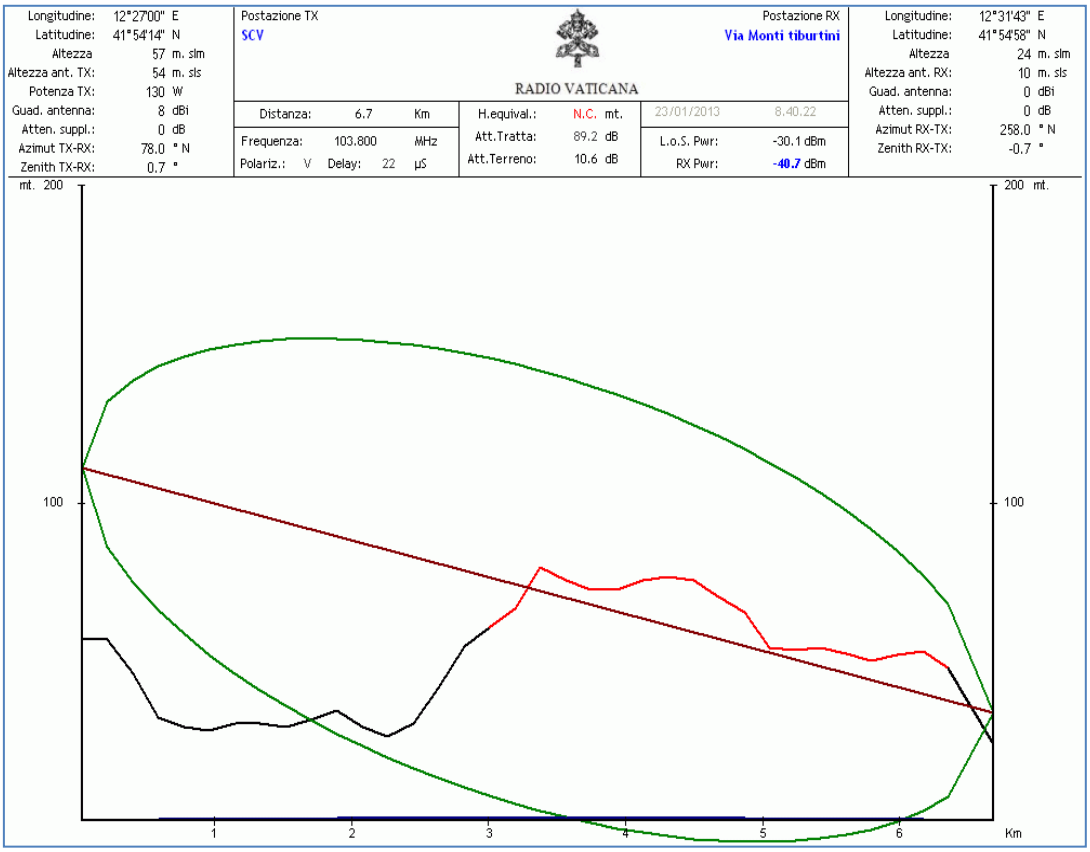
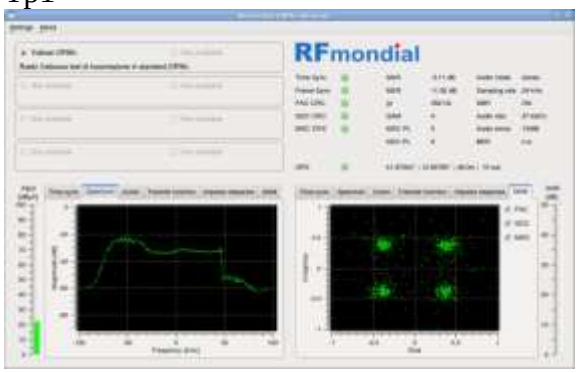


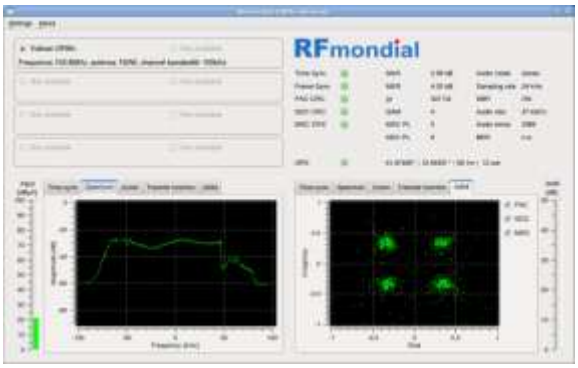
FIGURE 7



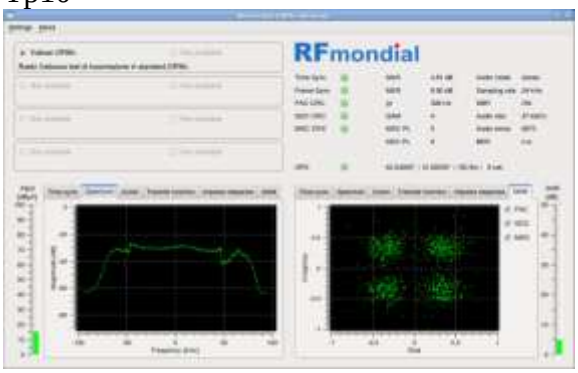
The figures below give an idea of the interference scenario; they show screenshots of the software DRM+ receiver taken in test points Tp*1*..*n* in Map 1.

Tp1

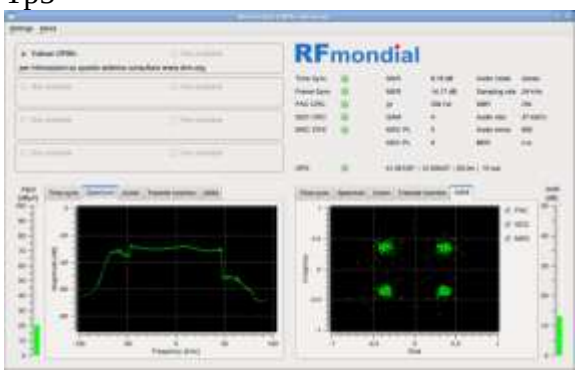




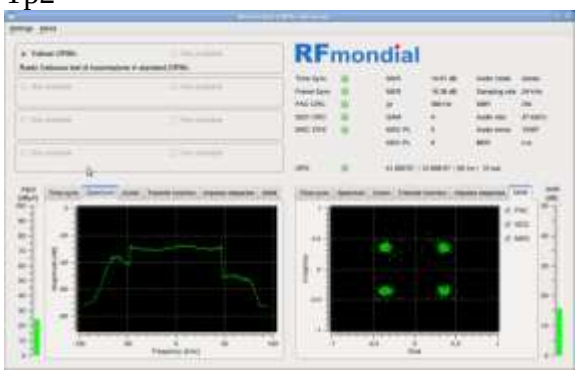
Tp10



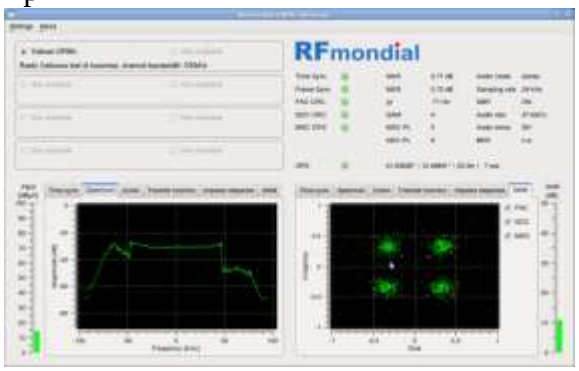
Tp5



Tp2

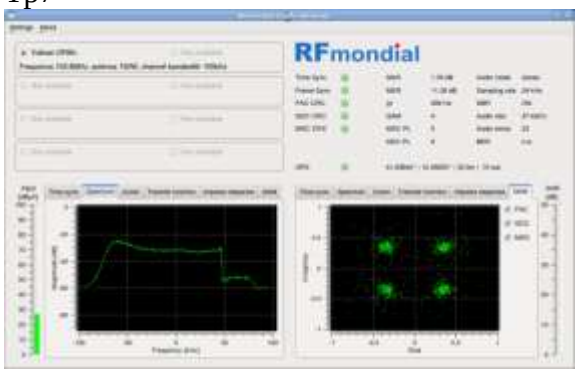


Tp4



Tp6

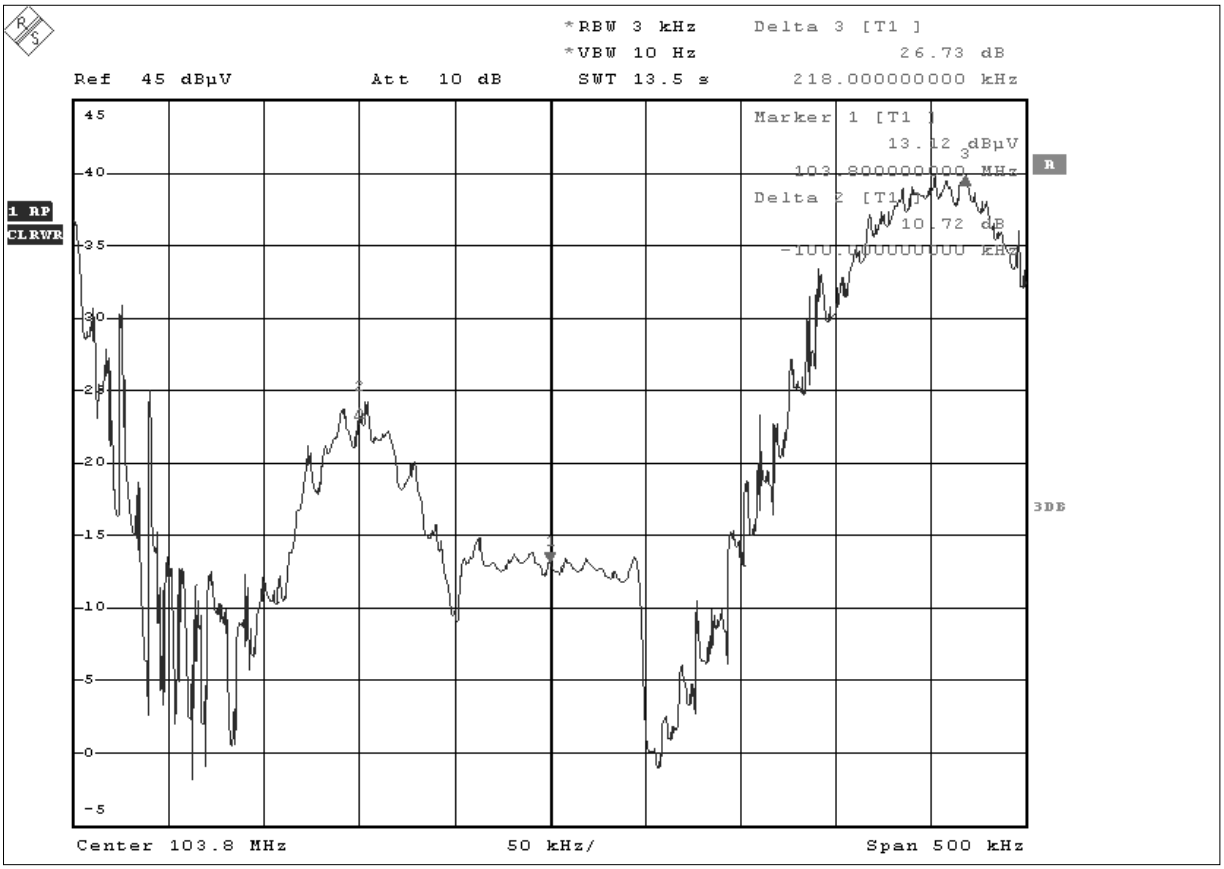
Tp7



Tp8

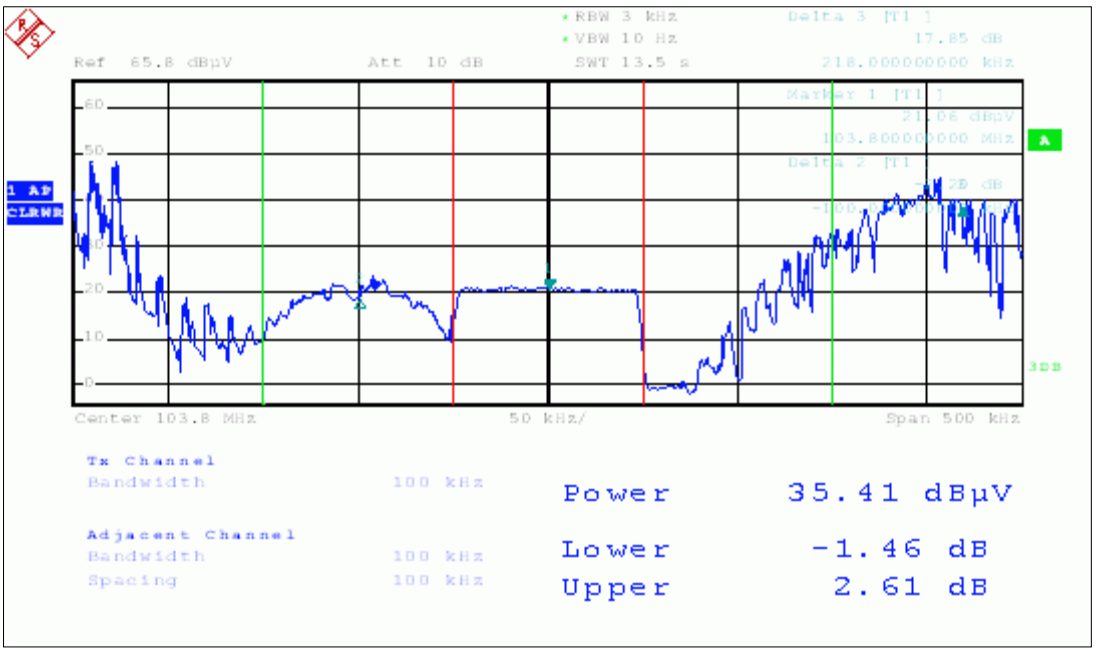
Spectrum plot of the interference scenario in Tp1:

FIGURE 8



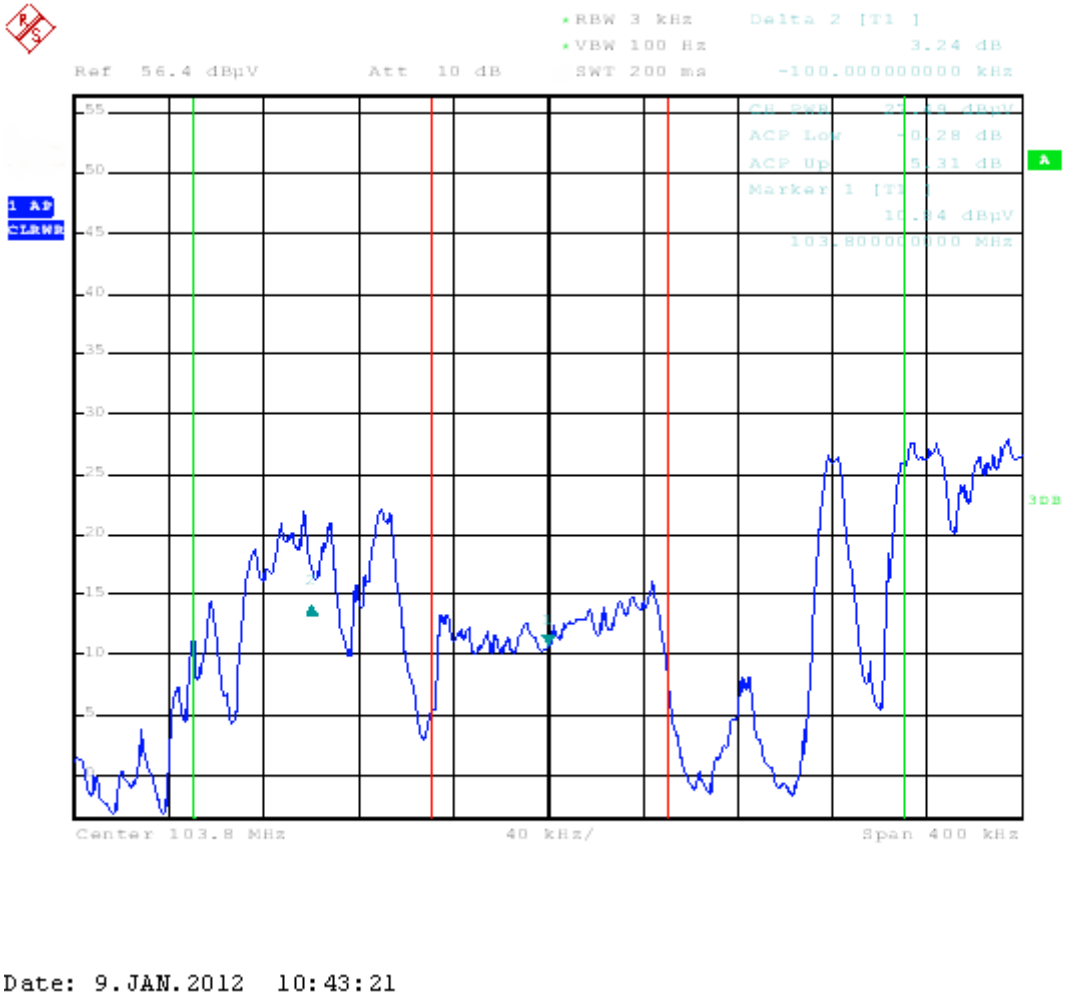
Power measurement on the interference on 103.7 MHz taken at Tp2:

FIGURE 9



Power measurements taken at Tp7 and shown as reference:

FIGURE 10



4 Our conclusions and proposal

– Mobile reception of a low power DRM+ broadcasting transmitter has been investigated in the very congested FM environment of the urban area of Rome.

– Acceptable stereo coverage in mobile reception conditions has been verified in areas where predicted field strength is comparable with 44 dBµV/m and interference is negligible.

– Using the most robust configuration for DRM+, it has been possible to achieve better coverage with a full stereo program than the one achieved with an analogue FM signal; the overall subjective listening experience was better than that of FM interfered with by splashes coming from adjacent stations.

In view of a possible transition of existing analogue FM services to digital technology it has been found that the use of DRM+ has the following merits:

– possibility to re-use the existing antenna system without any particular precaution, except the one relevant to the maximum peak envelope power of the digital signal;

– no modification of the target service area as a consequence of re-using the existing antennas; this means that the original "shape" of the target service area remains unmodified with benefits for those local broadcasters that have their main audience in a specific service area;

– possibility to use SFN techniques, with the attendant benefits for regional operators who may be able to re-use the frequency to achieve regional coverage.

On the other hand, the current absence of a wide variety of low cost sets capable to receive DRM+ signals presently represents a problem.

We propose that Working Party 6A should properly reflect the tests described in this contribution and their very encouraging results in a draft new ITU-R Report in the BS.-series, and it should appoint a Rapporteur Group to verify widespread interest in the idea to migrate FM sound broadcasting to digital technology, and to encourage contributions on it in view of developing a possible future new Recommendation on this concept and its implementation.

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