AIR – DRM

DRM+ Showcase

New Delhi, 23rd – 27th May 2011

The Report was prepared by

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&
All India Radio (AIR)

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Index:

1 Introduction

The first ever DRM+ trial measurements in New Delhi, India, was organized jointly by All India Radio (AIR) and Digital Radio Mondiale (DRM) Consortium. The trial took place as part of a **week-long workshop** on DRM technology (23rd-27th May 2011), covering crucial issues of planning, transition, simulcast, content and receivers. A large number of participants from all across the country attended the sessions that also had interactive discussions with DRM experts.

Digital Radio Mondiale (DRM) is the global standard for Digital Radio from the AM up to the VHF bands. While robustness modes A—D describe the available modulation configurations for broadcast frequencies below 30 MHz (referred to as "**DRM30**"), "**DRM+**" is the common technical expression for DRM robustness mode E for DRM broadcasts in the VHF bands above 30 MHz, including the FM band.

For the DRM+ trial in New Delhi, a single test frequency of 100.1 MHz carried three program channels - Gold DRM (FM), Rainbow DRM (FM) and AIR news in Journaline. Reception quality was measured using a test vehicle going in four directions from central New Delhi where the transmitter was installed.

Two test modes were measured - robust 4-QAM and high capacity 16-QAM.

This report contains a description of the DRM+ system parameters, system setup and equipment that was used in the trial and the measured results that were obtained.

2 DRM+ System parameter

The DRM+ system parameters are shown in the following table:

System parameter	
Modulation	OFDM
Robustness mode	E
Data rate	37—186 kbps
Subcarrier modulation	4/16-QAM
Signal bandwidth	96 kHz
Subcarrier spread	444.444 Hz
Number of subcarriers	213
Symbol duration	2.25 ms
Guard interval duration	0.25 ms
Frame length	100 ms
Number of programs	up to 4

2.1 Encoding

In the DRM system [1] Equal Error Protection (EEP) and Unequal Error Protection (UEP) are implemented. With UEP the parts of the audio bit-stream that are more susceptible to errors causing audible disturbances are provided with more protection.

With Robustness mode E, 4-QAM modulation and EEP, the MSC (Main Service Channel), which carries the useful data such as audio and text content, offers four different protection levels with the following code rates and resulting net bit rates (capacities):

MSC: 4-QAM		
Protection level	**Code rate**	**Bit rate [kbit/s]**
0	0.25	37.3
1	0.33	49.7
2	0.4	59.6
3	0.5	74.5

In Robustness mode E with 16-QAM modulation, the MSC uses multilevel coding, and the following EEP protection levels with the corresponding code rates and bit rates can be chosen:

MSC: 16-QAM		
Protection level	**Code rate**	**Bit rate [kbit/s]**
0	0.33	99.4
1	0.41	122.4
2	0.5	149.0
3	0.62	186.3

Further configurations with UEP are possible.

The SDC (Service Description Channel) contains signaling information such as service labels, emergency alert warnings or alternative frequency information. In Robustness mode E it is always modulated with 4-QAM. The following code rates are available:

SDC: 4-QAM
Code Rate
0.5
0.25

The FAC (Fast Access Channel) carries basic modulation and service information. In Robustness mode E it uses a fixed code rate of R = 0.25.

Depending upon the modulation parameters and Protection Level, different minimum field strength is necessary for a proper reception. For example, a field strength of 42.27 dBµV/m is necessary for mobile reception with 4-QAM, Protection Level 1, whereas field strength of 49.57 dBµV/m is necessary for 16-QAM, Protection Level 2. These two configurations were used in the field test.

2.2 Interleaving

In order to improve the robustness of the bit stream against channel errors, bit interleaving is carried out over one transmission frame (100 ms) and convolution cell interleaving over 6 transmission frames (600 ms) for Robustness mode E.

3 System setup

The whole transmission chain was set up at the headquarters of All India Radio in central New Delhi.

3.1 Transmitter Setup for the test, existing AIR TX tower was used.

Figure 1: 100m Tower with 4 bays antenna

The four bays of antenna as mounted at a height of 74 m above ground on one side of the tower were used. The frequency of 100.1 MHz was used with a TX output power of 300 W. With losses and the antenna gain this results in around 500 W ERP directed towards the south-west. Antenna cable loss is of the order of 0.5dB, and antenna gain is 3.25dB (in case of omnidirectional operation).

Figure 2: 300W DRM+ Transmitter

A 300 W Nautel VS-1 amplifier/exciter was connected to a RFmondial DRM+ Modulator.

The DRM MDI signal (Multiplex Distribution Interface) including all audio and text data as well as DRM signaling information was generated by a Fraunhofer DRM ContentServer setup in an AIR studio.

3.2 ContentServer Setup and DRM Multiplex Configurations

The live audio Signals of 'FM Gold' and 'FM Rainbow' were made available in AIR Studio 24 of New Broadcasting House (NBH). This studio had been provided for the content setup. Additionally, one more live audio source and a fourth audio signal were made available to an AXIA Livewire sound card connected to the Fraunhofer DRM ContentServer.

Figure 3: Audio console in Studio No.24 of NBH

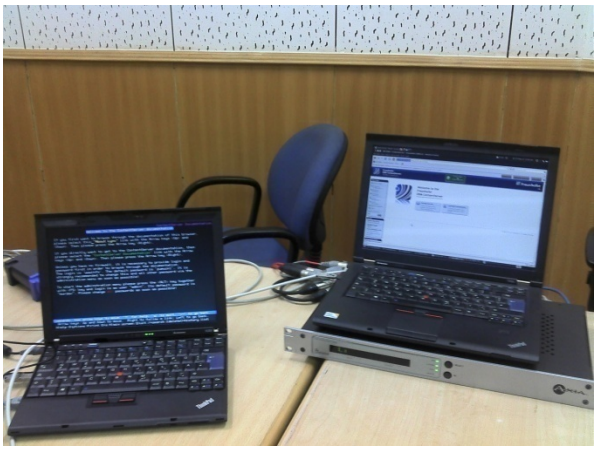

Figure 4: Fraunhofer DRM ContentServer for MDI generation

The Journaline text information service was composed of different RSS-feeds provided by newsonair.com and BBC News Hindi. The DRM ContentServer took care to update those input sources automatically every few minutes.
The one Journaline service was carried only once in the DRM transmission signal, but was signaled to the listener as a stand-alone DRM service as well as PAD (Programme Associated Data) linked to each audio programme.

Figure 5: Journaline output of 3 channels of DRM+

Additional DRM TextMessages were provided as PAD for the two radio programmes 'FM Gold' and 'FM Rainbow' – composed of latest RSS headlines (with automatic updates from the RSS sources) along with static messages uploaded in advance to the DRM ContentServer.

In the 16-QAM, mode the live stereo audio source was converted on-the-fly into 5.1 MPEG Surround Sound (compatible with all mono/stereo receivers) based on the "SX Pro" technology, which is part of the DRM ContentServer.

To support the field measurements, a PRBS (Pseudo Random Bit Sequence) signal was generated by the DRM ContentServer and transported as part of the DRM transmission. This special data stream allows calculating the exact Bit Error Rate of the received DRM signal.

The DRM Multiplex signal (MDI) was sent via Distribution and Communication Protocol (DCP) with strong forward error correction (FEC) over the AIR Local Area Network using a combination of electrical and optical fiber cable to the DRM Modulator in the transmitter room.

For the measurement two DRM Multiplex configurations were prepared; the ContentServer could be ordered to switch between those configurations at any time manually or based on a pre-defined calendar/scheduler. Both configurations came with the live radio programs of Gold and Rainbow FM and associated DRM TextMessages and Journaline as PAD, a dedicated 'Journaline' DRM Service, and a PRBS Sequence.:

- The robustness optimized DRM Multiplex configuration used the 4-QAM mode with PL 1, resulting in an available net capacity of 49.7 kbps. It carried 'FM Gold' with an assigned bit rate of 22 640 bps, 'FM Rainbow' with 22 720 bps, and Journaline and the PRBS sequence with 1 840 bps each.
- The capacity optimized DRM Multiplex configuration used the 16-QAM mode with PL 2, resulting in an available net capacity of 149.0 kbps. It carried 'FM Gold' and 'FM Rainbow' with an assigned bit rate of 70.0 kbps each, Journaline with 3 840 bps, and the PRBS sequence with 4 560 kbps.

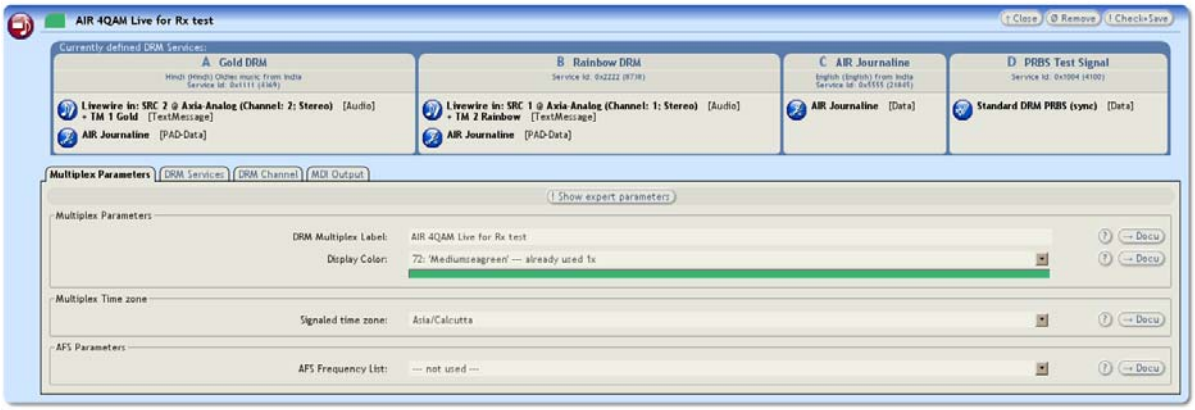

Figure 6: Configuration of the robust 4-QAM mode

Figure 7: Configuration of the 16-QAM mode with high data rate

3.3 Receiver setup

- Antenna: Kathrein K 51 16 4 / BN 510 351 magnetic monopole antenna mounted on the roof of a van at a height of around 2.5 m
- RFmondial DRM+ Frontend
- RFmondial DRM+ Software Receiver
- Additionally, a software receiver from KETI was used

3.4 Measurement parameters

The following parameters were recorded and analyzed during the measurements:

- GPS coordinates
- Audio Frame availability
- The complete RSCI information was recorded
  (Receiver Status and Control Interface, see RSCI specifications [2])
- Field strength measurements at some places with a field strength meter and a dipole antenna

4 Measurements

Measurements have been conducted in New Delhi on 4 radial routes.

The first measurement was conducted with the 4-QAM Multiplex configuration on Sunday May 22nd towards the west. This measurement was taken with a smaller car with magnetic monopole antenna. Reception was possible up to a distance of 28 km from the transmitter. Some dropouts caused by the new AIR transmitter station nearby transmitting FM signals with several kW are marked in Figure 8.

Figure 8: Measurement with 4-QAM from AIR towards the west

On the way back a route from the west to the south and back to AIR was chosen.

Figure 9: Measurement with 4-QAM from the west to the south and back to AIR

The first measurement with the AIR measurement vehicle was conducted on Tuesday May 24th with the 4-QAM configuration towards the east. As this was not the main antenna direction, good coverage was verified up to a distance of 12 km. Even at further distances reception was still possible in open areas. Figure 10 shows the results.

At the 'Nizamuddin Bridge' a spectrum plot was taken (Figure 11). The distance to the transmitter was around 5km.

Figure 10: Measurement with 4-QAM towards the east

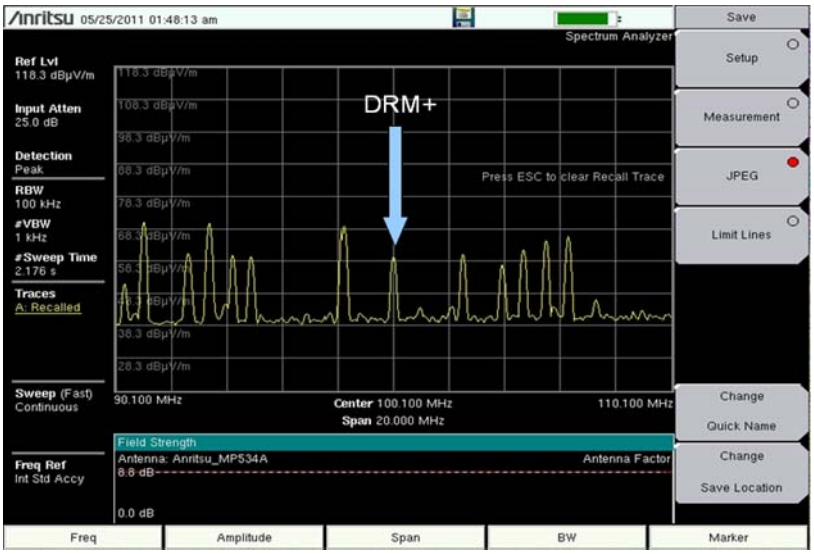

Figure 11: Spectrum measured at the 'Nizamuddin Bridge' with a span of 20 MHz

On the way back to AIR the transmission was switched to the capacity-optimized 16-QAM configuration. As expected the coverage with this Multiplex configuration was smaller than for the robustness optimized 4-QAM configuration: good coverage was measured up to 7.5 km distance of the transmitter (see *Figure* 12).

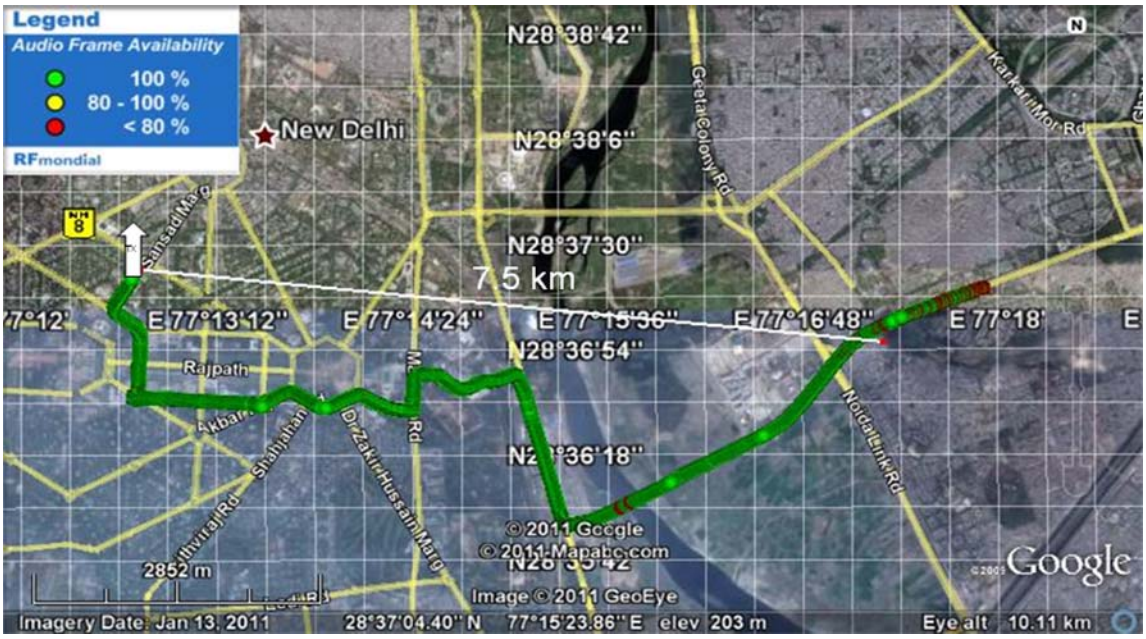

Figure 12: Measurement with 16-QAM from the east to AIR

Toward the north, the field strength was lower than towards the east. This effect could have been caused by a notch in the antenna radiation pattern. Figure 13 shows the measurement results towards the north using the 16-QAM configuration.

At 'Vikas Nagar', another spectrum plot was recorded which shows the low power of the DRM+ signal (Figure 14).

Figure 13: Measurement from AIR towards the north with 16-QAM

In addition the field strength was measured at some places with a field strength meter and a dipole antenna at a height of around 3 m. The location and measured values (45 and 37 dBµV/m, respectively) are indicated in yellow in the map in Figure 13.

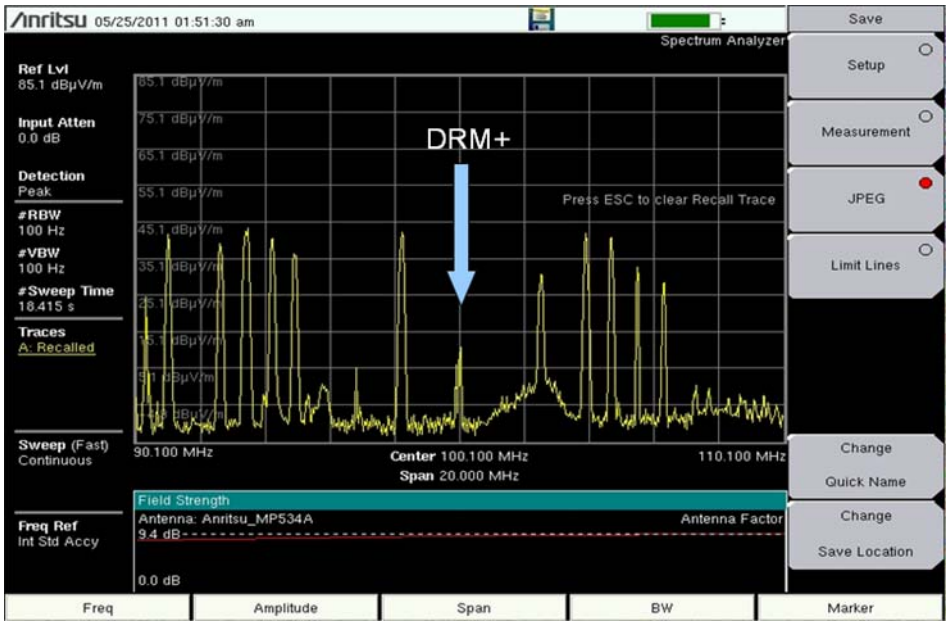

Figure 14: Spectrum plot measured at Vikas Nagar with a span of 20 MHz

When reception based on the 16-QAM Multiplex configuration faded, the transmitter was switched to the 4-QAM configuration. The results are shown in Figure 15. At the location marked in the north-west corner, a field strength of 59 dBµV/m was measured. However, due to the nearby AIR tower with strong FM transmissions the receiver frontend was overloaded.

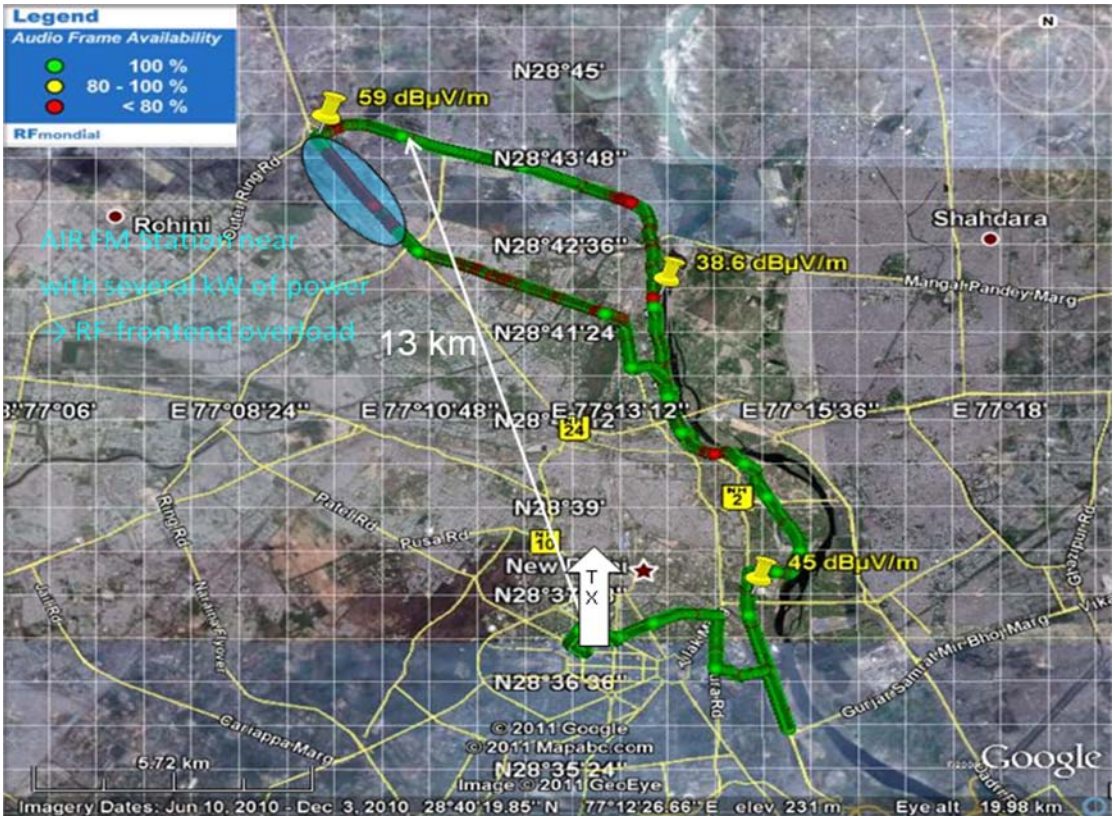

Figure 15: Measurement toward the north with 4-QAM

The following table shows the field strength measurements conducted on the route to the east/north over the distance. The nonlinear behavior here again is caused by a notch in the antenna pattern.

Distance to TX [km]	Fieldstrength [dBµV/m]
3.3	45
4.8	37
8	38.6
13.5	59 (could be as height due to interferences with the nearby FM TX)

On Wednesday May, 25th measurements were conducted towards the south. Good reception could be achieved up to a distance of 23 km in the 4-QAM configuration (Figure 16). On the way back, the transmitter was switched to the 16-QAM configuration (Figure 17). As expected, the coverage area was a bit smaller (~16 km). In this mode, an evaluation of the KETI receiver is shown in Figure 18. It also showed very good results.

Figure 16: Measurement from AIR towards the south-west with 4-QAM

The following table shows the field strength and distance to the transmitter measured with the dipole antenna and field strength meter on the route to the south-west.

Distance to TX [km]	Fieldstrength [dBµV/m]
2.5	73.7
9.5	53.5
15	49.2
18	47.8
23	44

Figure 17: Measurement from the south-west back to AIR with 16-QAM

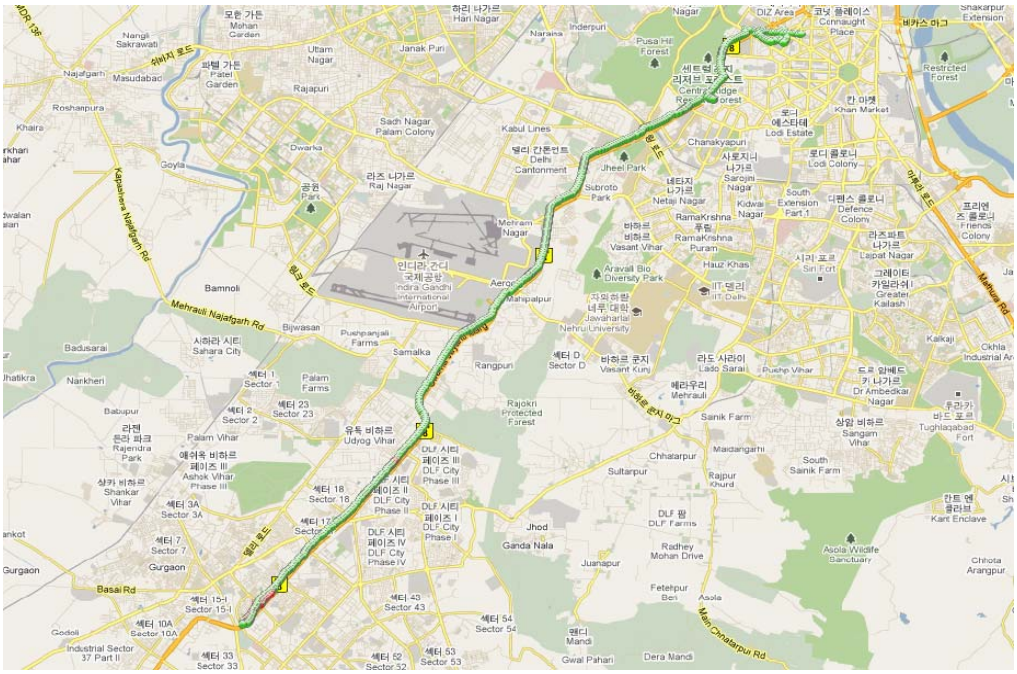

Figure 18: Measurement from the south back to AIR
with the KETI receiver
(Green: no audio error within 4 seconds
Red: at least one audio error within 4 seconds)

Figure 19: Measurement overview: 16-QAM Multiplex configuration

Figure 19 shows a summary of the measurements taken with the 16-QAM Multiplex configuration.

Figure 20 shows an overview of the measurements based on the 4-QAM Multiplex configuration, along with a coverage prediction conducted with the program Radio Mobile. Radio Mobile is based on the ITS (Longley-Rice) propagation model.

The program uses topographic data (SRTM data from the Space Shuttle Radar Terrain Mapping Mission), but no morphology (buildings, woods, etc.). The prediction in Figure 20 has been conducted with a transmission power of 300 W with a probability of 95% of the locations and 95% of time.

Mobile reception with DRM Robustness mode E, 4-QAM, Protection Level 1 should be possible with a field strength above 42 dBµV/m according to the DRM+ planning parameters. Based on these values, reception should be possible in the green and yellow areas shown in Figure 20. However, due to the morphology not being taken into account at all for this prediction, the predicted field strength in urban areas can be affected by severe fading which results in a lower median field strength. Figure 20 shows that this fits quite well. In open areas the reception was possible also with lower field strength.

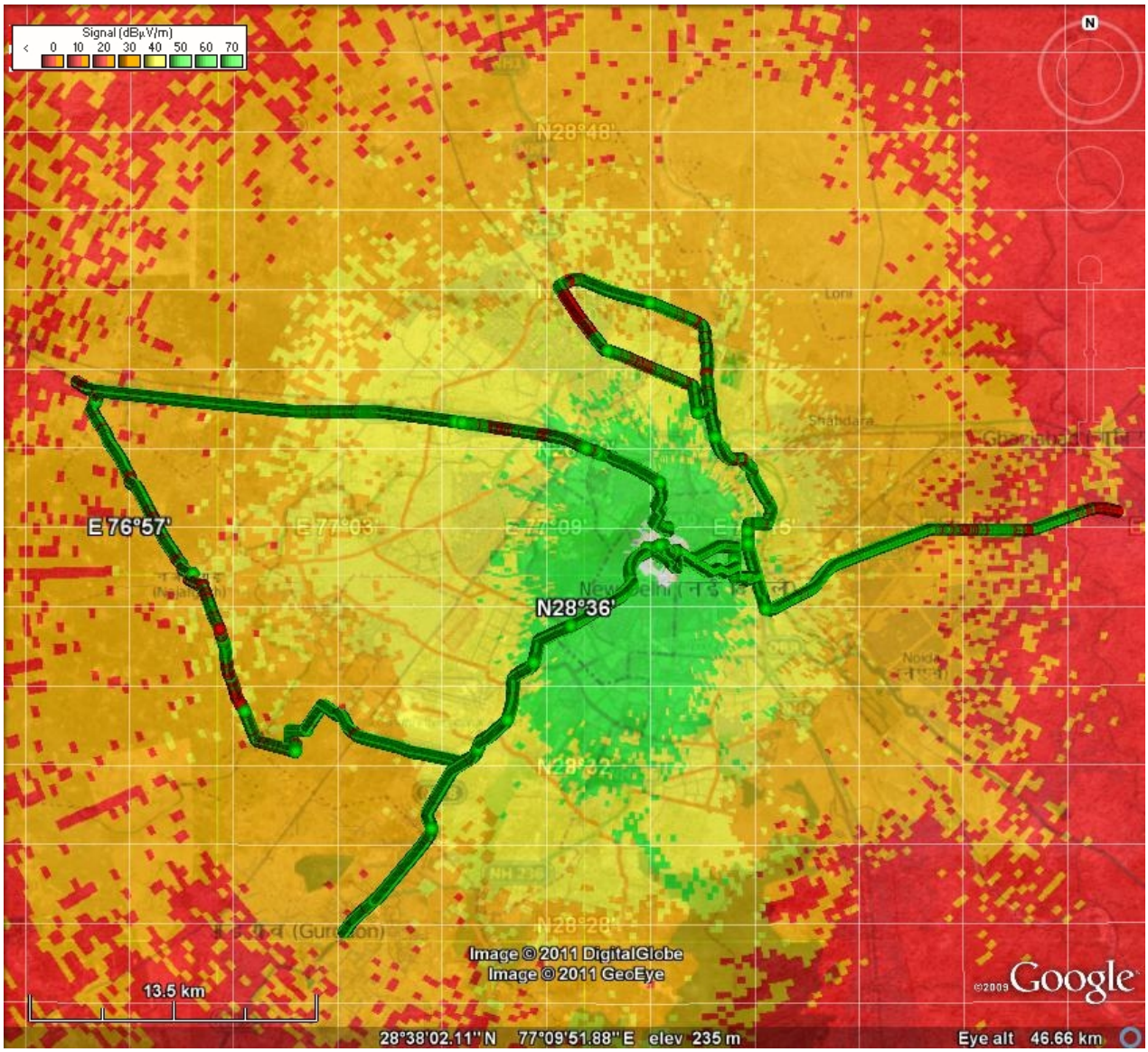

Figure 20: Measurement overview: 4-QAM Multiplex configuration
(with coverage prediction for mobile reception, not respecting morphology)

5 Conclusions

The first DRM+ trial in India was conducted successfully in New Delhi in May 2011.

The functionality of the DRM standard particularly for the VHF bands (DRM+) could be presented with the field trial in the FM band II.

Two live radio programmes (FM Rainbow and FM Gold), a Journaline text information service and a PRBS test sequence were transmitted.

Measurements were conducted in four radial directions from the transmitter located at All India Radio.

The trial has shown that DRM in the FM band is capable of good coverage at reduced power levels compared to analog FM.

Many thanks to all the people and organizations involved in the trial!

6 References

[1] ETSI. ES 201 980, Digital Radio Mondiale (DRM), System Specification. 2009.

[2] ETSI. TS 102 349, Digital Radio Mondiale (DRM), Receiver Status and Control Interface (RSCI). 2009.

www.drm.org