BBC

R&D White Paper

WHP 032

July 2002

Digital Radio Mondiale longterm test results
(February 2002)

A. Giefer

Research & Development
BRITISH BROADCASTING CORPORATION

BBC Research & Development
White Paper WHP 032

Digital Radio Mondiale longterm test results (February 2002)

A. Giefer

Abstract

In December 2001 the DRM System Evaluation group started a series of regular DRM transmissions under the project Radiate. Broadcast up to seven hours a day from the UK and the Netherland Antilles, these signals were received at three reception points in Western Europe.

Although the tests are scheduled to run for much longer in 2002, this document gives a summary of the results obtained so far, i.e. between December 2001 and the middle of February 2002.

This document was originally written as an input document to the ITU study group WP6E and submitted by DRM.

Key words:

White Papers are distributed freely on request.

Authorisation of the Head of Research is required for publication.

BBC Research & Development
White Paper WHP 032

Digital Radio Mondiale longterm test results (February 2002)

A. Giefer

1 Glossary

AAC	Advanced Audio Coding. One of the source coding techniques included into the DRM system which makes it possible to transmit audio using the available bit rates.
BBC	British Broadcasting Corporation
Datablock	A datablock contains the information that a field trials receiver records during one reception minute.
DRM	Digital Radio Mondiale, the consortium committed to introduce digital radio on frequencies below 30 Mhz.
EEP	Equal Error Protection. Every MSC bit is protected the same way against errors.
FhG	Fraunhofer Gesellschaft
MSC	Main Service Channel. Contains the main programme, i.e. audio or multimedia data.
Radiate	EU IST project to carry out DRM field trials.
SBR	Spectral Band Replication. Enhancement to AAC which allows to add treble information to the transmitted audio.
SDC	Service Description Channel. Specifies the content of the MSC.
Slot	A slot is defined by a continuous reception of a DRM signal at one location, on one frequency, using one set of transmission parameters (MSC & SDC constellation, code rate, interleaving, robustness mode etc…)
QAM	Quadrature Amplitude Modulation
Thales	Thales Broadcast & Multimedia

2 Introduction

In December 2001, the DRM System Evaluation group started a series of regular DRM transmissions under the project Radiate. Broadcast up to seven hours a day from the UK and the Netherlands Antilles, these signals were received at three reception points in Western Europe.

Although the tests are scheduled to run for much longer in 2002, this document gives a summary of the results obtained so far, i.e. between December 2001 and the middle of February 2002. The report was submitted to ITU study group WP6E in February 2002.

3 Setup

This section describes how the tests were carried out.

3.1 Transmission sites

Two transmission sites were initially available: Bonaire in the Netherlands Antilles (operated by Radio Netherlands) and Rampisham in the south of England (operated by Merlin Communications).

The following table gives the transmitter details:

Name	Short	Coordinates	Carrier Power	DRM power	Antenna	Azimuth
Bonaire	BON	12˚10'N 68˚15'W	25 kW	10 kW	CHRS 4/4/1	50˚
Rampisham	RMP	50˚50'N 02˚40'W	125 kW	50 kW	HRS 4/2/0.5	80˚

3.2 Schedule

The transmission schedule is shown in the table below.

Start	Stop	Origin	Days	Frequency
UTC	UTC			kHz
8:00	9:00	Bonaire	Monday to Sunday	11970
9:00	10:00	Bonaire	Monday to Sunday	12035
10:00	11:00	Bonaire	Monday to Sunday	15420
12:00	15:00	Rampisham	Monday to Friday	5875
15:00	16:00	Rampisham	Monday to Friday	7320

The two transmission sites chose the following transmission parameters:

Transmission site	Audio coding	Robustness Mode	Constellation		Code rate	Interleaver	Bitrate
			MSC	SDC			bits/s
Bonaire	AAC	B	16-QAM	4-QAM	EEP/0.5	long	11560
Rampisham	AAC+SBR	B	64-QAM	4-QAM	EEP/0.6	long	20880

3.3 Reception sites

The following table lists the different receivers used during the tests, indicating for each receiver whether it was able to measure the field strength on a calibrated antenna and which company developed it (receiver type).

Rx Name	Location	Short	Coordinates	Calibrated?	Rx Type
DW1	Bockhacken	BCK	51˚06'N 07˚16'	yes	FhG
RNW2	Hilversum	HLV	52˚08'N 05˚06'E	no	Thales
BBC1	London	LDN	51˚10'N 00˚07'E	yes	BBC
BBC2	London	LDN	51˚10'N 00˚07'E	no	Thales
BBC3	London	LDN	51˚10'N 00˚07'E	yes	FhG

Note that all three receiver-types are still under development. Consequently, their software was upgraded on several occasions, which could have altered the individual receiver's performance.

Furthermore, only the FhG (from the beginning of February) and BBC receiver types provide information on the signal strength.

Lastly, London is not located inside the target area of the Rampisham transmissions.

3.4 Analysis site

The analysis site is situated at BBC R&D at Kingswood Warren. After each reception day, the reception sites dispatch an email containing the day's accumulated results to Kingswood Warren. Once received, the data is extracted, fed into a data base and summarised into a PDF report which is sent via email to interested parties (mainly the transmitter and receiver operators).

3.5 Comment on the choice of transmission parameters

Bonaire chose to transmit a signal that offers a higher robustness to low signal strength (MSC 16–QAM, protection level 0) due to the following reasons:

- The distance between Bonaire and the three reception sites is larger than it is the case for Rampisham, requiring the signal to travel two hops before reaching its destination.
- Bonaire's DRM transmitter cannot be linked to an antenna that targets the reception sites directly. Instead, the signal is broadcast to Southern Europe.
- The output power of the DRM transmitter is comparatively low.

Rampisham's transmission signal was configured to correspond to the currently recommended default settings for shortwave transmissions (MSC 64-QAM, protection level 1, robustness mode B).

4 Results

During the first two months, none of the reception sites were able to provide accurate field strength data, therefore this report concentrates on the evaluation of the received digital audio.

4.1 Measurement of slot quality

The slot quality is measured as the percentage of data blocks that showed an accumulated dropout length of less than 1 second with respect to the total number of received data blocks with digital audio content.

For this purpose, a reception slot is considered to have started 1 minute after the first uncorrupted digital audio frame was received and to have stopped 1 minute before the last uncorrupted digital audio frame was received.

As an example, let us assume that DRM transmission was scheduled on 11970 kHz between 8:00 UTC and 9:00 UTC. But the transmission started late and the first error-free audio frame was received at 8:03:43. Furthermore, we assume that the transmission stopped prematurely so that the last uncorrupted audio frame was received at 8:55:27. The following datablocks contain audio dropouts:

- 8:43 1 dropout of 2.2 s
- 8:45 2 dropouts of 0.6 s each
- 8:49 1 dropout of 0.8 s

In order to calculate the slot quality, only the data blocks between 08:04:00 and 8:55:00 would be taken into the equation, yielding 52 reception minutes (datablocks) with digital audio content. Datablocks 8:43 and 8:45 would be counted as unacceptable reception minutes, while datablock 8:49 would be counted as acceptable reception minute.

The slot quality would consequently be calculated based on the fact that 2 out of 52 reception minutes were unacceptable, yielding a slot quality of (52-2)/52=96%.

The table below aims to give a better feeling for various slot qualities.

Slot Quality	**Illustration**
100%	No dropout longer than 1 second was registered.
99%	On average, the accumulated dropout length measured for each datablock exceeds 1 second once every 100 minutes.
95%	A total dropout length of more than 1 second is observed every 20 minutes
90%	A total dropout length of more than 1 second is observed every 10 minutes
80%	A total dropout length of more than 1 second is observed every 5 minutes
50%	A total dropout length of more than 1 second is observed every 2 minutes
0%	A total dropout length of more than 1 second is observed every minute

4.2 Excluding transmitter and receiver problems

The following results represent the slots for which neither major transmitter nor major receiver problems could be identified.

However, slots that merely showed a short transmitter failure (trip) are included since this degraded the slot quality only by a few percent: A short interruption of the transmission can affect up to 2 datablocks which degrades the quality by 2/60=3% for the 1-hour slots and 2/180=1% for the 3-hour slot.

4.3 Results in Numbers

The following tables contain the calculated slot quality. For values below 90%, the most likely cause for failure is given. At the moment, this is only possible for the receivers that provide additional information, such as signal strength and estimated SNR (BBC1, DW1 and BBC3 , the latter two from the beginning of February).

The value of 90% was chosen arbitrarily, but it appeared to be a suitable boundary in order to differentiate between severe problems (which are usually easier to explain) and occasional reception dropouts (for which a more detailed analysis based on more data is necessary). In fact, the comparison of the three receiver types (see 5.3) suggest that a considerable number of dropouts yielding slot qualities between 90% and 100% are probably due to receiver bugs or algorithms that could be improved.

4.3.1 Bonaire 8:00-9:00 11970 kHz

BON 07:57:00-09:00:00 11970 kHz

Day	Date	DW1	BBC3	BBC1	BBC2	RNW2	Likely reason for Q<90%
Fri	11/1/02			36%	7%		Low signal strength
Thu	24/1/02				8%	10%	Unknown
Tue	5/2/02	100%			100%	98%	
Wed	6/2/02	94%			97%	66%	
Thu	7/2/02	98%			98%	95%	
Fri	8/2/02	100%				97%	
Sat	9/2/02	100%				97%	
Sun	10/2/02	92%				65%	Unknown
Mon	11/2/02	98%	98%	89%	94%	84%	Short drop of signal strength
Tue	12/2/02	92%	98%	87%	100%	20%	Unknown
Wed	13/2/02	100%		100%		98%	
Thu	14/2/02					3%	Unknown
Fri	15/2/02	100%		95%	100%	75%	Unknown
Sat	16/2/02		100%			95%	
Mon	18/2/02	100%			97%		
Tue	19/2/02	98%	98%	100%	98%	85%	Unknown

72% of the reception slots showed a quality of 90% or more. The most likely cause for impaired datablocks was low signal strength.

4.3.2 Bonaire 9:00-10:00 12035 kHz

BON 09:00:00-10:00:00 12035 kHz

Day	Date	DW1	BBC3	BBC1	BBC2	RNW2	Likely reason for Q<90%
Thu	20/12/01			93%			
Thu	3/1/02			95%			
Wed	9/1/02			100%			
Thu	10/1/02			100%			
Fri	11/1/02			87%			Temporarily low signal strength
Tue	15/1/02			81%			Temporarily low signal strength
Thu	24/1/02						
Fri	25/1/02						
Wed	6/2/02	91%					
Thu	7/2/02	66%			100%		Sudden degradation at 9:30
Fri	8/2/02	98%			90%		
Sat	9/2/02	100%					
Sun	10/2/02	100%					
Mon	11/2/02	100%	100%	97%	98%	86%	Unknown
Tue	12/2/02	94%	95%	76%	84%	70%	Rx performance
Wed	13/2/02	100%	100%	93%	98%	93%	
Fri	15/2/02	100%	100%	89%	91%	66%	Rx performance
Sat	16/2/02		76%		52%	11%	Low signal strength
Mon	18/2/02	98%	98%		83%		Rx performance
Tue	19/2/02	100%	100%	91%		41%	Unkown

67% of the reception slots showed a quality of 90% or more. The most likely cause for impaired datablocks was low signal strength. Note that the 12th of February shows significant differences in the performances of BBC1, BBC2 and BBC3.

4.3.3 Bonaire 10:00-11:00 15420 kHz

BON 10:00:00-11:00:00 15420 kHz

Day	Date	DW1	BBC3	BBC1	BBC2	RNW2	Likely reason for Q<90%
Thu	20/12/01			91%			
Fri	21/12/01			83%			
Wed	2/1/02			94%			
Thu	3/1/02			84%			
Wed	9/1/02			96%			
Thu	10/1/02						
Fri	11/1/02						
Tue	15/1/02			79%			
Mon	4/2/02	0%					
Tue	5/2/02	5%				21%	
Wed	6/2/02	4%					
Thu	7/2/02	4%			100%		
Fri	8/2/02	13%			93%		
Sat	9/2/02	32%					
Sun	10/2/02	8%					
Mon	11/2/02	0%	72%	79%	97%	25%	
Tue	12/2/02	10%	88%	84%	95%	44%	
Wed	13/2/02	29%	89%	78%	98%	64%	Interfered
Thu	14/2/02					33%	Probably interfered
Fri	15/2/02	24%	87%	92%	90%	38%	Interference with low signal str.
Sat	16/2/02		68%		81%	26%	Interference
Mon	18/2/02	4%	75%		88%		Rx performance/Interference
Tue	19/2/02	12%	91%	100%	98%	86%	Interference

25% of the reception slots showed a quality of 90% or more. These slots are interfered with by a clandestine AM station which was identified by Deutsche Welle Monitoring station as *Denge Mezopotamya* (Voice of Mesopotamia), broadcasting via Samara to Iran, Iraq, Syria and Turkey.

The numbers show that the interference was generally strongest in Bockhacken, followed by Hilversum and London.

Note the different performance of the three co-sited receivers, with BBC2 leading the field.

4.3.4 Rampisham 12:00-15:00 5875 kHz

80% of the reception slots belonging to the first Rampisham transmission of the day showed a quality of 90% or more. These slots showed a relatively good performance with a few exceptions.

The bad performance of DW1 on the 7th of February could be linked to low SNR which increased during the slot. The problems of BBC2 and RNW2 could not be explained since the receivers do not provide sufficient data.

RMP 12:00:00-15:00:00 5875 kHz

Day	Date	DW1	BBC3	BBC1	BBC2	RNW2	Likely reason for Q<90%
Mon	17/12/01						
Tue	18/12/01						
Wed	19/12/01			97%			
Fri	21/12/01			94%			
Tue	8/1/02			95%			
Thu	10/1/02			91%	83%		Unknown
Fri	11/1/02			93%	88%		Unknown
Mon	14/1/02			92%	91%		
Tue	15/1/02						
Wed	16/1/02			80%	73%	100%	RX Performance
Thu	17/1/02				95%	97%	
Fri	18/1/02					98%	
Mon	21/1/02					96%	
Tue	22/1/02					98%	
Wed	23/1/02					92%	
Thu	24/1/02					64%	Unknown
Fri	25/1/02			96%	94%	92%	
Tue	29/1/02			98%	90%	98%	
Mon	4/2/02	100%			92%	100%	
Tue	5/2/02						
Wed	6/2/02						
Thu	7/2/02	82%			87%	83%	DW1:Low SNR
Wed	13/2/02	100%	100%		86%	97%	RX performance
Thu	14/2/02	100%	96%	93%		100%	
Fri	15/2/02		99%	98%	92%	96%	
Mon	18/2/02		98%	98%			

4.3.5 Rampisham 15:00-16:00 7320 kHz

80% of the reception slots showed a quality of 90% or more. These slots were found to be impaired by two effects. Firstly, an interfering F1B data signal was identified on the several occasions which could have appeared at other times without being noticed. Here are the details, as provided by Bockhacken:

Frequency: 7319 kHz
Modulation: F1B 200 baud
Azimuth: 60˚
Location: 54˚37'N 54˚19'E

Secondly, the last five minutes starting from 15:55 occasionally showed a bad performance, due to two AM carriers at +/-5kHz which probably appeared because the associated transmitters were set-up for the following transmission hour.

RMP 15:00:00-16:00:00 7320 kHz

Day	Date	DW1	BBC3	BBC1	BBC2	RNW2	Likely reason for Q<90%
Mon	17/12/01						
Tue	18/12/01						
Wed	19/12/01						
Thu	20/12/01			93%			
Mon	7/1/02			86%			Interference of from 15:55
Thu	10/1/02			84%			Occ. Low SNR (interference?)
Fri	11/1/02			93%	70%		Unknown
Mon	14/1/02			95%	96%	100%	
Tue	15/1/02			100%	94%		
Wed	16/1/02			98%	84%	100%	Rx performance
Fri	18/1/02						
Mon	21/1/02						
Tue	22/1/02						
Wed	23/1/02					100%	
Tue	29/1/02			100%			
Mon	4/2/02	95%				90%	
Tue	5/2/02	91%					
Wed	6/2/02						
Thu	7/2/02	95%			63%		Unknown
Wed	13/2/02	93%	89%	100%		93%	
Thu	14/2/02	100%	96%	96%	79%	98%	Interfering F1B data signal
Fri	15/2/02	97%	98%	97%	98%	100%	
Tue	19/2/02	98%	92%	98%	78%	88%	Rx Performance

5 Analysis

A look at the results yields the following observations.

5.1 Bonaire transmissions

The Bonaire transmissions were occasionally affected by low signal strength that even the high robustness of the signal could not overcome. But this does not surprise given the low transmission power and the fact that the main target area is the south of Europe. In addition, the 10:00 reception was impaired by a clandestine AM interferer, degrading DW1's and RNW2's receptions noticeably.

5.2 Rampisham transmissions

Most of Rampisham's reception slots were recorded in London which is not located inside the transmission's target area. An occasional drop to low signal strengths was therefore to be expected. DW1 did not record a sufficient number of slots to form an impression yet, whereas RNW2 showed generally a good performance with a few exceptions that could not be explained due the limited data currently provided by the receiver. However, it appears that the last minutes of the 15:00 transmissions were impaired by the carriers that appeared in preparation of transmissions that occurred at 16:00 on the adjacent frequencies. Furthermore, a F1B data signal was observed on the 14th of February which could also have affected other receptions.

5.3 Comparison between receiver types

For a few days, it was possible to set-up all three receiver types in Kingswood so that they could be fed by the same antenna signal. The measured slot quality turned out to be noticeably dependent on the receiver type (compare the columns for BBC1, BBC2 and BBC3).

Due to the fact that BBC3 (FhG type) uses traditional analogue filtering techniques to mix the reception signal down to its 12kHz intermediate frequency, it was expected to give very good reception results which it usually does. However, in the face of the clandestine AM interferer appearing between 10:00 and 11:00 UTC, BBC2 (Thales type) gave better results. Furthermore, a look at the Rampisham transmissions between 15:00 and 16:00 reveals that BBC1 (BBC type) usually performed better than BBC2.

This comparison illustrates that the slot quality values are still noticeably influenced by the performance of the individual receivers. In the case of BBC1 (BBC type), a careful analysis of the receiver behaviour during live receptions on a transmission frame basis (i.e. at a resolution of 400 ms) revealed a few inconsistencies. These bugs (for example an error in the frequency synchronisation) are currently in the process of being fixed, and this should result in an increased receiver performance.

6 Summary

This document presented the first results obtained during the long-term field trials between December 2001 and February 2002. They revealed

- Occasional dropouts due to low signal strength from Bonaire.
- Audio quality impairments due to co-channel interferers.
- Dropouts related to the performance of the individual receivers.

As a consequence, a slot quality of 100% was rarely achieved, whereas slot qualities of 90% and better were often observed. Some of the observed audio dropouts were certainly linked to insufficient receiver performance (probably synchronisation issues), since they appeared on one receiver type and not on others while all three receivers were fed with the same aerial signal.

At the time of writing, it is therefore impossible to assess how much the slot quality figures will improve with future revisions of the receiver soft- and hardware.