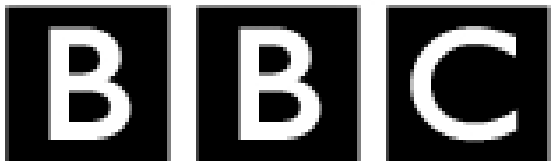

Project Mayflower:

The DRM Trial

Final Report

April 2009

Project Mayflower: The DRM Trial

Trial Summary

Introduction

The BBC and its transmission provider, National Grid Wireless, have recently undertaken a trial of digital radio mondiale (DRM), a technology which allows digital broadcasting at frequencies lower than 30 MHz. The trial ran for a year from April 2007. The final report of the trial is made up of three separate documents:

- this trial summary report, which provides some background and draws together the headline conclusions;
- a final audience research report, which outlines the results of the research undertaken with an audience panel over the year[1]; and
- a BBC R&D white paper, which provides the results and analysis of continuous unattended measuring and logging of the transmission[2].

Reflecting the way in which the trial was organised, each of these reports has been written by a different part of the team involved. The final audience research report has been written by the company employed to undertake the research – Leapfrog Research & Planning – with the assistance of BBC Marketing, Communications & Audiences. The technical note has been written by a member of the team who built the continuous logging network at BBC Research & Development and who was involved in developing the underlying DRM technology.

[1] *"Project Mayflower - Digital Radio Mondiale (DRM) Trial: Final audience research summary report"*, Daniel Amarasinghe (Leapfrog Planning & Research), Russell Chant (BBC MC&A); August 2008

[2] BBC Research White Paper 174, *"The Plymouth Digital Radio Mondiale (Drm) Trial: Long-term Reception Results"*, Andrew Murphy; February 2009

Background to the trial

The digital radio mondiale (DRM) technology is an international standard which was designed to allow digital broadcasting at frequencies below 30 MHz, that is in the broadcasting bands which currently rely on AM transmission. It was developed by a consortium in which the BBC is a member and has been on-air in various parts of the world either as a test service or as a permanent service for a number of years. It is designed not only to provide digital transmission but also to overcome some of the well known limitations of the AM bands, particularly as they apply to international broadcasters. For example, vectoring between the same station over a number of different frequencies, or across wave-bands, is handled smoothly, primarily to address the frequent re-tuning which is required when listening to shortwave radio.

Although DRM has been standardised for a number of years, it had not previously been tested as a replacement for a medium-wave service in the UK. Previous trials – undertaken by Arqiva, National Grid Wireless, and Radica – had concentrated on the use of the currently sparsely allocated 26 MHz band as this presented a relatively large chunk of spectrum which might be easily exploited (albeit that it suffers from considerable interference caused by sun spots). Given the obvious interest in DRM as a replacement technology for AM in the medium-wave band, the BBC and National Grid Wireless decided to conduct a trial based around the conversion of a single current assignment. The objects of the trial were three-fold: first, in the limit, to demonstrate that broadcasting DRM at medium-wave as a permanent "service" was possible; second, to explore the audience reaction to the new technology; and, third, to explore the technical performance and characteristics of the technology.

Trial design

Frequency, location, and power

The BBC's assignment on 855 kHz in Plymouth, which was in use for BBC Radio Devon, was chosen as the candidate for the trial. The choice of Plymouth was for both technical and political reasons: it offered a relatively contained community in which to undertake the audience research; it offered the opportunity to investigate a wide variety of topographical conditions (given that the transmission was expected to extend out on to Dartmoor); and BBC Radio Devon had relatively recently started simulcasting its medium-wave output on a dedicated FM frequency for the city.

Under rules agreed by the International Telecommunications Union, countries can "convert" AM assignments in the medium-wave band to DRM operation using the same frequency subject to a power reduction. The power reduction is designed to keep the amount of outgoing interference – that is, the interference experienced by other users of the frequency – at a comparable level between the two transmission systems. On investigation, it was determined that the antenna system at the transmitting station at Plymouth was about 40% efficient; thus, about three-fifths of power from the transmitter was lost. This meant that the 1 kW AM transmitter was

actually developing an EMRP of around 400 W; hence the DRM transmission was required to be no more than 80 W in EMRP.

Complete transmission characteristics for the transmissions are given in the appendix to this summary report.

A second transmitter

A second transmitter was installed at the main VHF transmitting station for the south west, North Hessary Tor, which is in the middle of Dartmoor and hence north of Plymouth. The intention of this transmitter was to allow the investigation of co- and adjacent-channel interference (both DRM into AM and AM into DRM), as well as checking the potential of single frequency networks.

In the event, because of the ground conditions, this transmitter was not able to develop much EMRP – not more than a few watts – so it did not provide any additional coverage to any of the audience panellists. That notwithstanding, even at such low power levels, it did allow the investigation of the technical items it was designed for.

Audience panel

In the meantime, an audience panel of around one hundred listeners had been recruited from Plymouth and the surrounding area. These were gathered by on-air and on-line appeals on BBC Radio Devon and so reflected their listening base; indeed, the panel was recruited so as to broadly reflect the demographics of Radio Devon's audience. The panel were given DRM-capable radios and were asked to complete three week-long exercises during the trial, in addition to discussion on the trial messageboard and certain ad hoc exercises. In addition, three sets of detailed interaction were undertaken with particular panellists: one formal focus group; one focus group with various senior staff from the BBC; and one series of in-home visits.

One of the intentions in keeping the trial on-air for so long was to attempt to lose the 'trial effect' amongst the panel so that their typical listening patterns could be observed.

The panel was run for the BBC by an external audience research company, Leapfrog Research & Planning.

Monitoring network

A small network of unattended monitoring stations were designed, built, and deployed by engineers from BBC Research & Development. These were put in at sites around the transmission area and were intended to continuously log various parameters of the received signal. Two were put in at the transmitting stations used in the trial in order to monitor the output of the transmitter as it went into the antenna; this would permit the removal of data in instances where the transmitter

itself was acting abnormally. Of the remainder, one was put into a domestic location on the edge of daytime coverage; one in the BBC's studios in Plymouth (which are solidly within the night-time coverage area); one at a transmitting station on the western edge of the service area; one in a domestic location in the centre of Plymouth; and one in a domestic location north of the city.

Drive surveys

Finally, a number of surveys were undertaken by engineers from BBC Distribution in order to drive through the service area during both day- and night-time conditions. In each instance, the vehicle was fitted with an external antenna and connected to a continuous measuring unit which was broadly the same as those used in the monitoring network. The information collected by this method provides a view of the extent of the coverage area, as well as some data which may be useful when calculating protection ratios and planning parameters.

Timings

The DRM transmission was brought on-air on 23 April 2007. The audience research started at around the same time and continued for a year. Once the findings had been gathered, the panel were released from their duties; however, the transmission remained on-air so that final demonstrations and discussions could be completed. It was eventually closed down on 31 October 2008.

Results

The other reports obviously give the results in more detail and with all the necessary caveats and qualifications; the intention here is to summarise these in broad terms without those except where absolutely necessary.

DRM conclusively sounds better than the AM it replaced

The audience research demonstrates that the panel found the experience of DRM better than the AM they had had before. When it worked, it offered consistent and clear audio, which was quantifiably better than AM. This is even though the DRM signal permitted a maximum audio bit-rate of around 22 kbps – and a proportion of that was used to transmit parametric stereo information, leaving about 18 kbps for the AAC audio itself.

Without specific guidance and repeated listening, panellists rated the audio quality of DRM as comparable to FM, although when pushed through detailed exercises most rated DAB as better than DRM.

It should be remembered that, in the main, the audience panel were not recruited on the basis of being expert listeners (so called "golden ears") and were listening to the output of Radio Devon as part of their normal, everyday listening: the source material for the trial was therefore principally speech and adult-contemporary music.

Thus, what sounds 'good enough' – which includes DRM – is likely to be good enough in practice.

DRM daytime coverage is very much larger than an equivalent AM service

From the drive surveys, the DRM coverage can be shown to be vast, even given the relatively low power of the main Plymouth transmitter. DRM was successfully decoded on the north coast of Devon and as far south and west as Falmouth; this compares to a technical coverage of AM which does not extend north of the middle of Dartmoor.

This extent of coverage is based on an antenna with some directional capability mounted outdoors and feeding into a computer-based logging system whose performance when it comes to decoding is likely to be somewhat better than that of currently available receivers. This suggests it may be overstated and not necessarily the coverage that would be experienced to domestic receivers in practice; nevertheless, these considerations would also affect the AM coverage, so the two will drop (or expand) in sympathy with one another.

Single frequency networks are possible – and highly resilient

The additional transmitter at North Hessary Tor allowed experiments with single frequency networks (SFNs) and it was shown that these were almost impossible (in the circumstances of the trial) to break. The very long guard interval inherent in DRM means that SFNs are highly reliable and can make use of contributions from a very long way away.

Night-time coverage is much smaller than day-time coverage

Given the additional interference to medium-wave services from distant interferers which is apparent at night-time, the night-time coverage was always expected to be smaller than the daytime coverage. Indeed, the DRM coverage at night is larger than the equivalent 'clean' AM coverage at night.

It is important to note that the frequency we were using for DRM at Plymouth is particularly susceptible to interference from distant transmissions, although it is not atypical of the situation that occurs on many AM frequencies assigned to BBC Local and network radio in the UK. In some areas, the frequency allocated may be very much clearer of interference and so the difference between daytime and night-time reception will be less marked: it is possible that the frequency allocated to BBC Radio Scotland (810 kHz) is one such example.

However, a difference between the daytime and night-time coverage of the transmission will always present a problem, even if the night-time coverage is greater than the claimed AM coverage at the moment. This is for three principal reasons.

First, the enormous area which appears to be served by DRM during the day means that the contrast between the night-time and daytime coverage is even greater and potentially affects even more people. Medium-wave transmitters are typically planned on the edges of cities, so that the main centre of population is comfortably within the night-time coverage area of the AM. However, if DRM is capable of serving a wide-area then it stands to reason that neighbouring centres of population – previously outside both daytime and night-time coverage – will now be daytime only.

Second, whilst the night-time coverage of DRM is greater than the equivalent 'clean' AM coverage, it is apparent that the technical limit of AM coverage is not the same as the limit at which listeners will stop listening to it. Thus, listeners will tolerate much more cross-talk from interfering sources than is catered for in international planning standards, even more so if it is content that they especially wish to hear. Similarly, listeners will listen to field-strengths well below the international limits even if the result is audio which is covered in static and noise. For this reason, the area in which listeners expect to be able to receive AM at night is almost the same as the area in which they can receive it during the day; and is very much bigger than the technical limit of AM coverage.

Third, the failure mode of DRM is – as with all digital systems – dramatic. The transition from working perfectly to not working at all is fairly sudden, even considering that DRM is designed to provide a measure of graceful degradation for longer than some other digital systems. Thus, listeners who previously received a degraded, interfered-with AM service at night now received nothing. At other times, given the dramatic fluctuation in interfering signal strength, listeners found the radio services dropping out – or burbling, or becoming 'metallic' in sound[3] – and taking some while to restore, despite any actions they took.

Conclusions

The Plymouth trial tested a particular situation: a one-for-one conversion of an existing service on an existing assignment from AM to DRM, subject to the required international parameters. As a result, it turned up a number of issues for DRM's use in the UK if deployed in this manner. It is clear, though, that all of the problems experienced from a technical perspective can be overcome if there was a willingness to increase the power of the transmissions, add more medium-wave transmitting stations to the network, and re-plan the use of frequencies.

One of the aims of the trial was to look at whether DRM could act as a complement to DAB coverage for local radio in areas to which the DAB operators may never extend. The results of the trial seem to show that if Plymouth (with its level of co-channel interference) is typical of the rest of the country then DRM, based on the current pattern of the BBC's domestic transmission network, could only fulfil this role with careful spectrum planning and network design.

[3] This particular observed effect may have been a function of the design of the receivers

Acknowledgements

The trial could not have happened without the assistance of many people, both inside and outside the BBC. The most important of those are the members of the audience panel, who gave of their time freely over a very long period. Without their assistance and patience, and that of the management and staff of BBC Radio Devon, the trial could not have occurred at all.

The following were all closely involved in the trial and their valuable contribution is very much appreciated:

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Gerry Thorn

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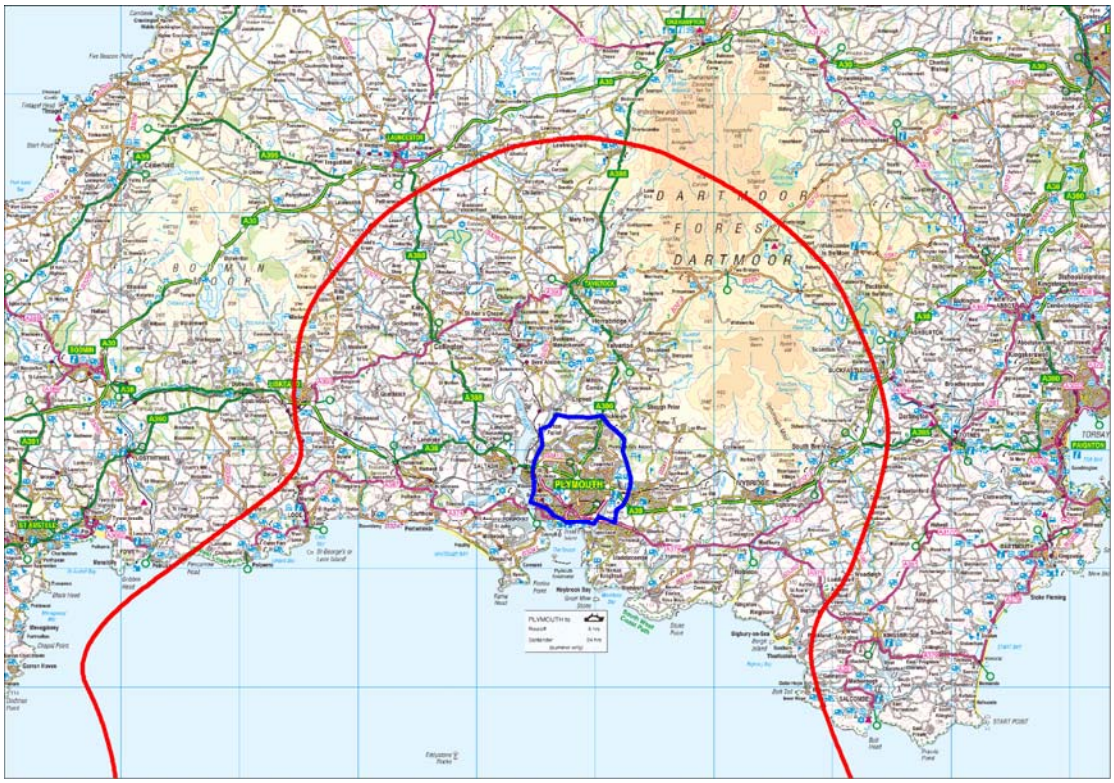
April 2009

Appendix: Transmission Characteristics

1. AM (prior to the trial commencing)

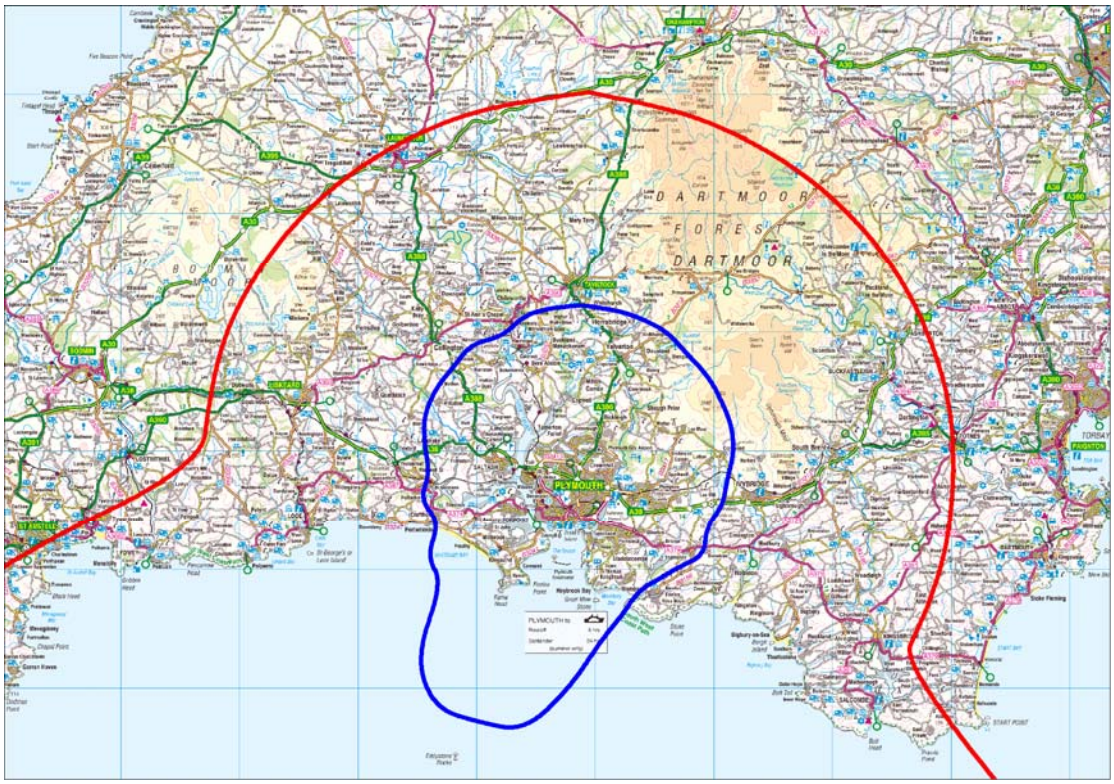
Site Name	:	Plymouth MF	
Location	:	SX 490 589	
		50° 07’ N	4° 23’ W
Frequency	:	855 kHz	
Max. power to the antenna	:	1 kW	
Approximate E.M.R.P.	:	400 W	
Horizontal Radiation Pattern	:	Omni	



Predicted interference limited coverage of AM from Plymouth on 855 kHz.
(Red – daytime; blue – night-time)

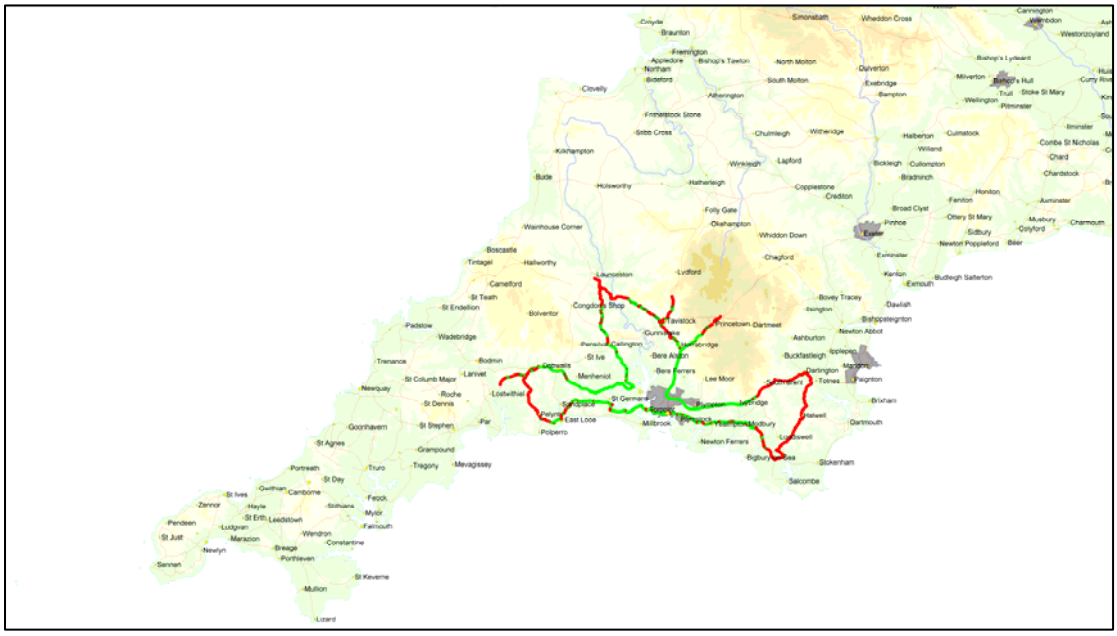
2. DRM (during the trial)

Site Name	:	Plymouth MF
Location	:	SX 490 589
		50° 07’ N 4° 23’ W
Frequency	:	855 kHz
Max. power to the antenna	:	200 W
Approximate E.M.R.P.	:	80 W
Horizontal Radiation Pattern	:	Omni



Predicted interference limited coverage of DRM (Mode A, 64 QAM, Rate 0.6) from Plymouth on 855 kHz.
(Red – daytime; blue – night-time)

Measured daytime audio quality of DRM (64 QAM) from Plymouth on 855 kHz
(green – good; red – bad)



Measured night-time audio quality of DRM (64 QAM) from Plymouth on 855 kHz
(green – good; red – bad)