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DRM - A KEY ELEMENT OF A DIGITAL DISTRIBUTION STRATEGY FOR THE FUTURE

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ABSTRACT

The DRM ™ [1] standard was established in 2001 and started to be used on a quasi world-wide scale in 2003 in the SW (Short Wave), MW (Medium Wave), and LW (Long Wave) broadcast bands. Results have shown that a near-FM quality stereo signal can be transmitted and received with good reliability over long distances, along with some data services, within the confines of 10 and 9 kHz channels.

DRM being well suited for the transmission of good-quality audio over large distances, across borders, to entire continents, provides an interesting delivery solution for the broadcasting and multimedia community around the world.

The DRM System and its genesis will be presented and discussed, along with an outlook towards the future.

[1] Digital Radio Mondiale ™

INTRODUCTION

AM broadcasting has been with us since the beginning of the 20th century. Some say that the first Station to broadcast was XWA, from Montreal, which started operating in 1922.

Today the Frequency Bands used for AM broadcasting include the following:

- Long-Wave (LW) bands, which are used outside of the Americas to provide country and continent-wide coverage using powerful transmitters.
- Medium Wave (MW) known in many parts of the world as just "AM" which provides regional or national coverage using powerful transmitters. In Region 2, however, the transmitter power is limited to 50 kW, but coverage in night-time can be national, because of reduced interference due to coordination
- Short Wave (SW), which is used for national and international broadcasting.

In the recent years, however, AM broadcasting has lost much of its appeal, because of its inferior sound quality compared to FM and digital systems, and also because of its perceived lack of "user-friendliness" in the case of SW broadcasting.

AM broadcasters have therefore looked for a technical solution which would give new momentum to AM broadcasting, by improving the sound quality, station-tuning, and, importantly for marketing purposes, would be digital.

The DRM system provides a solution which is unique in its capacity to be accommodated within all the AM broadcasting bands.

The DRM Consortium was formed in 1998, with members coming from all sectors of the broadcasting industry. Major international broadcasters felt that analog short waves, the principal medium of the day for them (and still today for many), were in the greatest need of improvement, especially for the audio quality, robustness, and ease of tuning that digital systems promised. SW also represented a great challenge to the community as it uses one of the most difficult medium of propagation, the ionosphere. However, if a system could work in the SW bands, it should easily work in the MW and LW bands.

The DRM Consortium set the following requirements for the system:

- A major improvement in listening comfort through improved audio quality and ease of tuning
- To maintain the compatibility with the present and future spectrum usage
- To limit the migration costs by re-using as much as possible the existing infrastructure, and by making the receivers inexpensive via an open and non-proprietary system
- Provide new features through data transmission.

DEVELOPMENT OF THE SYSTEM

In order to facilitate the DRM system development 3 main technical sub-groups were formed under the control of the DRM Technical Committee. These groups were the Audio Coding, Coding and Modulation and the System Evaluation sub-groups. The first two of these groups were responsible for producing the system specification, which would enable a working system to be realized. The third group was responsible for determining and monitoring the rigorous test process, which would evaluate the performance of the system against the initial requirements.

To start the system development process, potential system proponents were asked to propose candidate systems. This led to three proposals from Thomcast (Thales, now Thomson), T-Systems (Deutsche Telekom R&D) and IBB(VOA)/JPL. The first proposal was for a multi-carrier system and the other two were for single carrier systems. All three proposals were designed to be compatible with current AM broadcast channel bandwidths with the minimum number of transmitter modification.

In order to evaluate the performance of the initial 3 candidate systems 5 propagation channels were defined, which were designed to cover typical applications from LW and MW daytime ground-wave propagation through to various conditions of MW and SW sky-wave propagation. These 5 channels were simulated in real time, using a DSP based system developed within the laboratories of Fraunhoffer IIS (FhG). Before the testing process was started the IBB/JPL decided to withdraw its system.

There were thus only two systems submitted for the tests carried out in the FhG laboratories during Jan/Feb. 1999. The results of these tests showed that each system had its particular strengths and weaknesses. It was therefore agreed in March 1999 that selected properties of the two systems would be merged to form the basis of the DRM system. In essence these were that the multi-carrier (OFDM : Orthogonal Frequency Division Multiplex) properties of the Thomcast system would be merged with the multi-level coding properties of the D-TAG (T-Systems) system. Work then proceeded to determine the appropriate parameter sets to combine these properties. Various iterations of the developing system were then tested in non-real-time laboratory simulations until there was agreement on the choice of parameters which would form the real-time DRM transmission system.

Alongside the development work to define the parameters of the multiplex, the coding and the carriers, work proceeded on the audio source coding to be used. At an early stage it was agreed that MPEG4 AAC (Advanced Audio Coding) would form the basis of the primary audio source coding, but low bit rate speech coders, CELP (Code Excited Linear Prediction) and HVXC (Harmonic Vector Excitation Coding) from the MPEG4 standard were also proposed, as they would provide additional system flexibility. Also, at an early stage of system development, the addition of SBR (Spectral Band Replication) was proposed to the DRM technical groups as a way of enhancing the performance of AAC coding at the anticipated low bit rates (~15-25kb/s) considered feasible in an AM broadcast channel (i.e. within 9 or 10kHz channels).

With agreement on a set of transmission and audio encoding parameters and after further laboratory testing, it became possible to begin field testing of the system. However, it was not practical at this stage to produce hardware based audio encoding and signal multiplexing and coding equipment, so a sequence of test signals was generated in non-real-time and recorded, as files, on CD-ROMS. This then allowed the necessary real-time on-air signal to be generated by being read back from the disk in the small number of prototype DRM exciters, which were then available. In fact the use of pre-recorded files was an advantage at this stage since it meant that it was always known exactly what data and carrier sequence should have been transmitted and received. This made it easier to analyse the received signals.

Field tests were equally carried out in the LW, MW and SW bands to test the results from local ground-wave through to long distance sky-wave propagation. HF sky-wave services were tested from single to multi-hop propagation, including NVIS (Near Vertical Incidence Sky-wave). These initial field tests showed both how well the system performed as well as its limits. All the results were logged as I/Q signals, together with frame BER (Bit Error Rate), and as decoded audio. This resulted in many tens of Gigabytes being acquired for post-transmission analysis.

This post-transmission analysis process showed that a number of changes were needed in order improve the signal's resistance to some of the more challenging paths, particularly for NVIS services, where Doppler and delay spread, rather than low SNR, caused service failure. A sixth test channel was added, to better represent such conditions.

After further lab testing of the modified system had been carried out, the system was again tested in the field and the results confirmed that the modifications made had produced the required performance improvements.

The system was then considered to be in a sufficiently advanced stage of development for introduction into the standards bodies enabling the system specification to be published. The DRM system specification was thus initially published in 2001 by ETSI (The European Telecommunications Standards Institute) as *TS 101 980 v1.1.1 (2001-09)* and after ETSI approval was then forwarded to the IEC for international approval. Subsequently the DRM system specification has been published as a joint IEC/ITU specification. The current DRM specification may be downloaded from the ETSI website (www.etsi.org) as *ES 201 980 v2.2.1 (2005-10)*, along with other specifications, which relate to DRM transmission and reception equipment interfaces, protocols and applications.

SYSTEM DESCRIPTION AND IMPLEMENTATION

A summary sketch of the DRM system is shown in Figure 1, with the following key components:

1. A **source encoder** which will encode the audio and compress it to a lower bit rate. Coders used in the DRM system are:

    - MPEG4 HVXC and CELP coders which are used for bit-rates between 2 and 8 kb/s. Both provide good and intelligible speech at these rates
    - MPEG4 AAC is used for higher bit-rates up to 34 kb/s, and up to 74 kb/s if 2 transmission channels are used (18/20kHz total bandwidth)
    - SBR is also used to further increase the *perceived* audio bandwidth by the listener. SBR "restores" the higher frequency content of a signal by using a lower bit-rate "guiding" signal which "describes" the missing harmonics. In a similar fashion, SBR Parametric Stereo uses another lower bit rate guiding signal to deliver a realistic stereo-like experience for the listener.
    - Depending on the desired robustness of the transmission, normal or high protection will be selected.

2. Data can be multiplexed with the coded audio for insertion into the **Main Service Channel** (or MSC). The MSC is time-interleaved to better resist to short-time fading, common for sky-wave paths.

3. In addition to the MSC, a **Fast Access Channel** (FAC) and a **Service Description Channel** (SDC) are also added. The FAC provides the information which is used by the receiver to properly decode the signal: Bandwidth, interleaving, number of audio services, etc. The FAC is not time-interleaved in order to provide for fast acquisition of the signal. The SDC provides detailed information on how the audio signal is to be decoded, and also carries frequency information in case of parallel transmissions. It is time-interleaved but of lower complexity compared to the MSC.

4. **A Pilot Generator** provides information which will allow for coherent demodulation of the transmission.

5. The system uses **COFDM** to transmit the date coming from the MSC, the FAC and the SDC. COFDM is well adapted to situations where multipath and selective and variable fading are to be expected, as is the case with Ionospheric propagation.

- A guard interval is used between the symbols to deal with the resulting delay spread phenomenon, while COFDM itself will help with the Doppler shift. The number of COFDM carriers is reduced when more robustness is desired, and the guard interval is lengthened. This means that the bit rate, and available space for audio and data payload is reduced. The number of carriers goes from slightly less than 100 for the most robust mode to more than 200 for the least robust mode (9/10 kHz bandwidth occupancy).

- Finally, the OFDM mapper collects all the data cells of the MSC, the FAC and the SDC, and places then on a time-frequency matrix, effectively "dispatching" each data cell according to its priority, and robustness desired. The FAC needs to be received and decoded first as it provides for receiver synchronization.

Table 1 provides a summary of the different modes used in the DRM system.

Robustness Mode	**Main Service Channel**	**Signal Modulation Bandwidth (sub- or multiples of 9kHz or 10kHz channels)**	**Typical uses**
A	16QAM, 64QAM	4.5 to 20kHz	Ground Wave service, Line-of-Sight SW (6.3 to 75 kb/s)
B	16QAM, 64QAM	4.5 to 20kHz	Long-distance Sky-wave in MW and SW (4.8 to 56.1 kb/s)
C	16QAM, 64QAM	10 and 20kHz	Sky-wave SW with higher robustness (9.2 to 45.5 kb/s)
D	16QAM, 64QAM	10 and 20kHz	Near-vertical incidence SW; highest robustness (6.1 to 30.6 kb/s)

Table 1 – Robustness Modes (adapted from [2], used with permission).

It should be noted that in the table above, the bandwidth of the channel varies from 4.5 kHz (½ x 9kHz channel) to 20 kHz (2 adjacent 10 kHz channels), including 5 kHz (½ x 10kHz channel) 9kHz and 10 kHz.

6. If a linear transmitter is used, the composite COFDM signal replaces the low-level AM signal at the transmitter input. In the case of a current non-linear transmitter, the signal is split into its amplitude and phase components. The amplitude component is injected into the modulator audio input, while the phase component is injected into the frequency drives circuitry.

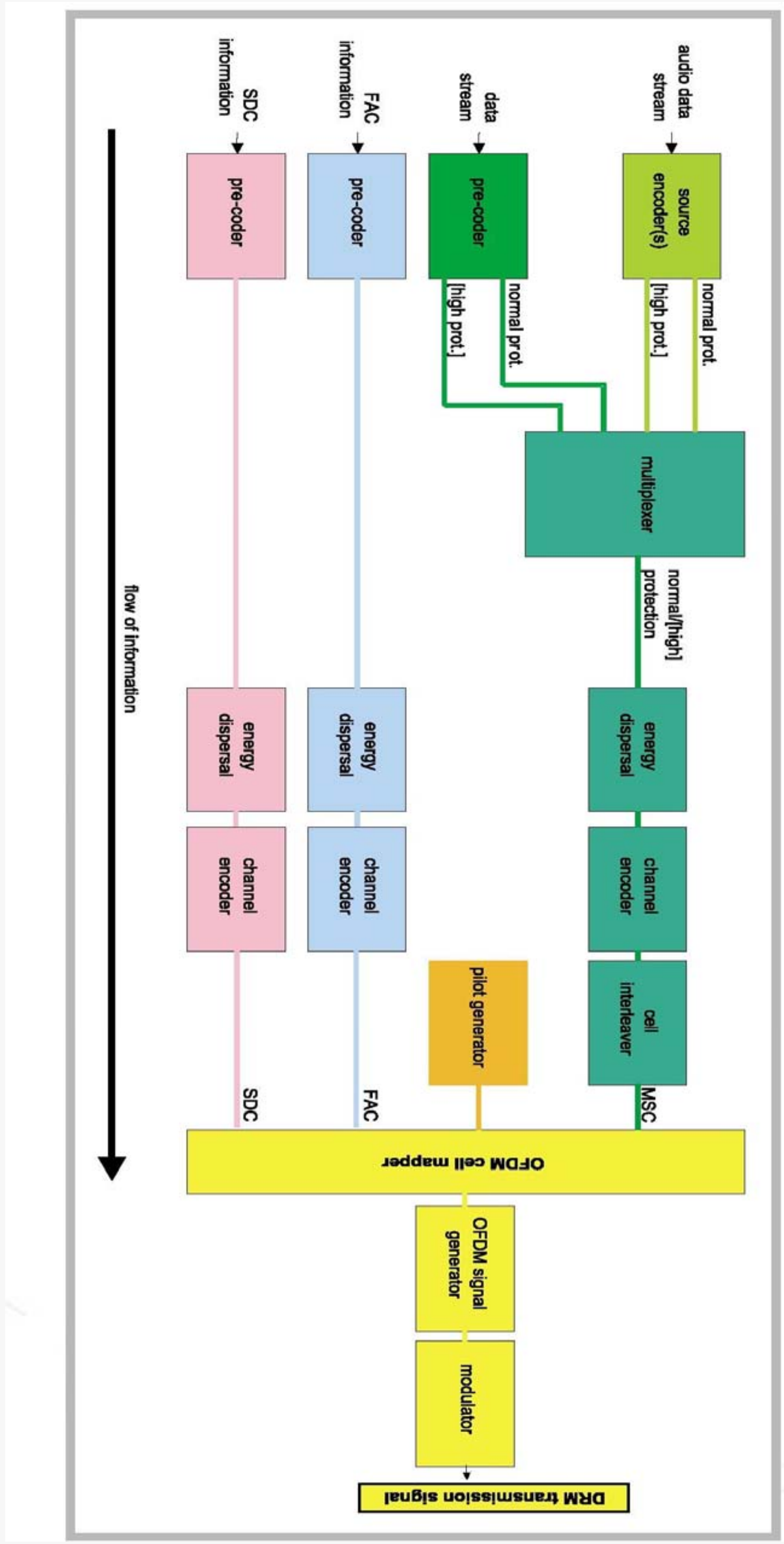

Figure 1 System Summary (reproduced from [2], with permission)

For the DRM system to work, the modulator often needs to be upgraded or modified, and the following characteristics need to be verified:

- The modulator and the final amplifier need to be DC coupled
- The bandwidth of the modulator needs to be increased, typically at least three times the bandwidth of the DRM signal(e.g. >30 kHz for an 10 kHz bandwidth DRM signal).
- Care should be taken to ensure that group delay characteristics remain flat over the pass-band of the modulator

Without proper care given to the above characteristics, the transmitted DRM signal will be degraded, and there will significant radiation outside of the assigned channel.

Recent modulators include pre-correction circuitry to help improve the group delay characteristics.

Key performance indicators of the Transmission system include the following:

- Out of Band (OOB) radiation : Although a DRM-specific Spectrum Mask has not yet been finalised, the one used for analogue AM (ITU-R SM. 328) is currently utilized . Accordingly, the OOB radiation is required to be :
    - Equal or below –35 dBc at 0,7 of the necessary bandwidth
    - Equal or below –60 dBc at 2,98 times the necessary bandwidth, with a slope of 12 db/octave.
- Modulation Error Rate (MER). Each carrier being modulated in phase and amplitude can be represented by a vector. Errors in the modulation process coming from phase and amplitude response, noise, etc. can also be represented by a smaller vector. The MER is the ratio between the desired vector and the undesired one. The MER should be at least 30 dB.

DRM SERVICES CURRENTLY AVAILABLE.

After some initial tests and demonstrations, regular DRM services started in June 2003, mainly in Europe, but also in the Americas, and other parts of the world. Today, round-the-clock services are available in Europe and in some parts of China, while prime-time services are available in the Pacific, Brazil and in the USA. In total, slightly more than 700 hours of transmissions are made each day[2].

[2] A detailed recent schedule can be obtained at : www.drm.org/livebroadcast/livebroadcast.php

1. Utilisation in the MW Band

   5 stations are currently broadcasting DRM services, each more than 12 hours per day, with a transmitter power higher than 10 kW. Most of these stations are located in Europe.

2. Utilisation in the SW Bands (with sky wave)

   Europe is the region where most of the DRM services are available. Target areas vary from local, national, continental and transcontinental with transmission aimed at North-America. As some of these transmissions are available 24 hours per day, most of the SW frequency bands are used. Bit rates also vary as long-distance transmissions require the more robust modes. Transmitter powers used range between 10 and 200 kW. It is of particular interest to note that commercial broadcasters have started DRM services.

   DRM activity is increasing in the Pacific, and in the Middle-East / Africa.

   DRM services are also available in the USA, mainly coming from CBC's Sackville station. The Station has recently been upgraded with the latest equipment and reception is particularly good in the North-East. Depending on the time of the transmission, under present low solar activity, successful transmissions are made in the "B" mode, with bit rates of 14 and 21 kb/s. Parametric stereo is used for 2 hours daily at the 21 kb/s bit rate.

3. Utilisation in the SW Bands (Line-of-sight)

   The 26 MHz short wave band (25.670 to 26.100 MHz) although allocated to international broadcasting by the ITU, is rarely used as it requires very high solar activity to benefit from sky wave propagation. Present low solar activity levels mean that it is practically not used. However, the 26 MHz band has some advantages : it is allocated to broadcasting, and it is high enough in the spectrum not to be plagued by electrical noise. Experimentation showed that this band could be used to offer line-of-sight (i.e. non sky wave propagation) DRM services to urban and semi-urban regions.

   DRM services in this band are available in some cities in Europe. Most are 24 hours/day, and the transmitter powers used vary from 40 W to 1.7 kW.

4. CBC's experience with the DRM System

   Since June 2003, the Sackville station has been broadcasting 5 to 6 hours daily of programs coming from CBC/Radio-Canada, RCI, and other important international broadcasters. With the help of dedicated listeners who provide reception reports through Forums on the Internet, and through listeners' e-mails, it has been possible to develop an understanding of the coverage of our DRM transmissions. Such reports are available on the Internet[3].

Present SW propagation conditions are poor, as the solar activity is at its minimum in the 11-year cycle. These poor conditions are even worsened by winter conditions prevailing at the time this is written. To ascertain completely the potential for the SW coverage of the DRM system, its performance over an 11-year solar activity cycle would need to be studied. Given only a few years experience the following observations can be made:

Under the recent Solar activity, with dusk and night-time conditions:

- Judging from the listeners' reaction, an availability of 98 % or better seems to be satisfactory.
- The one-hop coverage (distance of 2000-4000 km from the station) using the DRM system is similar to the coverage obtained in analog mode, using the same transmitter and antenna (250 kW analogue, 70kW DRM, HR 2/1/0,45 antenna at 268 degrees).
- Mode "B", at a bit-rate of 21 kb/s usually provides satisfactory one-hop coverage.
- Using Mode "B", 2-hop coverage will necessitate a bit rate of 14 kb/s or lower.
- The bit rate of 14 kb/s usually leads to a sound quality "equivalent to AM or slightly better".

Although the DRM system can transmit data in the form of text, pictures, or information from a web-site, CBC has limited itself to the transmission of a single audio program. This was felt to be the best way to showcase the improved sound quality of the system, using CBC/Radio-Canada programs and the programs of other international Broadcasters.

RECENT DEVELOPMENTS

1. Simulcast for the MW Band

   Simulcasting both analogue and DRM transmissions is necessary, to foster the transition to digital. This is of prime importance in the MW and LW bands, but of a smaller priority for the SW Bands, as many broadcasters usually use more than one frequency for each transmission. This would mean that one frequency could be converted to DRM, while others remain analogue.

   Broadcasters using the MW and LW bands are rarely allocated more than one frequency per service, and there is a need to find a way to “squeeze in” the DRM signal in the band.

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[3] Publicly available on the DRMRX Website : www.drmrx.org

Simulcast Tests have been made in the laboratory, but a test has been done recently in Mexico City [4]. The test was performed on a modified 50kW transmitter which carried the combined AM-DRM signal. The AM Signal was at 50kW on 1060 kHz, and the DRM signal was at 1.25 kW at Fc+10kHz. Both static and mobile reception tests were done, in different regions of the City, using consumer-grade receivers for he AM part. Mode "A" was used for the DRM signal, at bit rates from 26.6 to 11.7 kb/s. Some of the interesting observations are :

- The DRM signal had no perceptible effect on the subjective quality of the AM signal.
- Test points where the DRM signal was not quasi-error free were subject to low field strength and high industrial noise.
- The DRM signal was usually more resilient to fading and electrical noise, while delivering a near-FM like signal.

2. DRM in VHF (Band I and II)

Given the technical success of DRM in the AM Bands, the DRM Consortium is developing an extension of the system so it may be used in Band I and Band II (VHF frequencies below 108 MHz). Requirements for such a new system have been put forward and they include :

- Better spectral efficiency that FM
- Higher reliability than FM
- Improved audio, multi-channel sound, frequency information and data services
- Possibility of a SFN (Single Frequency Network)

These requirements along with a system overview, have been submitted to the ITU for consideration [5].

3. DRM Services in the 26 MHz band

In addition to the existing services described earlier in section **4.**, a test was performed in Mexico City in 2005 to demonstrate and ascertain the capabilities of the DRM system for local coverage, using the 26 MHz band [3].

These tests demonstrated that the sound quality can be much improved by the DRM system, allowing for parametric stereo, and that significantly less power (200 W for DRM vs. 10 kW for AM MW) is needed to achieve equivalent coverage compared to the regular MW Band. The 26 MHz band, however, is not without its problems, like sensitivity to obstructions, multipath caused by airplanes, etc. However, it was found that a signal increase by a few dB's would allow for near-perfect audio reception in the City.

CONCLUSION

The DRM system represents a very good and gradual replacement for the existing AM services around the world, allowing each station to digitize its output at a moderate cost.

As the Industry becomes more and more aware of the advantages of the DRM system, it is hoped that an increasing amount of consumer-type receivers will be available, contributing to the momentum. Being able to function in all the AM bands, and soon in Band I and Band II, DRM offers unique migration paths to an all-digital audio transmission system:

- Where channels are available, DRM-AM simulcasting can be used
- 26 MHz Line-of-sight DRM broadcasting can be used to introduce DRM services into metropolitan markets, at low cost and the future system extension will allow DRM services in Band I and Band II
- Short Wave services, no longer impaired by the limits of Ionospheric propagation can be used to simulcast in DRM to selected target areas during prime-time hours
- Intelligent receivers, using the Data services, will render seamless switching, for the listener, between all the delivery methods

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[4] Digital Radio Mondiale : MW Simulcast Tests In Mexico D.F. ITU-R Document 6E/403-E, 14 August 2006

[5] Digital Radio Mondiale : Narrowband Digital Broadcasting With The DRM System In Bands I AND II. ITU-R Document 6E/413-E, 14 August 2006

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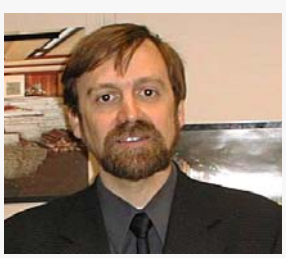
The authors would like to thank Ms. Anne Fechner, DRM Project Director, Bonn for her kind help and encouragement.

Peter Jackson currently lives in the south of France and, until his retirement at the end of March 2005, worked within the Digitalisation Group of VT Communications where he spent most of his time involved in the representation of the company within DRM (Digital Radio Mondiale). Although retired, Peter continues to provide occasional assistance to the DRM Project Office.

Peter worked for the UK's then largest commercial radio broadcaster, Capital Radio, between 1973 and 1993, and for the last 10 years as its Chief Engineer. In 1993 he joined BBC World Service and whilst there, in 1997, he was invited to become involved, together with other WS staff, in the formation of Merlin Communications. This led to Merlin's eventual successful bid to purchase and/or operate the assets used for BBC WS transmissions. In November 2001 Merlin Communications was sold to Vosper Thorneycroft (now VT Group) and currently operates as VT Communications.



Jacques Bouliane joined CBC/Radio-Canada in January 1980 as a transmission project engineer. He moved to Radio Canada International in 1986 to become Director of Engineering, where he oversaw the installation of five transmitters and RCI's move into a brand new production centre, among other things. Jacques also spearheaded the DRM standard at CBC/Radio-Canada from the outset. He currently heads up International Services in CBC/Radio-Canada Transmission.

Jacques is a member of the Ordre des ingénieurs du Québec, as well as the IEEE. He completed his electrical engineering studies at Université Laval, and holds an MBA (Manager) from UQÀM along with an MBA (Executive) from Université Paris-Dauphine.

Annex 1 - Equipment available today

A list of the available equipment has been established. This list does not constitute an endorsement either by the authors or by the CBC. However, this list might be helpful for organizations who would be interested in finding out more about equipment. It should be kept in mind that this list is not exhaustive.

a) For Broadcasters

The equipment available to the broadcaster for DRM transmission can be categorised under a number of types.

CONTENT SERVERS/MULTIPLEXERS

This equipment typically contains one or more audio source encoders and a means to insert data into the DRM multiplex either in real time (from e.g. an external source) or from internal storage. It may also allow audio or test sequences to be played from internal storage. The encoded signals will then be internally multiplexed together to produce the DRM bit stream. Units can generally be externally controlled or autonomously operate according to a pre-programmed schedule to allow multiplex re-configuration when required. This unit may be located at the studio centre or at the transmitter and be connected to the modulator using a DRM standard MDI (Multiplex Distribution Interface) interface.

MODULATORS

These units take the output of the content server/multiplexer (usually via an MDI interface) and produce the analog signals which can be applied to the transmitter. In general they produce a low power DRM COFDM signal at the required transmission frequency, suitable for applying to a linear transmitter, as well as amplitude and phase signals, which may be applied to the audio modulator and RF carrier inputs respectively of a non-linear transmitter. The modulator will thus be located at the transmitter site.

Exciters

This is generally the combination of the above two units to be considered as a system which will generate the signals required by the transmitter from the incoming base-band audio signal (and auxiliary data).

Monitoring Receivers

These are intended for professional use and should ultimately conform to a DRM standard interface specification as well as allowing a range of agreed standard signal parameters to be monitored and then output in a defined format.

In addition to these standard parts of the broadcast chain a number of manufacturers produce DRM signal generators and test measurement sets as well as units designed to provide (adaptive) pre-correction for transmitters.

Some of the manufacturers providing equipment falling into one or more of the above categories are:-

Digidia
(www.digidia.fr) – Content server, Modulator, Exciter, Test signal generator

Fraunhofer IIS
(www.iis.fraunhofer.de/dab/products) – Content server, Test equipment, monitoring receiver

Harris Corp.
(www.broadcast.harris.com/radio/transmission/) – Content server, Modulator, DRM-capable transmitters

Nautel
(www.nautel.com/DRM.aspx) – DRM-capable transmitters

RIZ
(www.riz.hr/drm/equipment/drmequipment.html) - Content server, Generator, Modulator, Transmitter pre-correction module, DRM-capable transmitters

TCI
(www.tcibr.com) – Low power, low sky-wave radiation 26MHz antenna for DRM local services, high power, long distance antenna systems

Thales (now Thomson)
(www.thales-bm.com/html_gb/frameset.html?name=products_radiobroadcast.html)
Modulator, Exciter, Multiplexer, Monitoring receiver/analyser, DRM-capable transmitters

Transradio (formerly Telefunken)
(www.transradio.de/html/drm.html) – Modulator, Exciter, DRM capable transmitters.

b) Consumer Receivers

Stand-alone Radio Receivers

Morphy-Richards DRM-DAB Radio
(www.t-online-shop.de/tonline/urwfilter/product/do/action/getProductDetail/product/19704/pn/Morphy_Richards_DRM_Radio/index.html)

Sangean DRM-40
(www.sangean.nl/English/?opt3=DRM-40&opt5=297)
(available early 2007)

StarWaves W37 multi-channel receiver
(www.starwaves.com/index_eng.htm)

Himalaya 2009
(http://www.himalaya.com.hk/)
(available early 2007)

Receivers to be used with a PC-type computer

Coding Technologies
Digital World Traveler (USB Radio Receiver for the PC Platform)
(www.codingtechnologies.com/products/assets/digitalworldtraveller_v2.pdf)

Winradio WR-G313e
http://www.winradio.com/home/g313e.htm
(available with optional DRM decoder/demodulator)

Some normal analog receivers can be modified to output a 12 kHz IF, and decoding software is available. For more information go to www.drmrx.org.