

## Digital Radio Broadcasting

This article is intended to make Community Radio Broadcasters think very carefully whether it is worthwhile, practical and economically viable to get involved in Digital Radio Broadcasting.

There are several competing Digital Radio Broadcast Systems, at least two are Satellite Based, XM and Worldspace and at least three Terrestrial systems, DRM, IBOC and DAB.

Internet Streaming, and Pod Casting are forms of "Wired Digital Broadcasting" and not discussed here.

Interesting information on Satellite and Terrestrial systems can be found on the internet

- [www.xmradio.com/](http://www.xmradio.com/)
- [www.worldspace.com/](http://www.worldspace.com/)
- [www.drm.org/](http://www.drm.org/)
- [www.iberiquity.com/hdradio/](http://www.iberiquity.com/hdradio/)
- [www.worlddab.org/](http://www.worlddab.org/)

Digital Satellite Broadcasting does cover large areas with Political and Economic reasons making it highly unlikely for general Community Radio Broadcasters to get access to it.

Digital Terrestrial Broadcasting is confined to smaller areas removing Political reasons and objections.

Digital Radio Broadcast Transmission Systems, particularly Eureka 147, capable of handling a number of Radio Broadcast and Data services are very complex and expensive to set up and will most likely be owned by large Financial Institutions or Owner Groups formed by a number of Broadcasters who will operate the system for profit by renting out capacity, and generally act as Service Providers.

In order to get good area coverage, a large City will require several Digital Transmission Systems located in different places, generally referred to as Multiplex Assemblies which for practical and technical reasons all must have the same owner, who to maximize profits will no doubt carry as many Audio Broadcast and Data Services as possible on each Multiplex Assembly.

Indications from the UK support the above theory with many complaints about the Audio Quality of some of the Eureka 147 DAB Transmissions, see [www.digitalradiotech.co.uk/](http://www.digitalradiotech.co.uk/) for details.

The Service Provider or Multiplex Assembly Owner will also, without doubt, charge as much he can get away with for these services, probably making it financially impossible for a general Community Radio Broadcaster to participate.

The Eureka 147 DAB System is currently, undergoing trials in Sydney and Melbourne which are planned to continue till 30 June 2007 with bit rates used ranging from 64 to 224 K Bits/Sec.

ACMA are committed to facilitate trials of all digital radio technologies, including Eureka 147, Digital Radio Mondiale (DRM), In-Band On Channel (IBOC), ISDB-TSB and other existing or emerging systems.

Official start date for Digital Radio Broadcasting in Australia is January 1 2009 according to information from ACMA.

Strong indications are that Australia will not adopt the standard Eureka 147 System using MPEG-2 Layer 2 Audio Compression which is capable of good audio quality at bit rates of 192 K Bits/Sec or higher, but becomes marginal at 128 and 160 K Bits/Sec.

Indications are also that ACMA will limit the Bit Rate to a maximum of 128 K Bits/Sec per broadcast service and adopt the better audio compression system, Advanced Audio Coding (AAC) or (AAC+) Instead of standard MPEG-2 Layer 2 as used by the standard Eureka 147 system.

This will unfortunately render most existing Eureka 147 DAB Receivers obsolete and therefore useless. Another Digital Audio Broadcast System is IBOC now coming into use in the USA.

IBOC makes use of existing FM Transmission Frequencies and is likely to be more cost effective than Eureka 147 but will require the stations to buy new Transmitters and other equipment.

It will however allow the Broadcaster to own and keep control of his own Transmission System.

To my knowledge, there are no firm plans for evaluation of the IBOC System in Australia.

Digital Radio Mondiale, DRM is a European System being experimented with, supposedly suitable for Digital Audio Transmission on the Medium and Short Wave AM Bands.

I am not aware of any plans for evaluation of DRM in Australia at this stage.

Looks like Australia will be standardizing on a variant of Eureka 147 called DAB 2.

There are some interesting facts and observations about Eureka 147 published on the Internet. Finland, a country known for advanced electronics, and the homeland of NOKIA have recently turned DAB off, reason given being lack of interest by Commercial Broadcasters and the general public.

Sweden, another advanced country has after spending in excess of \$ 100 Million, decided not to proceed with planned expansions to the DAB Network, for pretty well the same reasons given by Finland.

Estonia, a small country, south of Finland broadcast 4 Government Controlled DAB channels, each at 256 K Bits per Second which is the highest Eureka 147 quality possible, and no doubt sounds very nice.

The UK, the country where Eureka 147 was designed or invented use the lowest bit rates in the world, most services use 128 K Bit per Second or lower, and voice the majority of complaints about DAB sound quality.

This is no surprise as most of the Multiplex Assemblies there are owned by private companies and operated for maximum profit, all carrying too many services on each assembly to give good audio quality.

I have personally listened to both Eureka 147 and IBOC transmission at the 2005 SMPTE exhibition in Sydney, some Eureka 147 transmissions sounded fine while others sounded absolutely terrible.

IBOC sounded fine, possibly because the Program Audio feed to the IBOC Demonstration Transmitter was a selection of high quality CD Music Tracks, Unprocessed (No Audio Processor), Moderate Audio Data Compression to 265 K Bit Sec MP3, and delivered from an Elan Audio RAD-01 Emergency Program Player.

As an aside, both the ABC and SBS has for some time been broadcasting "Digital Radio" as a sub channel on their Digital TV services, I have been unable to obtain information on the Bit Rates used but neither service sounds particularly impressive, the ABC "Dig-Radio", although not actually distorted lack details and sounds like "Elevator Music", but maybe that is the "Beautiful Digital Sound" often referred to in adverts.

Bit rates used in the UK are 192, 160, 128, 96, 80, 64 to as low as 48 K Bit/Sec.

Data Rates of 192 K Bit/Sec should be excellent, 160 OK, and even 128 passable with anything lower only suitable for Mono Speech such as Sports Reporting.

The UK observations and complaints about poor audio quality at 160 and 128 K Bit/Sec strongly suggest that Cascaded Audio Compression, and unsuitable Audio Processing is a major reason for audio quality loss.

### **First a bit about Audio Data Compression**

All types of Audio Data Compression used in broadcast applications work on the "Loss" Principle" by throwing away subtle details such as low level sounds, harmonics and overtones which, it is assumed will be masked by louder sounds and therefore not missed.

For this to work well, audio to be compressed must retain its Original Energy and Spectral Distribution properties or the audio compression will results in some strange sounds and artifacts.

Compressing Raw CD Data, 1.41 M Bit/Sec to say 128 K Bit/Sec MP3 means throwing away about 11 times more Data than that available from the original and is all that is left to Re-Construct to something resembling the original sound.

Carefully Ripped, or Compressed 128 K Bit/Sec MP3 Audio is passable for AM and FM Broadcasting although 160 K Bit/Sec or higher is much better.

Unfortunately once you have thrown away the subtle audio details, they are gone, and you cannot Re-Compress again (Cascaded Audio Compression) without audible loss of quality and the creation of audible artifacts.

To make matters worse, using a Dynamic Audio Processor to maximize loudness and to maintain correct audio levels, as is standard practice for normal AM or FM Broadcasting, will further degrade sound quality by changing the Energy and Spectral Distribution and should never be used ahead of any form of Audio Compression.

Unfortunately and presumably for economic reasons, Cascaded Audio Compression is used in most Digital Audio Broadcast Systems, and is probably the main reason for the Sound Quality problems observed and complained about in the UK.

### **Elements of a Digital Audio Broadcast System**

There are several possible variations to DAB Systems, all of them complex and expensive, and all involve one or more stages of Audio Compression and De-Compression.

A typical worst case scenario envisaged is a small Community Station wishing to broadcast in DAB using existing PC Based Digital Audio Delivery Equipment and existing Stored Audio Material.

Audio material is compressed and stored on Hard Disk at 128 K Bit/Sec in MP3, usually with Audio Levels all over the place.

The Digital Audio Signal from the Hard Disk Based System is then De-Compressed to become an Analog Signal for Broadcasting which may be acceptable for AM or FM where a good Dynamic Audio Processor will more or less take care of variations in audio levels.

The Analog Audio is Multiplexed to become Composite Stereo, and sent to the Transmitter Site via a conventional Analog UHF Studio to Transmitter Link, or Digitized at an uncompressed high bit rate and sent to the Transmitter Site via a Digital STL.

For Digital Broadcasting, the signal path between the Studio and the Transmitting System is much more complex.

First, the Audio Signal must be sent to a Distribution Center, most likely owned and controlled by the owners of several DAB Transmitters in an area where it will be multiplexed and assembled with other Broadcast Audio Signals, and from there sent on to DAB Transmitter Sites.

Sending the Audio Signal from the Studio to the Distribution Center at a high bit rate as Uncompressed Digital Audio via STL type equipment is probably not an option in Metropolitan Areas as useable Link

Frequencies and Paths for additional Links are unlikely to be available, and sending it via a Telstra Broadband High Speed Data Link is likely to be too expensive for Community Broadcasters.

ISDN may be an option, still expensive, and unfortunately require Audio Data Compression at the Studio and De-Compression at the Distribution Center causing further degradation to the Audio Quality to take place, made worse by the Dynamic Audio Processing necessary to maintain correct Audio Levels, before it can be accepted by the Digitizing and Data Compression circuitry of the ISDN Codec.

As mentioned earlier in this, a normal Dynamic Audio Processor such as used for normal FM Broadcasting will degrade sound quality by changing the Energy and Spectral Distribution and should, according to various articles about the subject, never be used ahead of any form of Audio Data Compression.

The Compressed Audio Signal received at the Distribution Center will either need to be De-Compressed back to Analog, or Digitally Converted to a format compatible with the Eureka 147 Transmission System.

The same amount of degradation to Audio Quality will take place whether the signal is De-Compressed to Analog, or Digitally Converted to a Different Standard which currently is either MPEG-2 Layer II designed to operate at Bit Rates of 192 K Bit/Sec or higher, but often applied at lower bit rates, or as considered for Australia AAC Coding, reputed to produce good audio quality at 128 K Bit/Sec.

The Digitized Audio, is then chopped up into small pieces, joined in a special sequence called Coded Orthogonal Frequency Division Multiplexing or COFDM, and sent to the Transmission Site as a complete Multiplex Assembly ready for Transmission except for Time Correction or Synchronization which in some situations is necessary and usually done at the Transmitter site.

Final De-Coding back to Analog takes place within the Eureka 147 DAB Receiver.

The complexity, involving three stages of "Lossy Audio Compression", and an unsuitable Audio Processor used to maintain correct Audio Levels, may in part explain why some DAB services are reputed to sound terrible on Bit Rates of 160 K Bit/Sec or even higher.

The Audio is so badly mangled by the Digital Audio Compression processes, leaving maybe only 4% of the original information by the time it is decoded to Analog Audio in the receiver.

After all, you throw away information away that won't be missed too much on the first Compression and De-Compression stage, the information is gone, you must throw away a similar amount of information in the second stage, this time you are forced to throw away information that is certain to be missed, the mind boggles what is thrown away in the third stage.

On the other hand, some stations using 128 K Bit/Sec are reputed to sound quite respectable and is possibly explained by the following.

Audio is carefully transferred to Hard Disk, and stored Uncompressed in the Raw CD Wave Format, Audio Levels are carefully monitored and controlled by a skilled operator using an Analog Mixing Console, Minor Output Level discrepancies from the Console are corrected in a high quality AVC or Leveling Amplifier, which, unlike most FM Audio Processors, does not change or modify Energy or Spectral Distribution of the Audio Signal.

The Signal is then converted to Uncompressed 48 KHz 16 Bit AES/EBU Digital Audio Data and transmitted to the Distribution Center in that format via a Broadband STL or high speed Data Circuit.

At the Distribution Center, the AES/EBU Data is compressed to MPEG-2 Layer II, or AAC in Australia if the plan for AAC Coding goes ahead, at the Bit Rate to be transmitted and Multiplexed with other services and sent on to the Transmitter involving only one Audio Compression stage.

The above scenario would be ideal, and possibly be the method used by the ABC and the larger Commercial Broadcast Networks, but for economical reasons highly unlikely be the case for Community Broadcasters.

## **To sum up**

Eureka 147 Digital Audio Broadcast quality can be excellent, or it can be absolutely awful.

To set up and operate DAB will be very expensive, particularly if high quality is required.

The number of listeners will be small initially due to a very limited number of DAB receivers.

Audio quality from a conventional first-rate and correctly operated FM Broadcast System is excellent.

The number of potential FM listeners is huge due to a very large number of existing receivers.

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