ROLLING OUT COMMERCAL NETWORKS: SOME BUSINESS & ENGINEERING ASPECTS

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Abstract

The Eureka 147 DAB System for digital radio is a solved problem as far as systems engineering is concerned. However, many significant challenges remain in translating this technology into the network infrastructure that will serve the third age of radio.

The United Kingdom is playing a lead role in developing both public and private digital radio, with an established BBC network, and the licensing process for commercial services now underway. This paper addresses some of the major commercial and engineering issues involved in rolling out commercial digital radio networks. These involve planning criteria for national and metropolitan services, cost effective system design and an awareness of the need to provide an easy entry point for commercial broadcasters.

The paper draws on the authors' work in planning digital radio networks in the UK, and is supported by a case study, which is effectively a blueprint for the digital radio service of the future.

Introduction

This paper addresses some of the major business and engineering issues associated with introducing digital radio networks for commercial radio broadcasters. Although the Eureka 147 DAB system is a proven robust and reliable system in engineering terms (1), there are many questions still to be answered before the commercial DAB networks become an established media landscape.

In the United Kingdom, there is a sense of inevitability that digital radio will happen. However, this is tempered by uncertainty about receiver penetration rates, the scale of the upfront investment required to build the new infrastructures, and the potential benefits from increased listening and advertising revenues.

As a consequence of this it is essential that the engineering philosophy deployed in the design and construction of the new networks takes account of this inherently agnostic industry attitude, and delivers cost effective solutions that meet genuine customer concerns.

ntl has been working very closely with its customer base of commercial broadcasters to develop appropriate designs and network implementation strategies. The results of some of that work are presented here, together with a detailed case study, which addresses many of the major themes in the discussion.

Regulatory background

The regulatory regime for digital broadcasting in the UK is generally regarded as benign. Enabling legislation was passed in 1996 (2) to allow digital broadcasting licenses to be offered. Licensed multiplex operators will offer capacity to broadcasters and other service providers.

Among the incentives offered to commercial broadcasters is an automatic right of carriage for the three existing national analogue stations (Classic FM, Virgin 1215 and Talk Radio), plus rollover of those stations' analogue licences if the guaranteed place is taken up.

Local broadcasters have no automatic right of access to local multiplexes, but if they invest in digital radio there is the incentive of an automatic licence extension, which can secure a longer term revenue generation position. BBC local radio however, has the right to have capacity on local multiplexes reserved for their use.

All digital radio in the UK in the near future will be accommodated on seven frequency blocks in Band 3, and will thus be a mixture of national and local/metropolitan services. This makes for some interesting service planning issues.

Planning Issues

The main parameters involved in planning any system of DAB networks are co-channel and adjacent channel interference, interference to neighbouring countries, and efficient reuse of available frequency spectrum. Within these broad classifications there are some interesting differences between planning for national and local services.

National Planning

The BBC national DAB network currently covers in excess of 60% of the UK population from a network of 29 transmitters (3). This network was rolled out from September 1995, so in DAB terms it could be said to be a mature infrastructure.

The development of the only national UK commercial DAB network will follow the topography of the BBC one. Since much of the planning work has already been performed by the BBC, the main planning criteria are interference limits to neighbouring countries outside the UK. This may have an impact on network destiny, especially in the coastal areas such as the south coast of England, and East Anglia. A secondary planning concern is the effects of long distance interference on the integrity of the 250s DAB (Mode 1) guard interval. This is particularly relevant when analysing signals from sites which have a potentially very large geographic reach, such as ntl's Emely Moor site, which is the tallest free-standing structure in the country. Ensuring that long distance radiation from this site does not cause problematic interference will require careful antenna design.

In general, successful planning of the national commercial multiplex will require a great degree of co-operation with the BBC, and strict adherence to the published Radio Authority list of Reserved Assignments. (4)

Local Commercial Multiplex Planning

Planning for local DAB multiplexes forces the broadcaster to address many new areas of concern which are relevant to analogue services, nor indeed to national DAB.

Key among these is the issue of adjacent channel blocking, where local services on adjacent channels to high power national services will suffer degradation due to the national service punching a "hole" in the local coverage area in the vicinity of the national transmitter. A local multiplex on an adjacent channel which is not co-sited with the national transmitter may also cause similar interference problems to the national service. Careful siting of local and national services is the key to optimising performance in this area.

Co-channel interference, both outgoing and incoming, is another key problem, and will affect frequency re-use distances. Careful design of local SFNs, such that outgoing "spill" is minimised, is necessary here. Related to this is the need to match the DAB coverage footprint to the analogue Total Survey Area (TSA) of existing services. It is worth pointing out that the TSA is a purely marketing boundary, and does not necessarily correlate to a station's Measured Coverage Area (MCA) on FM. DAB offers the opportunity to match very closely the TSA to actual served areas because of the ease of adding co-channel fillers. However, there will be a cost associated with this, and the key to successful planning is to balance the opportunity to define accurate coverage areas with the need for sensible costs of entry. The radio authority has recognised this issue in its notes of guidance by allowing licensees to address "primary" and "secondary" coverage areas, which may offer different levels of protection to incoming interference. (5)

System Design

The need for a cost effective migration path for commercial broadcasters will to a very large extent dictate the engineering design philosophy. Since the commercial potential of DAB is directly related to the rate of receiver penetration, it is felt that "gold plated" engineering solution are inappropriate in the early days.

A more practical solution is to design systems that have an inbuilt capacity for added redundancy, but offer cost effective early deployment. This means, for example, that multi-module, multi-redundancy amplifiers may be fitted from Day One, but that only single-ended COFDM coders and drives be fitted initially. However, sufficient rack accommodation and connectivity ought to be provided to allow for the fitting of back-up systems in the future, probably based round a break-point related to a suitable metric such as receiver penetration.

A similar principle applies to distribution design, with a simple terrestrial ring distribution architecture being complemented by a satellite based solution once the national network has grown to sufficient size (say a network of 40 transmitters or more). Local multiplexes will use terrestrial links, which may be a combination of wired and wireless systems.

Case Study: Melody FM, London

ntl has been working very closely with a key customer, Melody FM, in creating a testbed study to blueprint the digital radio systems of the future. This case study describes the objectives, deliverable's and progress to date of this project.

Objectives

The primary objective of this project was to build a fully digital radio station, from microphone to receiver loudspeaker. The system would incorporate advanced digital audio techniques in the studio and be distributed via digital links to a Eureka 147 DAB pilot transmission system in the London area.

Deliverables

The deliverable's from this project are concerned with gaining knowledge and expertise in the following areas:

- digital audio production, compilation and distribution techniques in radio studios
- provision of data service enhancements to audio programming using DAB's data capabilities
- the effects of complex signal processing techniques on MPEG-encoded DAB signals
- DAB distribution, multiplexing and transmission techniques

Project Design

It was decided from the outset that the project should simulate as closely as possible a real-word commercial radio environment. Melody FM in London was chosen because the station's Chief Engineer, Philip Bond, had already contributed to DAB datacasting experimental projects in conjunction with ntl, and also senior management at the station were sympathetic to the aims of the project.

However, it as realised that no disruption could take place to the normal operation of the station, so the methodology involved running a "parallel" digital version of the station with added data enhancements. But as far as the presenters and other air staff were concerned, it was business as usual.

Studio System Design and Programme Content

Melody FM has an advanced computer-controlled studio supervision system which among other things controls the output of the station's dynamic RDS radio text stream. Thus the status of each fader on the studio control surface is known at any given time. It was decided to use this control information to drive a second digital mixing system housed in the station's Master Control Room. The inputs to this system would be the digital sources of the studio's existing CD players, commercial playout system and so on. Even the main on air microphone was changed for a digital model.

Programme Content

The programme content for the digital service consists of the existing Melody audio programme, plus four data services. One data service is embedded a PAD the audio stream; the remaining three are multiplexed together in a separate data channel. The total capacity used on the multiplex is 224kbps. This is summarised in TABLE 1.

TABLE 1-PROGRAMME CONTENT DETAILS

ServiceCoding Rate	Content
Audio 160kbps	Melody FM programme audio
DLS Embedded in MPEG stream @ 0.667KBPS	Radiotext, enhanced with real time programme related information
Quiz Mux'd in 64kbps channel	Quasi-interactive music quiz
EPS Mux'd in 64kbps channel	Electronic programme guide
Video Mux'd in 64 kbps channel	Studio camera, promotional video/graphics

Transmission Chain

Studio to multiplex link

The Melody Digital service appears as a service on ntl's London pilot DAB multiplex. Commercial multiplex operators are likely to have a more complex job in multiplex complication than their public service counterparts because they will be combining services from a range of geographical studio locations, from commercially competing broadcasters. (At present the BBC national multiplex is compiled from services that all originate in one studio centre).

Because of this, an important part of the project was to provide a distribution system that would allow for the transport of a fully integrated audio and data service mix. This was achieved using a high bandwith radio link operating at 1.4GHz, with suitable coding and interfacing equipment. A line of site path existed between Melody's studio building and the multiplex hub at ntl's Croydon transmitting station. A secondary aim of the project will be to provide a similar link using terrestrial fibre to provide diversity.

Transmission system

The distributed signal from Melody is combined with other services at ntl's Croydon base to form the main service channel of the London DAB pilot service. At present this uses two transmitters in a single frequency network: one radiates 10KW erp from Croydon, and the second is a lower power 50W filler designed to provide solid coverage in the built up central London area. It is located at ntl's satellite teleport just off Oxford Street. These two transmitters are frequency locked and made time co-incident by means of a GPS reference signal.

Early Results

There are already useful results being produced from the trial. These are summarised below:

1. **Standardisation**

Stick to standards such as AES/EBU balanced 110 ohm format for audio and synchronisation. Most professional digital audio equipment uses it. Use SP-DIF if necessary but outboard converters may be required-see Watkinson. (6)

2. **Establish alignment levels**

There are widely differing calibration levels, but use a consistent standard on station. Allow for limited headroom, and measurement on conventional PPMs. Beware of the lack of gain adjustments within digital audio distribution equipment.

3. **Synchronisation**

Use an in house master sync pulse generator, but ensure that it is correctly locked to the main service multiplexer independently of any intermediate clocking within point to point links.

4. **Cabling and connectivity**

Use specialist cable designed for wide bandwidth use, screened and impedance matched to source and load equipment. Provide ample buffering, distribution and access. Dedicated monitoring and patch matrices may be required instead of jackfield.

5. **Dubbing & transport of compressed audio**

Keep tabs on the number of transfers of digital audio material. Find how many processes can take place before audio is effected. Account for processing carried out by programme contractors and production studios – especially if MPEG based ISDN links are involved.

6. **Monitoring**

Use equipment with minimal processing delay where possible. Forget live off-air monitoring in headphones for presenters. Use responsive high resolution bargraph meters to check critical points in the programme chain. Quality assessment of final sound is possible only when microphones are not live.

7. **Bandwidth capability and limitations**

For lengthy programme items, don't use lower sampling rates needlessly. DR offers audio bandwidth up to 24KHz. Consider this when using low bit rate programme archive systems as subsequent re-use of the material will result in a loss of audio quality.

8. **Dynamic Audio Processing**

Take care adjusting the processing. Sound characteristics which may have been possible on FM may not always transfer to the digital domain.

9. **Analogue interfacing**

Provide sufficient analogue to digital conversion equipment. Ensure that analogue paths can also be provided for backups, safeguards etc..

10. **RDS Extensions**

For FM/Digital Radio simulcasting, consider adding cross band linkage. This gives the FM listener the chance to receive the digital service if it is available.

11. **Information and data production**

Allow the generation of complementary visual/multimedia elements for programme related data services. New skills will be required.

12. **Transmitter system timing and frequency issues**

It has proven difficult to mix manufacturers' equipment in the field due to different centre frequencies and network adapter delay management.

13. **Distributed programme service sources**

The inclusion of a remote service provider as a complete digital realisation and the requirement to lock the service provider's studio to the main multiplexer is not a trivial task. It is expected that the deployment of the STI interfact will help in this area (7)

14. **Adjacent channel interference**

The Classic FM multiplex is transmitted adjacent channel to the ntl multiplex and the addition of the Newman street transmitter did not knock a hole in the Classic FM multiplex coverage. This needs further investigation and measurement but is an encouraging early sign that adjacent channel blocking may not be so severe a problem as anticipated.

Conclusions

This paper has shown that the successful introduction of commercial digital radio services will require not only sound engineering but also a solid grasp of the commercial and business issues involved. The engineering design philosophy will follow on from the need to minimise the cost of entry yet maximise impact of the early networks. To this end careful spectrum planning and cost effective system design and key.

The case study at Melody FM is a very worthwhile rehearsal for the digital radio services of the future, with a truly microphone to loudspeaker digital implementation. It is expected that many of the experimental techniques developed in this project will find permanent application in the new digital radio age.