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Brian O'Neill
Dublin Institute of Technology, brian.oneill@dit.ie

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Back to the Future: The emergence of contrasting European and US approaches to digital radio

Brian O'Neill, PhD, Dublin Institute of Technology, Dublin 6, IRELAND
Email: brian.oneill@dit.ie

Author Bio: Brian O'Neill is Head of Research for the Faculty of Applied Arts, Dublin Institute of Technology. He has researched and published widely on media literacy and on policy aspect of technology, new media, and information society issues. He is a member of the Digital Radio Cultures in Europe research group (COST Action A20), the EU Kids Online thematic network, and Deputy Head of the IAMCR Audience and Reception Studies section.

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Abstract

Digital radio has been in development for over 25 years and yet is no nearer a point of successful adoption. This paper explores the emergence of contrasting European and American approaches to digital radio. The most established of these, Eureka-147 or Digital Audio Broadcasting (DAB), which originated in Europe, is contrasted with the so-called IBOC or /HD Radio approach, as alternative collective conceptualizations of how technology can bridge contemporary broadcasting practice to an 'imagined' digital future. Drawing on the concept of 'symptomatic technology' (Williams 1974), DAB's origins in European R&D policy of the 1980s and its affinity with established European broadcasting practice is characterised as a distinct technological vision for how the frontiers for radio broadcasting could be expanded within the European political and cultural landscape of the time. DAB's attempt to map a global solution for digital radio, combining satellite and terrestrial broadcast strategies, met with significant US opposition which subsequently supported the development of the alternative 'in-band, on-channel' approach. While neither solution is guaranteed long term success, their importance lies in the mobilization of the relevant national and international policy frameworks for the construction of radio's future.

Paying close attention to the discourses of technology inherent in these approaches and drawing on relevant contemporary engineering and technical descriptions, this analysis seeks to complement social shaping of technology studies (Mackay and Gillespie 1992) by focussing on the promotional efforts designed to support a particular technology's adoption.

Back to the Future: The emergence of contrasting European and US approaches to digital radio

Introduction

Digital radio broadcasting as a concept and as a technology has been in development for over 25 years. Despite many years of investment in research and technology development and the high priority given to digital broadcasting by both broadcasters and government regulators across the world, there is less consensus now about the future of radio than at any time in the past. What once may have appeared to have been a fairly straightforward proposition of updating the transmission system, much like the transition from AM to FM at an earlier stage in radio history, now seems much more complicated. Digital radio now represents a complex and thorny problem, complete with competing options and platforms, fragmentation in the market place and disagreement among radio broadcasters and regulators. Recently, digital radio has been disparagingly characterised as the 'Betamax' of radio (Plunkett 2008) or likened to other failed technology implementations such as AM stereo, introduced in response to new competitive threats (Leblibici, Salancik et al. 1991).

This paper retraces some of the steps involved in the development of digital radio. Moving back from the current environment where digital radio is hotly debated, particularly among radio professionals who are concerned about the direction the medium is taking in response to competition from satellite and internet radio, this paper examines the origins of digital radio as a proposition when its future seemed to be more certain. Through an analysis of some of the early technical papers in which the concept of digital radio broadcasting was expounded, I examine some of the original objectives that this new approach to broadcasting was designed to achieve. In particular, I look at a sample of the technical descriptions and promotion undertaken for the European solution, the so-called Eureka-147 or DAB (Digital Audio Broadcasting) system. The Eureka-147 system though initially positively received in the United States, was subsequently rejected in favour of an alternative approach, the IBOC/HD-Radio system developed by iBiquity. The two systems, the European

Eureka-147 standard, and the US IBOC or HD Radio alternative, provide very different responses to the evolution of radio into the digital era. Yet, I argue, both derive from a model of broadcasting that is now under considerable pressure and undergoing substantial change itself.

Digital radio as symptomatic technology

The basis of the presentation that follows is that the architecture of digital radio within the technical system within which it is organised comprises an encoded understanding of how radio functions in the world. The concept of the 'technological imaginary' provides a useful way to describe what is a collective conceptualisation of the potential and promise that a new technology such as digital radio offers (Lister, Kelly et al. 2003). The technological imaginary provides a discursive ground to technology study, particularly appropriate to radio, through which the articulated ideas and visions, particularly evident in scientific promotional discourse, express 'dissatisfactions with social reality and desires for a better society..projected onto technologies as capable of delivering a potential realm of completeness' (Lister, Kelly et al. 2003: 60). In this way, the collective conceptualization of how European digital radio, for instance, can be seen as a distinct technological vision for how the frontiers for radio broadcasting could be expanded within the European political and cultural landscape of the time. Likewise, the technological imaginary of digital radio in a US context can be seen as a response to perceived competitive pressures and a vision of how they could be overcome through a planned, evolutionary approach to broadcasting practice.

In his celebrated account of the social history of the origins of television, Raymond Williams (1974) acknowledged the deeply established technological determinism implicit in ways of thinking about communications media and which now largely define the orthodox view of technology and social change. Less determinist in nature was his category of 'symptomatic technology', a concept which considered 'particular technologies, or a complex of technologies, as *symptoms* of change of some other kind' (Williams 1974: 13). In Williams' view, neither pure technological determinism nor a more nuanced notion of symptomatic technology were adequate accounts and made the process of development of technology appear self-generating:

> The new technologies are invented as it were in an independent sphere, and then create new societies or new human conditions. The view of symptomatic technology, similarly, assumes that research and development are self-generating, but in a more marginal way. What is discovered in the margin is then taken up and used.... These positions are so deeply established, in modern social thought, that it is very difficult to think beyond them. (Williams 1974)

Compared to pure technological determinism, 'symptomatic technology' is determining in a more 'marginal way' and linked causally to the social context in more complex fashion. The concept itself is not developed in any further detail in Williams' work and is ultimately rejected in favour of a social theory of technology which removes the dichotomy between technology and society.

I argue in the following, however, that there is some merit in the notion of thinking of digital radio as a symptomatic technology, and that among its determining features are such important considerations as the conceptions and ideas brought forward within the specialised environments of broadcast engineering, their respective institutional ideologies, as well as the overarching priorities determined by funding agencies and sponsoring institutions. Such an approach, I suggest, fits well with the tradition of research centred around social shaping of technologies and is not a reversion to an abstract determinism. The social shaping of technology approach or SST (MacKenzie and Wajcman 1985) has defined an important research agenda in examining the processes involved in technological innovation (Williams and Edge 1996). Signifying a broadly constructivist approach to the development of new technologies, social shaping approaches, as Williams and Edge argue, comprise a 'broad church' of sociological studies of social and economic contexts in which technologies emerge, develop and are ultimately 'shaped' to social ends.

Mackay and Gillespie (1992) characterize Williams' account of the development of television as pioneering example of an SST approach. They argue, however, that as it stands, SST studies have paid insufficient attention to the role of ideology either in a micro or a macro level in the development of the technology development. Paradoxically, they observe, ideology is conspicuously absent in Williams' account of the social shaping of television (Mackay and Gillespie 1992: 692) and that this is far from being an isolated case in studies of communication technologies. While due attention to technology as social construct has been centrally important in extending our understanding of why technology is as it is, insufficient attention to the ideologies underpinning its development and to the crucial developmental input of engineers and technologists misses an essential part of the story. It is such ideological constructions, I suggest, that make technology symptomatic, an articulation of the distinct conditions linked in discourse of what a technology purports to do. There are, as Flichy argues, many potentially different such histories of technologies, comprising the distinct perspectives of 'designers, R&D engineers, marketing specialists, salespeople, repairers, partner companies (manufacturers of components, content providers, etc.)' (Flichy 2002: 136). Within such relationships, engineers' representations represent crucially important choices that are subsequently significant for the trajectory of the development of the technology.

This points to the second dimension in which Mackay and Gillespie (1992) suggest an SST approach needs to be extended, namely, by acknowledging the role of marketing or promotion in the shaping of the technology. The set of needs that technology is designed to address, in other words, is not created 'in the autonomous sphere of individual motivation…but heavily dependent on the productive system' (1992: 695). Central to the R&D process is the essential function of communication and dissemination of research results, and promotion of the benefits of scientific findings. Over its extended history of development, digital radio has been widely discussed, disseminated, and promoted in a variety of settings including scientific and technical conferences, industry exhibitions, technical press and trade publications as well as policy and strategy documents. Within this arena, the functionality and applications of digital radio have received their fullest expression and provide the basis for much of the foregoing analysis. Closer attention to the technical discourses provides access to an important articulation of the rationale underpinning the technology, what it was designed for and the problems it was intended to solve. This is not to privilege a 'technicist' version of digital radio but rather to complement, through symptomatic analysis, how digital radio is intended to meet needs identified and articulated through the scientific and technical broadcasting community.

In the case of digital radio, a crucial element of the effort involved in securing acceptance of the new standard was wide dissemination, promotion and marketing of the system's attributes and benefits for both radio professionals and for listeners. The combined efforts of organisations such as EuroDAB, later WorldDAB, the European Broadcasting Union as well as individual broadcasters sought to bring awareness of the new system to as wide an audience as possible and to promote a consistent and well rehearsed message of the advantages that DAB offered. This body of combined technical and promotional appeals regarding the features, benefits and potential for the new technology conveyed an overall vision of what, in the minds of its developers, the medium was capable of and how it might further develop in the future.

Why digital radio?

The concept of digital radio refers to the technology in which sound and other information is processed and transmitted as a stream of binary digits in both one way and two way communications (World Broadcasting Unions 1998: 7). The extension of digitalization to the transmission system completes a process that has been well established in other parts of the production chain and includes digital audio production, processing and recording techniques. A number of reasons are typically offered as to why digital radio is seen as an important and necessary stage in the development of the medium. The prevalence of digital technology and systems in professional radio production environments, replacing older analogue production techniques, as well as the wide penetration of digital consumer formats such as mp3, CD and DVD, has meant that the concept of digital audio and its associated features are deeply embedded features of both popular and professional approaches to radio and audio media.

At the mid point of the 1980s, with the momentum of digitalalisation in areas such as telecommunications (ISDN) and storage media for audio (CD), it was widely recognised in industry circles that radio sound broadcasting had a pressing need for improvement (Gandy 2003: 3). Satellite systems for digital transmission, including Digital Satellite Radio and Astra Digital Radio, had already been developed but significantly were unsuited to mobile reception where, it was claimed, analogue radio transmission suffered most (Hoeg and Lauterbach 2001).

The digitalisation of broadcast transmission systems has been an important research theme for at least 30 years. In the area of sound transmission, developments such as the introduction of NICAM as a digital system by the BBC, for the transmission of stereo sound, as well as the development of digital transmission technologies for satellite radio (Digital Satellite Radio and Astra Digital Radio) generated significant momentum in the search for replacement technologies for conventional AM and FM broadcasting (Hoeg and Lauterbach 2003). The greater efficiency of transmission, resulting in lower costs for broadcasters and transmission networks, as well as greater frequency efficiency allowing better utilisation of spectrum and the ability to provide more services has made the goal of digital broadcasting an important and attractive one for regulators and governments. The digital dividend of freeing up spectrum released through shutting off analogue or the reorganisation of its services may not be as great as for television though a focus on spectrum efficiency remains an important consideration (Ofcom 2006). There is also a strong commercial imperative for radio to become a digital medium and to become part of the trend towards full digital convergence in the media market. Radio, as noted in the European Commission study of the digital content industry, is often forgotten about when thinking of convergence and interactive media (Screen Digest, 2006). Online music distribution, by contrast, has developed into a major new industry expected to be worth €1.1bn by 2010 and three times that in the United States (Screen Digest, 2006: 12). The same study estimated that there are currently 15 million listeners to online radio in Europe, expected to reach 32 million listeners or 7 per cent of Europeans by 2010, and a further 11 million listeners for podcasting also by 2010 (2006: 13). Against this, the total revenue anticipated by 2010 for all digital radio will be just 5 per cent of the overall advertising revenues for the radio sector and as a result there is major pressure on the industry to find ways to ensure it builds a higher profile in digital content distribution.

As it stands, radio is poised on the cusp of a rapidly expanding environment for digital media services where it can potentially contribute to diverse platforms including handheld mobile devices, online streaming and download services, and multimedia-rich cable and satellite services. This represents a considerable metamorphosis of radio as traditionally conceived as the one-to-many broadcasting model to stand-alone receivers. It is also quite different to the original conception of broadcast digital radio as developed in such systems as DAB and HD-Radio/IBOC and the remainder of this paper explores the emergence of these two approaches to broadcast digital radio in their respective historical contexts, contrasting the competing visions and strategies towards digitalisation offered.

Eureka-147 and the development of Digital Audio Broadcasting

Brief Historical Overview

Digital Audio Broadcasting or DAB, also known as Eureka-147, has its origins in the European high technology research environment dominated by an infrastructure of large equipment manufacturers, large broadcasting and telecommunications organizations, and various public and private research institutes. Its development was part of a general effort in the 1980s to develop more efficient transmission systems arising out of the ability to carry information in the form of digital signals. To date, the history of its development has not been extensively documented and only brief historical surveys are available (See for example:Kozamernik 1995; Gandy 2003; Hoeg and Lauterbach 2003; Lembke 2003; Kozamernik 2004).

The DAB project began as a collaboration between Institut für Rundfunktechnik (IRT), the research and development institute for the German broadcasters ARD, ZDF, ORF, and SRG/SSR, and the Centre Commun détudes de Télédiffusion et Télécommunication, the research institute of France Telecom and TDF. Two essential ingredients of the system were already in development prior to the formal organisation of the Eureka consortium: the audio compression or bit-rate reduction system, pioneered by IRT in Germany, and a new radio frequency modulation system called COFDM, led by CCETT in France. The initial basis of the research was the development of an integrated services digital broadcasting system, not specifically dedicated to radio. The DAB bit-stream could in fact be used to transmit all kinds of data including images and slow scan television (Gandy 2003:3). However, with the crucial support of the European Broadcasting Union (EBU) and leading broadcasting organisations across Europe, including the BBC, a formal consortium of 19 organisations from France, Germany, The Netherlands and the United Kingdom was formed in 1986 to develop DAB as a successor for AM and FM radio broadcasting.

The Eureka Project 147 was established in 1987, with funding from the European Commission, to develop a system for the broadcasting of audio and data to fixed, portable or mobile receivers (ETSI2006). Phase I of the project consisted of the development of the formal specification of the digital broadcasting system with a second phase up to 1994 to investigate and finalise all aspects of the system to facilitate its adoption as a worldwide standard by international bodies like the European Technical Standard Institute (ETSI) and the International Telecommunications Union (ITU). The official project summary describes the research as 'development of a European technical standard for Digital Audio Broadcasting' comprising 'final system standardisation and design, system verification and investigation of implementation aspects'. The technical development envisaged a digitalisation of broadcasting distribution, which would produce improved reception compared to FM, particularly mobile reception, and with the potential to offer additional services such as text and other data, conditional access, enhanced traffic services, and picture transmission (Eureka-147 n.d.: 4).

The DAB system was designed for terrestrial and satellite as well as for hybrid and mixed delivery. Following its adoption by ETSI in 1995 as the single European standard (ETS 300 401) and its recognition by ITU as a terrestrial and satellite broadcasting system, DAB was widely promoted, and demonstrated with regular services being launched in many European countries (Lambert 1992). In 1995, the European DAB Forum (EuroDAB) was established to co-ordinate the introduction of DAB services. It became the World DAB Forum (World DAB) in 1997 and launched a wide range of promotion and marketing strategies aimed at supporting a consumer launch from 1997 on (Witherow 1996). Following completion of the project in 2000, membership of the Eureka 147 consortium merged with World DAB. More recent developments have included the development of the related digital multimedia broadcasting system or DMB, and the adoption of an improved audio codec in a revised DAB+ specification. The current body, now known as the WorldDMB Forum is exclusively dedicated to the commercial development and adoption of the DAB family of systems.

European technology: global vision

Rather than any one distinct contribution of innovation, the development of DAB represents an example of a co-ordinated, collaborative combination of engineering innovations designed to solve specified research problems. It is a product of the European R&D high technology infrastructure, emanating from research labs specialising in telecommunications and radio communications research, sponsored by large broadcasting corporations and funded through the inter-governmental Eureka investment programme. But to what extent might one describe DAB as a symptomatic technology, one that was distinctively shaped by the environment in which it was developed, and to what extent did it proceed to carry meanings and purpose that were expressions of the visions of its creators?

One element of this symptomatic explanatory framework relates to the policy objectives underpinning the efforts involved in bringing forward digital radio technology. Lembke (2003) has described the particular policy and technology investment framework in which DAB was developed as one which was focused on supporting European technology leadership at a global level, particularly in the field of consumer electronics. An objective of European investment in technologies such as digital radio, mobile communications and in satellite navigation systems, Lembke argues, was to enable standardisation at firstly a European and then at a global level in order to create opportunities for world leadership in high technology systems and thereby providing a counterbalance to the dominance of the electronics sector in the Far East (Lembke 2003: 212). In relation to digital radio, it was assumed that with the establishment of a common European standard, significant opportunities would be available for the European entertainment electronics industry to develop a whole range of new products for the domestic and automobile sectors. Attempting to repeat the success of GSM, a global standard for mobile phone communication developed with strong European backing, Lembke quotes a researcher's view of the opportunities and risks involved:

> After the digitisation of communications, digital radio is probably, after digital TV, the last chance for Europe to enhance its competitiveness in the consumer electronics sector. […] Europeans who developed the system and invested most in DAB, have to put all their efforts to participate in the exploitation of

> the system. With such a joint European efforts DAB can and will repeat the success story of GSM. (in Lembke 2003: 214).

Initial expectations for the potential of DAB as a consumer electronics item were high and market research suggested that Europeans could buy 50 million DAB sets in the first 10 years, with sales then rising to 35 million a year. This was compared with 'the ubiquitous CD player', which took eight years to achieve annual sales of 5 million (Fox 1994).

Central to this strategic vision of developing a global standard for digital radio broadcasting was the requirement for public intervention at a pan-European level, necessitating a political commitment and institutional backing to include the development of a stable regulatory framework, co-ordination of frequency allocation and a co-ordinated strategic approach to supporting market adoption of the system.

Strengthening the competitiveness of the European audiovisual industry has been a mainstay of European policy since the mid 1990s with an emphasis on the development of a single market, support for regulatory harmonisation and an enhanced, centralised role for the European Commission in the communications sector (Kaitatzi-Whitlock 1996; Levy 1999; Harcourt 2002).   While the focus of European policy has concentrated on the cinema and television sectors, for instance through the Television Without Frontiers directive and the MEDIA programme, a central aim of the participating partners in Eureka-147 was to lobby Brussels for an equivalent level of political attention and support for the digital radio sector. From its inception, the ambition of the DAB consortium was to be the defining global standard for the digital system to replace analogue AM and FM broadcasting. Within European policy terms, Eureka-147 was the radio industry’s vision of its role within communications convergence and the digital revolution. Its successful early development and adoption as the first digital broadcasting standard, before rival systems such as DVB, suggested that little public intervention would be needed (Liikanen 2001). Its subsequent sluggish pace of adoption led to renewed calls for more direct European support. Michael McEwen, then chairperson of WorldDAB, argued to the European Commission in 1998 that the rest of the world was looking to Europe for a lead in the roll-out of DAB. There was a window of opportunity, he suggested, of about two years in which to create the necessary momentum in the marketplace. "If it is not led by Europe," he went on, "then how can you expect the rest of the world to adopt a European technology?" (McEwen1998)

However, the policy commitment to removing regulatory barriers, market intervention and the principle of 'technological neutrality' in liberalised communications markets, meant in European Commission terms that, success or failure was primarily the responsibility of market players (Liikanen 2001: 4). The radio industry attempted to argue that there was a 'European' dimension to digital radio, i.e., an element of public policy that could only be satisfactorily addressed at a European rather than at a national level, and that diverging regulatory frameworks and implementation strategies in the Member States would lead to fragmentation of the European market. Manufacturers, for example, strenuously argued that the fragmented and disjointed roll-out of digital radio, with successful implementation in some countries and very little in other, was a serious impediment to the development of a new market for digital radio receivers. The prevailing understanding that radio was a local medium, and the primary responsibility of diverse national and regional authorities, however, worked against any further European co-ordinated action.

While decisive European Commission support was somewhat qualified, the credentials of DAB as a 'European' technology of significant proportions have always received strong endorsement through the close association of the European Broadcasting (EBU) for DAB. As the representative European organisation for national public broadcasting organisations, the EBU has from the very start been central to the development of digital radio broadcasting. The EBU had initiated the first series of studies on satellite DAB in the mid 1980s and supported the formation of the consortium for Eureka-147. EBU members were the driving force behind the consortium and the EBU's Technical Department actively participated in its various working groups. Crucially, the EBU as an international organisation provided essential logistical support in promoting DAB in the ITU and in the preparation prior to the adoption of DAB as an ETSI standard (Kozamernik 1995: 10). Public radio broadcasters were and continue to be in the forefront of European digital radio services and are the driving force for digitization 'from technical testing, to content provision, to marketing and promoting the platform' (EBU-UER 2007: 8). More importantly, the EBU has argued, public broadcasters have been to the fore in promoting the benefits of digitization to citizens and act as the social force underpinning the provision of services on a basis that commercial broadcasters would be unable and unwilling to do. As such, digital radio in the European context has always been closely associated with and allied to the institutional visions and infrastructure of European public broadcasting in both form and content, and as presented below, articulated through the actual architecture of a system suited to its needs rather than to other forms of broadcasting.

Technical attributes of Eureka-147

The digital radio system developed under Eureka-147 is widely acknowledged to be a highly successful technical feat of engineering that provides an innovative universal approach to audio and multimedia broadcasting (Hoeg and Lauterbach 2003). It has been claimed to be the most significant development since the introduction of FM stereo broadcasting (Bower 1998). It offers a wealth of advantages over conventional broadcast systems and is ideally suited, from an engineering perspective, to be a replacement technology for AM and FM radio broadcasting (Hoeg and Lauterbach 2003).

Hoeg and Lauterbach (2003) offer a comprehensive list of the benefits of the Eureka-147 system as follows:

1. *Quality of Service* – the utilization of digital technology to provide listeners with a higher quality of service including superior sound quality, better usability and perfect reception.
2. *Value-Added Services* – the capability of one multi-functional receiver to include broadcasting services, accompanying programme associated data, additional information services, and still or moving pictures.
3. *A Universal System Layout* – allowing for the wide availability of the service on fixed, mobile and portable receivers and across terrestrial, satellite, and cable networks.
4. *Flexible multiplex configuration* – a transmission method which enabled broadcasters to arrange multiple services in a DAB ‘multiplex’ and to vary the quantity and quality of services through bit rate adjustment.

5. *Transmission efficiency* – offered lower transmission costs for broadcasters and network providers as well as efficient spectrum use through the arrangement of Single Frequency Networks (SFNs)

The above characteristics of the Eureka-147 system fall into two distinct categories of firstly, those technical and operational advantages targeted at the radio industry and secondly, the improved quality of service and enhanced user functionality which was intended to provide audiences with a better listening experience. The benefits offered by DAB were widely circulated among diverse audiences and provided the basis for extensive promotion of the system in each of the markets in which it was introduced. This also included a wide range of technical presentations and demonstrations which sought to convey the essential vision of the new system and through cogent argument sought to persuade different stakeholders of DAB's merits.

The overriding advantage of Eureka-147, designed to appeal to both consumers and to the technical broadcasting community, was the proposed enhanced quality of transmission and interference-free, perfect reception conditions offered by DAB. The BBC claimed that the consistency of high quality transmission even in adverse conditions was the single most important reason for considering DAB as the future of radio (Gandy 2003: 2). So-called multipath interference caused by signal reflections and shadowing due to high buildings particularly in dense urban areas had been identified as one of the main problems of analogue broadcasting resulting in poor quality reception, fading and interference (Maddocks 1994). This was particularly the case for reception in cars and on mobile receivers and was considered a real constraint to further growth of the medium and to which DAB offered distinct advantages (World Broadcasting Unions 1998). Stereo FM, when it was introduced in the 1950s, was designed for reception via a fixed, static receiver with a roof-top, directional antenna (Shelswell., C. Gandy et al. 1991; Lau and Williams 1992). Clearly, improvements in receiver design had created acceptable listening FM conditions, which included switching to mono when reception deteriorated, but fundamentally, from an engineering point of view, FM was never designed for mobile and in-car reception. A design parameter for DAB was, therefore, quality of reception in fast-moving vehicles even in extreme conditions. DAB's innovative solution to the problems of reception was to constructively use multiple signal reflections in a new modulation system called COFDM (coded orthogonal frequency division multiplex) which successfully combated multipath interference (Bower 1998).

A related feature of the COFDM approach is the ability to use a single frequency block with multiple transmitters over an extensive area without mutual interference, allowing broadcasters to plan services in what is known as the Single Frequency Network (SFN) (Lau and Williams 1992: 12). Echoing its origins in satellite systems research, DAB's Single Frequency Network approach is such that it is typically optimized for large national or regional areas and offers the greatest spectrum efficiency. The more localized the service required, more frequencies are required and the system is less spectrally efficient. Equally, the optimal solution to ensure the most cost efficient coverage was discovered to be a network of closely-spaced, relatively low powers transmitters. As such, planning for digital transmission was conceived on the basis that nationally-based or regionally strong networks (such as the BBC) would be primarily responsible for managing the network rather than individual local stations organizing their own transmission.

A further feature of the DAB transmission system that was unfamiliar to broadcasters at the time was its organization into a service multiplex or ensemble of programme services, of typically up to six stereo channels (Riley 1994). The flexibility to dynamically vary the composition of the service according to need, such as splitting a stereo programme into two separate mono channels, or to provide an additional language channel as required offers the multiplex operator considerable control over service planning. From the listener's perspective, access to services is made as easy as possible and is based on adaptation of the RDS or Radio Data System whereby text labels identify station tuning and programme content. The multiplex organization is all but invisible to the listener who simply has to choose by station or service identification. From the broadcaster point of view, the organization of programming services into a complex arrangement involving different service provides represents a significant reconceptualisation of the transmission chain. From the relatively simple structure of broadcaster acting as programme provider and feeding final content into the broadcast chain for transmission and distribution, DAB introduces the distinct functions of programme provider, data service providers and multiplex or ensemble provider (Hoeg and Lauterbach 2003: 152). Organisationally, the DAB configuration requires effective co-ordination between each of the elements of the service and as such is again optimally suited to the large broadcaster, multi-service broadcaster with the relevant technical and programming resources to utilise all aspects of the DAB service. An idealised DAB service provision model, as such, maps closely to the kind of programme services envisaged by broadcasters such as BBC, Danmark Radio or Bayerische Rundfunk who provide suites of diverse programme material, associated programme data and other listener services within a common brand.

User features and consumer appeal

From the outset, DAB researchers paid close attention to the user interface and how needs of listeners might be built into newly conceived DAB receivers. The multiplexed nature of the DAB service, combining different types of information as potentially numerous programme channels, presented challenges for a suitable interface design. Accompanying the main audio service, for instance, is a host of additional information such alphanumeric text, information on the name of the service, e.g. 'BBC RI Digital'; a programme type label, e.g. 'News', 'Sport', 'Classical Music'; time and date, for display or recorder control; as well as traffic reports, news flashes or announcements on other services (Tuttlebee and Hawkins 1998: 266). A joint project involving WorldDAB, manufacturers including Clarion, Sony and Bosch, and broadcasters such BBC, Radio France and Swedish, was established in 1998 to consider various receiver design possibilities based on DAB's possible service applications. The HuMIDAB project (Marks 1998) examined the so-called 'human machine interface' and presented a series of concepts for receiver design that minimized the complex technology underpinning the system. The principle agreed was that DAB radios 'should be characterized by *abstraction from technical details* and that service access should be *content based*, so that a listener can "forget" the technical delivery mechanism' (Marks 1998: 5). Computer simulations developed by the BBC and by Swedish Radio explored various interfaces for in-car systems utilising touch screen interfaces and EPG menu systems as ways of accessing DAB audio and data information services (Riley 1994).

Early market research conducted by broadcasters suggested positive interest among the general public for the features offered by DAB. Three broad market segments or applications for such new services were considered to be particularly important (Tuttlebee and Hawkins 1998: 268).

First, the in-car application was a top priority for the DAB project. Eureka-147 was the first transmission system designed specifically with the motor vehicle in mind and had perfected a system to deliver near-CD quality with no signal loss or fading as a car traversed the country. The major defects of analogue radio, it was claimed, were most apparent in moving vehicles both in urban conditions and on cross national routes. Medium-wave reception was always of low quality, often ruined by interference from electrical equipment or distant stations while FM's reception fluctuated wildly as a vehicle went past buildings, over hills and down into valleys, and had to be retuned as the car moved out of range of one transmitter and into range of another (Fox 1994). DAB as a result offered a quality of service never previously attained through its robust reception and linkage to a single frequency network.

The attraction of an all-digital audio entertainment system as well as the potential of high speed datacasting to vehicles, incorporating GPS navigation systems, traffic management information and high quality images, was conceived as potentially DAB's 'killer application'(Shelswell., C. Gandy et al. 1991; Yamauchi, Kakiuchi et al. 1995: 74; Müller-Römer 1997). The mobility of high quality digital radio was also such as to rearrange the frontiers of broadcasting in a way that analogue broadcasting had severely constrained. An early description conveyed the promise of DAB as 'radio sans frontieres':

> Imagine driving the length of Britain, over the Channel and across Europe, listening all the time to the same radio station. The sound is in digital stereo, which gives it the same quality as that from a compact disc. There is no interference, and none of the fading and fluttering that normally blemish reception as you drive past tall buildings, over hills and down valleys. There is no need to keep retuning the radio because the chosen station remains on the same frequency throughout Europe - although, of course, you could retune to alternative national, international or local stations if you wanted to. (Fox 1991)

A second market segment envisaged as hugely important and to whom DAB was closely targeted was that of hi-fi enthusiasts. As a group of early adopters, audiophiles were considered to be an important means of broadening the consumer market for DAB for both fixed and portable receivers. An assumption of the period was the advent of digital audio formats such as the CD had created a demand for uniform, high quality audio in radio (Maddocks 1994). A number of high end audio receivers were developed by companies such as Arcam building on the wide acceptance of CD as the benchmark audio standard (Josse 2002). This emphasis on DAB's audiophile credentials was and continues to be an important component of the marketing strategy for digital radio, despite ongoing controversy regarding its implementation (Spikofski and Klar 2003), and claims for a radio listening experience of unsurpassed quality were central appeals of the new radio format. Again, a scenario envisioning the compelling features of the DAB listening experience is presented in this extract from a IEEE publication:

> Returning home from a business trip, Doug Digital turns on his car radio and enters code 15 for classical music. After the radio selects an appropriate strong-signal digital audio broadcasting station, Doug hums along, adding his voice to the compact-disk quality sound of the selection, which is free of any interference or signal fading despite the hilly terrain. He likes the music, but cannot put his finger on what it is, so he glances down at the radio's liquid-crystal display and reads the name of the selection and the performing artists. As he travels farther away from the station's transmitting facility, the radio switches to a stronger station airing the same classical programming, without his noticing the changeover.
>
> …When Doug gets home, he and his wife have dinner and then decide to listen to a live concert of the New York Philharmonic orchestra. Doug requests the concert from the pay-per-listen digital audio radio service he subscribes to and the two settle back, listening to it in five-channel Dolby Surround on their stereo system. After the concert, Doug decides to add features to his digital audio radio system, including programming it with a "pick list" for advertising offers so that be will automatically be informed of products that interest him. (Jurgen 1996: 52)

Finally, one further segment identified as an important potential new market for the features offered in DAB was that of personal computer users. PC-card DAB receiver applications targeted at internet users could better exploit the dynamic programme text capabilities of DAB and had the potential to integrate internet use with high quality audio reception (Tuttlebee and Hawkins 1998: 268). At a time when internet connectivity was still predominantly based on dial-up connections, DAB receivers as additional modules for PCs could enhance a multimedia experience and offer potential for greater interactivity and e-commerce applications. [automation interactivity and the car tracker]

Promoting DAB as the future of radio

In addition to the individual appeals regarding its technical attributes and benefits, an important element of the overall promotional discourse for DAB was its claims to be the definitive future of radio, underpinned by a certainty regarding the digitalisation of radio and television transmission. The dominant trope of mid 1990s technical discourse of audiovisual services was the conviction that all traditional media including radio, television and the press would adopt digitally-based delivery systems and that varying elements of convergence between different media would emerge (Kozamernik 1995: 3). Through various events and demonstrations, DAB was presented and believed to herald a new era on radio broadcasting which was revolutionary in nature (Nunn 1995; Witherow and Laven 1995). Allied to this was a further belief in the necessity for radio to rapidly embrace digital technology to survive in an increasingly competitive and complex market. DAB, it was said, provided the opportunity to keep 'radio not only alive but healthy in an increasingly competitive environment' (Witherow and Laven 1995: 61), and that radio would be marginalised in a multimedia environment if it remained analogue (Kozamernik 1999).

DAB's claims to be an international standard were founded upon the development of a mature technology that had been tested in the field and which offered flexible modes of implementation in a variety of situations for a path to digitalization of broadcasting operations. Prospects for successful adoption would rely, however, on co-ordinated international action on technology development, spectrum planning, regulatory approaches and a global marketing of digital radio. DAB did achieve rapid early success in attaining international standardization, for instance with adoption of the basic DAB standard by ETSI in 1993, followed by the ITU-R recommendation of DAB for satellite and terrestrial broadcasting in 1994. The World Administrative Radio Conference (WARC) in 1988 allocated 40 MHz of spectrum in the L-Band for satellite sound broadcasting. At the WARC 1992 conference, a portion of this was allocated primarily for terrestrial digital radio broadcasting, providing a boost to its international standing and supporting international efforts towards its implementation beyond Western Europe. L-Band was in many instances the only available frequency for digital broadcasting even though it was more suited to satellite rather than terrestrial applications. The consolidation of WorldDAB with 120 member organizations in 20 countries 1997 confirmed its global status with active DAB trials in countries beyond Europe including China, South Africa, India, Australia, Poland and Canada (Witherow 1996). However, as now widely known, the Eureka-147 DAB platform, despite initial interest in the United States, was rejected in favour of an alternative approach and the particular features of its reception highlight some of the critical questions regarding the notion of digital radio as a replacement technology.

Digital Radio in the United States

While many of the same social forces impacting on the digitalisation of audio and radio broadcasting were present in the United States in the early 1990s, it was widely acknowledged that Europe had taken the lead in developing the technologies and implementing new digital radio broadcasting services (Justus 1995). The world of audio had gone digital and listeners everywhere, it was suggested, would demand the same CD-quality music of their radio services. In contrast to the European support for evolution of digital radio broadcasting in a new band using the Eureka-147 technology, United States radio broadcasters from an early stage focussed on in-band, on-channel ('IBOC') and in-band, adjacent channel ('IBAC') technologies to enable broadcasters to deliver digital radio with the areas they currently serve without additional frequency allocations (Anglin 1995). The early response to digitalisation in terrestrial radio broadcasting was hesitant but the subsequent licensing of satellite radio services in the United States provided a major spur to the industry’s efforts to agree on a digital solution (Behrens 1997).

The initial reception given to Eureka 147 DAB technology when it was presented in the United States had in fact been very positive. A series of demonstrations at the National Association of Broadcasters (NAB) at Las Vegas in 1991 and at the NAB Radio Show in San Francisco had been well received following an impressive performance of the technology. Informed comment in 1990 recognised, however, the significant difficulties that adoption of a DAB-like system might pose and suggested that the advantages and promise of DAB might prove illusory, given the policy implications involved (Hakanen 1991). Opposition to DAB grew principally within

NAB, particularly among commercial broadcasters, who were adamant the technology did not suit the interests of the American radio industry and that their preference was for an in-band, on channel (IBOC) technology solution on the basis that it would be less disruptive to the industry (Flint 1993; Hoeg and Lauterbach 2003). Officially, adopting a 'wait and see policy' and reluctant to embrace any one technology, an extensive series of laboratory tests was agreed in 1995 by the Electrical Industries Association and the NAB to assess performance of the different approaches to digital radio, ultimately for presentation to the Federal Communications Commission (FCC) for a rule-making on digital sound broadcasting (Justus 1995; Jurgen 1996: 56). A number of different technologies were tested, five of which were variants of an in-band, on-channel approach, and two including Eureka 147 which required new bands to operate (Justus 1995: 140). The Eureka-147 system was given additional support during the trials by the Canadian industy group DRRI who had formally adopted DAB, providing technical equipment and demonstrations. However, despite numerous delays and technical difficulties in developing the technology, the FCC in 2002 finally approved In-Band On-Channel IBOC systems for the AM and FM band as developed by Ibiquity.

While space does not permit a detailed treatment of the debates that surrounded the development of in-band technologies in the United States, what follows is a brief summary of the main points of contrast in strategies towards digitalisation and the considerations that gave rise to an alternative vision for digital broadcasting. Pursuing the notion that emergent technology is symptomatic of the context in which it emerges, the following comprises a series of observations on the contrasting environments and competing responses to implementation of digital radio.

A major policy dilemma facing US broadcasting was the question of spectrum allocation and assignment for digital radio (Hakanen 1991: 493). DAB in the form of Eureka-147 required and was premised upon the allocation of new spectrum for digital broadcasting and central to its implementation was the process of negotiation to secure the required VHF and L-Band frequencies. Proposed out-of-band or new frequency allocations for digital radio were not favoured by American broadcasters for a variety of reasons including the fact that it would be likely to introduce new competition and would disrupt the status quo. An in-band solution, whereby digital signals would be allowed to piggy-back on existing frequency allocations, was deemed more desirable even if no suitable technology was available to make this happen and that FM frequency modulation for digital transmission had been rejected as unfeasible by Eureka-147 developers.

A further policy implication and difficulty identified in any migration to digital was the fact that digital broadcasting would level the field for radio broadcast markets, providing all operators with equivalent levels of digital quality and eliminating '50 years of careful definition of broadcast service areas, program formats, specially tailored news and current affairs programming' and would thus spell economic catastrophe for many operators (Hakanen 1991: 494).

Thus, the development of the so called in-band, or IBOC approach was portrayed as the search for a fairy tale solution to a business problem posed by the interests of the US radio industry (Behrens 1997). IBOC technology would be required to maintain the status quo in enabling broadcasters to remain in the FM band, utilise existing plant and equipment, avoid having to ask the FCC for new spectrum, and to prevent auctioning of spectrum and new competition. The IBOC solution was prescribed to the extent that it had to work in a hybrid mode within the broadcaster's existing service provision and coverage area, thereby maintaining the relative value of broadcasters' investments. In contrast therefore with the engineering-driven Eureka-147 approach to produce perfected technical systems that had potential though not proven applications, a solution without a problem as it were, IBOC was a technology in which there were significant, if not intractable, technical difficulties to which there might not in fact be a satisfactory solution, given the constraints imposed.

A further practical difference between US and European broadcasting interests in their approach to digital radio, is that US broadcasters typically own and operate their own transmission equipment and distinguish themselves in their local broadcast franchise area by the quality of their sound over their rivals. The concept of a multiplex involving sharing a wide frequency band between competing broadcasters and co-operating in the operation of transmission was anathema to the model well established in the United States of owner-operated transmission sites. Similar difficulties in competing commercial interests sharing transmission resources had also been experienced in Canada in implementing DAB trial services but had been overcome in the interests of a sectoral unity in its response to digital broadcasting (O'Neill 2007).

There was therefore a decisive ‘lack of fit’ for a European-originated DAB approach and service coverage pattern for conditions that pertained in the US radio broadcasting market. An obvious difference between contrasting US and European systems is that of the pronounced emphasis on localism in US radio broadcasting. Barboutis (1997) has described Eureka-147 technology as ‘tailor-made’ for national and international broadcasting which is at its most efficient operating through widely-deployed Single Frequency Networks. Again, the topology of US radio broadcasting militates against using linked frequencies in this way and by contrast seeks to maintain maximum distinctiveness within a local setting. Among the supporters for adoption of the Eureka-147 DAB system was, significantly, National Public Radio which identified the benefits to a national broadcasting approach and lobbied for allocation of 20% of DAB spectrum for non-commercial use and for expansion and development of a nation-wide public radio system (Walker 1991).

This lack of fit with respect to DAB was perhaps most obvious with the close association of the Eureka-147 standard with satellite broadcasting which only added to the perception among US radio broadcasters that as a technology DAB was totally unsuited to the structure of the American industry. Prior to WARC 1992, commercial radio interests in the US vigorously opposed the introduction of broadcast satellite service-sound as a huge potential threat to the industry. Despite the fact that there were major US interests in Worldspace satellite broadcasting in Africa, South America and Southern Asia using L-Band DAB technology, the US radio broadcasting industry was deeply suspicious of satellite broadcasting and perceived it as a direct competitor to its industry. An NAB resolution passed in 1991 stated its opposition to satellite broadcasting on the basis that it would introduce new competition to the sector by through new national, satellite-delivered systems, as well as on the basis that terrestrial systems were required to preserve the localism of American broadcasting (Walker 1991), a position opposed by public broadcasters who viewed the potential of satellite-delivered national radio services as a valuable opportunity to aggregate markets for high quality niche programming. The resulting position at WARC 1992 was one in which the US proposed an alternative S-Band allocation for satellite broadcasting, citing the government's need to 'preserve and protect' existing use of L-Band frequencies. The United States was thus set apart in relation to the rest of the world both in terms of frequency allocation for digital broadcasting and in relation to domestic consideration of the DAB standard (Office of Technology Assessment 1993).

Conclusion

In summary, the model of transition form analogue to digital broadcasting proposed by IBOC is fundamentally different to that of DAB (Rathbun 2000). Where DAB was designed on the basis of an expectation of a relatively rapid transition to digital and replacement of AM and FM broadcasting, IBOC was symptomatic of the broadcast industry's resolve that digitalisation would be a series of incremental and evolutionary steps. Some of the founding conceptions of the design of Eureka 147 as a system were such that AM and FM technologies were identified as being close to the end of a useful life and that new digital approach would replace them. This was clearly not the view of US broadcasting interests who were content to ensure that progress to digitalisation would be slow, cautious and evolutionary.

Neither, it must be said, has proven its case in terms of actual digital radio implementations. The UK market for digital radio, acknowledged to be the most advanced, remains at a precarious stage of development, having achieved substantial penetration of digital radio listening and audience interest, but failing to achieve a successful business model, as witnessed by recent by commercial withdrawals from the market.

In both instances, it may said, digital radio has been suffered from a liberal market approach where it has largely been left to market forces to decide the fate of particular technologies and general approaches to digitalisation. As with previous technological developments in the sector, this has often proved deeply unsatisfactory and has resulted in long delays in new technology development; competing, yet often not radically different solutions that are wasteful of resources; confusion for the radio industry and for audiences; and an uncertain environment for future planning.

The result has been damaging overall for radio in the new media environment and has constrained its ability to play a central role in emerging converged media services. The delays imposed by long periods of uncertainty has meant that other forms of audio media – podcasting, internet radio, audio blogs and online file sharing – are much more relevant and available in a multimedia communications environment. The digital radio solutions developed in the early 1990s now begin to look decidedly out of date alongside user-driven consumption patterns and sophisticated, multiplatform devices. Continuing lack of certainty regarding digital radio broadcasting exacerbates the gap between the free-to-air broadcast radio model and developing environment for audiovisual media services, leaving some of the original questions and problems that digital radio was designed to address unresolved and uncertain.

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