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Implementation considerations for the introduction of and transition to digital terrestrial sound and multimedia broadcasting

BS Series

Broadcasting service (sound)

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REPORT ITU-R BS.2384-2

Implementation considerations for the introduction of and transition to digital terrestrial sound and multimedia broadcasting

(2015-2019-2021)

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1 Introduction

With the transition to digital television broadcasting now well advanced it is appropriate to consider once again why there has been inconsistent interest among administrations or demand from listeners to make a complete transition to digital sound broadcasting. Some administrations have strongly supported a transition, others have taken a cautious approach and some have expressed little interest.

This Report seeks to highlight the benefits of digital sound broadcasting and reports on some successful implementations This Report also seeks to address some of the negative comments made during public consultations, particular by consumer groups, expressed on ceasing analogue sound broadcasting and goes on to address the technical and economic factors involved in bringing the advantages of digital sound broadcasting to all listeners around the world.

Sound broadcasting has developed over the past 90 years as essential part of daily life for providing the public with a rich, advanced and diversified information and entertainment and is set to play a continuing role in shaping and participating in the global knowledge and information based economy.

Rather than being in decline, audience monitoring figures from advanced media markets, such as the United Kingdom (see RAJAR[1] listening figures (http://www.rajar.co.uk/listening/)) reveal that sound broadcasting has undergone a resurgence of interest in recent years and is now increasing in popularity – the key factors being the universality, mobility, intimacy of the listening experience, and all without any access charges. Moreover, terrestrial broadcast delivery offers truly mobile reception, particularly in cars, that is both cost effective and reliable for content providers. However, the introduction of new forms of digital information and entertainment in several Regions, including satellite radio and Internet streaming of radio programming present challenges for analogue radio. Analogue radio needs to make a transition to digital broadcasting in order to allow analogue radio to add new programming and new features necessary to make radio competitive with new forms of digital entertainment and information.

The technical and propagation characteristics of sound broadcasting combine so that it remains the best medium for relaying of live news and information. The differing characteristics of the frequency bands available for terrestrial sound broadcasting should be seen as providing the flexibility for matching the various genres of sound broadcasting to audience expectations, rather than an unwanted source of complication for technical neutrality notions implicit in market-forces based spectrum management theories:

– the propagation characteristics of the broadcasting bands below 30 MHz are ideal for wide area/long distance coverage free from the constraints that can be imposed on other methods of delivering electronic communication services by economic factors or political gatekeepers;

– the propagation characteristics of the VHF broadcasting bands allow service areas to be matched closely to the distribution of population, the various types of distribution topologies required (i.e. national coverage segments, regional/county coverage, city-wide coverage as well as smaller local/community operations) and the terrain involved.

2 Why replace analogue sound broadcasting?

The traditional model of sound broadcasting faces challenges that make it essential to pursue the goal of moving to digital modulation techniques. For administrations and broadcasters, the analogue modulation techniques of amplitude modulation (AM) and frequency modulation (FM) used around

[1] RAJAR stands for radio joint audience research and is the official body in charge of measuring radio audiences in the UK. It is jointly owned by the BBC and the Radio Centre on behalf of the commercial sector.

the world for sound broadcasting do not provide the optimum use of spectrum. For listeners, audio quality is often compromised by adverse propagation conditions or interference, from a combination of man-made noise sources and over-use of the available frequency bands. However, in order to command the interest and support of listeners in making the transition from analogue to digital transmission, the technologies used must present the audience with very clear advantages.

For AM broadcasting in the LF, MF and HF broadcasting bands, there is no doubt that the levels of noise and interference from competing broadcasting stations in crowded frequency bands do not make for a satisfactory listening experience.

Although AM broadcasting in the LF, MF and HF bands has provided considerable advantages in terms of wide area coverage for regional, national and international sound broadcasting since the 1930s, it has suffered a decline in recent years, as high electricity costs and poor audio quality, relative to FM, have combined to make it less attractive to broadcasters and listeners. But replacement of wide area AM transmissions by FM or digital sound broadcasting networks needs careful planning and, except in cases where an in-band solution can be implemented, will require investment in an extensive infrastructure. (This may be problematic or impractical for serving some needs, particularly for external broadcasting operations.)

The particular characteristics of the various digital sound broadcasting systems that are being implemented around the world are considered in more detail in later sections along with the main technical and regulatory factors involved in managing the transition to digital sound broadcasting in the bands current devoted to analogue transmissions.

3 Observations and reactions on current and planned DSB and multimedia broadcasting implementations

The transition from analogue to digital television broadcasting is now well advanced, mainly through regional and sub-regional agreements on re-planning the use of Bands I, III and IV/V. Digital modulation techniques have allowed current television broadcasting requirements to be delivered in considerably less spectrum than previously, opening the way for the spectrum savings to be used for delivering an extended range of broadcasting and other multi-media content.

With sound broadcasting, however, there has been no concerted move to make a coordinated transition to digital sound broadcasting from AM in the LF, MF and HF bands and FM in Band II. Nevertheless, there has been progress over the last 20 years in deploying DSB systems around the world with several systems now in operation or in the process of deployment.

The service requirements for digital sound broadcasting systems at frequencies below 30 MHz and in the frequency range 30-3 000 MHz are set out in Recommendations ITU-R BS.1348 and ITU-R BS.774, respectively. The digital sound broadcasting systems that meet these service requirements are described in Recommendation ITU-R BS.1514, for use at frequencies below 30 MHz, and Recommendation ITU-R BS.1114, for use at frequencies between 30 and 3 000 MHz.

The objectives set out in Recommendations ITU-R BS.1348 for the technical and operational characteristics and capabilities of terrestrial digital sound-broadcasting systems intended for use in the LF, MF and HF bands are to:

– be capable of providing high-quality monophonic or stereophonic sound to vehicular, portable and fixed receivers;
– provide better spectrum and power efficiency than conventional analogue systems;
– provide significantly improved performance in a multipath environment;
– allow for a trade-off between extent of coverage and service quality for a given emission power;

– be capable of allowing, with a common receiver, the use of all means of programme delivery (e.g. mono, stereo, dual mono);
– be capable of providing facilities for programme-related data;
– be capable of providing additional data services;
– allow the manufacturing of low-cost receivers through mass production.

The objectives set out in Recommendation ITU-R BS.774 for the technical and operational characteristics and capabilities of terrestrial digital sound-broadcasting systems intended for use in the VHF and UHF bands are to:

– be capable of providing high-quality stereophonic sound of two or more channels with subjective quality indistinguishable from high-quality consumer digital recorded media ("CD quality") to vehicular, portable and fixed receivers;
– provide better spectrum and power efficiency than conventional analogue FM systems;
– significantly improved performance in a multipath and shadowing environment through the use of frequency and time diversity and co-channel space diversity at the transmitting end when needed;
– be capable of utilizing common signal processing in receivers for any terrestrial and satellite broadcasting applications;
– allow configuration/reconfiguration in order to transmit sound programmes with lower bit rates to trade-off quality and the number of sound programmes available;
– allow for a trade-off between extent of coverage for a given emission power, service quality and the number of sound programmes and data services;
– be capable of allowing, with a common receiver, the use of all means of programme delivery, such as:
  - local, sub-national and national terrestrial VHF/UHF network services;
  - mixed/hybrid use of terrestrial and national/supra-national UHF satellite service;
  - cable distribution networks;
– be capable of providing enhanced facilities for programme-related data (e.g. service identification, programme labelling, programme delivery control, copyright control, conditional access, dynamic programme linking, services for visually and hearing-impaired, etc.);
– allow for flexible assignment of services within a given multiplex;
– provide a system multiplex structure capable of complying with the layered ISO open system interconnect model and permitting interfacing to information technology equipment and communications networks;
– be capable of providing value-added services with different data capacities (e.g. traffic message channels, business data, paging, still picture/graphics, future integrated services digital broadcasting (ISDB), low bit-rate video/multiplex, etc.);
– allow the manufacturing of low cost receivers and antennas through mass production.

Several of the digital sound broadcasting systems found to have met these objectives have been deployed or are under active study pending decisions on deployment. This Report examines the various factors involved in introducing these systems.

3.1 The DAB system

A number of countries around the world have implemented the DAB (Digital Audio Broadcasting) system, classified as Digital System A in Recommendation ITU-R BS.1114, in Band III for delivering groups of multiplexed programming where the band is no longer needed for television broadcasting or other purposes (e.g. trunked mobile applications).

The DAB system started development some 25 years ago as the Eureka 147 project under the technical direction of the European Broadcasting Union and with the active support of the major European broadcasters and the WorldDAB Forum, a not for profit membership organization. The members of the project team decided to standardize the system at ETSI and the system standard was first published in 1995 as ETS 300 401 [ETSI_1]. The latest version of the DAB standard was published by ETSI in January 2017 as EN 300 401 V2.1.1 [ETSI_2].

Originally, the DAB audio coding mechanism, using MPEG Layer II coding, was included in the core specification, ETS 300 401 [ETSI_1]. Later developments in audio coding efficiency led to the introduction of DAB+ audio coding, based on MPEG-4 AAC coding, which is described in a separate specification, TS 102 563 [ETSI_3]. With the release of EN 300 401 V2.1.1 [ETSI_2] the DAB audio coding definition was also transferred into a separate specification, TS 103 466 [ETSI_4].

The DAB system was designed as a multiplex delivery system which loaded 5 or 6 stereo programme channels on to a common carrier. Such a transmission carrying more than one service is known as an ensemble. This was well suited to the situation where a number of programmes wanted to share the same coverage area. Where the same basket of programme is wanted to cover a much larger service area (like a whole country) the single frequency network capability of the DAB system allowed this to be done. To facilitate transition from analogue to digital both services have to run in parallel which requires additional spectrum.

Thus there were two main objectives underlying the introduction of DAB:

1) to save on radio frequency spectrum by moving to single frequency networking using DAB multiplexes;
2) to overcome various degradations of FM broadcasting experienced in dense urban environments and for in-car reception.

DAB technology did indeed meet these requirements, with significant spectrum savings over comparable FM networks achievable for the country-wide networks of large scale broadcasters, which reflects how the technology was developed. Norway was the first country to discontinue FM broadcasting entirely and other European countries are also considering the cessation of FM sound broadcasting.

References

ETSI documents

[ETSI_1] ETSI ETS 300 401 - Radio broadcasting systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers. *February 1995*

[ETSI_2] ETSI EN 300 401 V2.1.1 - Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to Mobile, Portable and Fixed receivers. *January 2017*

[ETSI_3] ETSI TS 102 563 (V2.1.1) - Digital Audio Broadcasting (DAB); DAB+ Audio Coding (MPEG HE-AACv2). *January 2017*

[ETSI_4] ETSI TS 103 466 V1.1.1 - Digital Audio Broadcasting (DAB); DAB audio coding (MPEG Layer II). *October 2016*

3.2 The DRM system

In common with several other digital sound broadcasting systems, such as the Eureka 147 DAB system, the Digital Radio Mondiale (DRM) family of transmission systems employs coded orthogonal frequency division multiplexing (COFDM) to transmit the encoded audio data.

DRM was originally conceived as a replacement for analogue sound broadcasting using amplitude modulation (AM) in the HF, MF and LF sound broadcasting bands. Detailed information about the DRM system is set out in Annex 1 of Recommendation ITU-R BS.1514, the evaluation criteria of which confirm that DRM is the only digital sound broadcasting system recommended for use in all the sound broadcasting bands below 30 MHz. In particular, the DRM system can provide additional data services, either to supplement the programme content or for completely independent purposes as required by Recommendation ITU-R BS.1348. Information about planning parameters for the DRM system can be found in Recommendation ITU-R BS.1615.

Building on this experience, the DRM Mode E digital sound broadcasting system was developed as a replacement for analogue sound broadcasting in the VHF bands. Detailed information about the DRM Mode E system is set out in Recommendation ITU-R BS.1114, where it is classified as "Digital System G". The technical basis for planning DRM Mode E services is included in Recommendation ITU-R BS.1660.

Initially, DRM Mode E was only intended to replace frequency modulated (FM) broadcasting in VHF Band II (about 87-108 MHz). However, the success of the DRM Mode E trials in Band II has led to consideration of using DRM Mode E to provide new broadcasting opportunities in Band I (47-72 MHz) and Band III (174-230 MHz). Laboratory measurements and the results of field trials of DRM Mode E in Bands I and III can be found in Annex 1 to Report ITU-R BS.2214. The technical and regulatory factors involved in using Band I for digital sound broadcasting are considered in Report ITU-R BS.2208.

3.3 The HD radio system

The HD Radio System uses In-Band On-Channel technology and has been in commercial operation since 2004. The main objective of the HD Radio system was to facilitate the introduction of digital sound broadcasting in both the MF and FM bands in areas with a robust analogue broadcasting infrastructure without the need for new spectrum. The HD Radio system uses a "hybrid" mode, which inserts digital carriers at low power levels on one or both sides of the existing analogue signal. The system permits broadcast to simulcast their existing programming in both an analogue and digital format. The system also has an all-digital mode that eliminates the analogue signal. This mode can be used in areas where regulators no longer want to protect analogue broadcasts from digital interference or in areas where there is spectrum available for reassignment for digital sound broadcasting.

Detailed information about the MF HD Radio system can be found in Recommendation ITU-R BS.1514 where it is classified as the IBOC DSB System for Operation Below 30 MHz. Information about the FM HD Radio system can be found in Recommendation ITU-R BS.1114 where it is classified as Digital System C. Information about planning parameters for the MF HD Radio system can be found in Recommendation ITU-R BS.1615. Additional information can be found from other sources. Detailed system specifications and test result information for both the MF and FM systems can be obtained from the National Radio Systems Committee ("NRSC") at www.nrscstandards.org. Information can be found under the link for NRSC Standards and Guidelines. The HD Radio system is standardized in the NRSC-5D standard.

3.4 Integrated services digital broadcasting – Terrestrial multimedia broadcasting for mobile reception system

The Integrated Services Digital Broadcasting – Terrestrial multimedia broadcasting for mobile reception (ISDB-Tmm), specified as System F in Recommendation ITU-R BT.1833, is designed for real-time and non-real-time broadcasting of video, sound, and multimedia content for mobile and handheld receivers. The system is based on the common technology of Multimedia System C in Recommendation ITU-R BT.1306 (known as ISDB-T) and Digital System F in Recommendation ITU-R BS.1114 (known as ISDB-T_{SB}).

The ISDB-Tmm system can utilize any combination of 13-segment format and 1-segment format. 13-segment format has a 6/7/8 MHz bandwidth and is compatible with ISDB-T. 1-segment format has $1/13^{th}$ the bandwidth of the 13-segment format and is compatible with ISDB-T One-Seg and ISDB-T_{SB}.

3.5 The RAVIS system

Digital terrestrial sound and multimedia broadcasting system RAVIS (Real-time AudioVisual Information System) is designed for use in the terrestrial VHF broadcasting bands. The frequency range used by RAVIS enables to deploy local broadcasting. At the same time the coverage radius of the transmitter is large enough to provide reception in remote places.

System receiver should enable to receive new digital programmes and programmes from analogue FM-broadcasting station with automatic detection of the programme type.

The RAVIS system is designed for high quality multi-programme sound, video with several sound accompaniment channels and other data (both related and unrelated to sound and video programmes) broadcasting services. These services should be provided in various conditions, including driving in dense city environment, in woody and mountainous terrain, in water areas; i.e. a reliable reception must be provided in motion, in the absence of direct line of sight of the transmitter antennas and multipath signal propagation.

The channel coding and OFDM modulation scheme in RAVIS system are defined as a functional block for adaptation of data from source encoder to transmission channel characteristics. The RAVIS system allows various levels of QAM modulation and various rates of channel coding in the main service channel, which are used to achieve an optimal balance between bitrate and reliability (interference protection).

The main service channel is designed for video and audio data transmission. Maximum bitrate in this logical channel is about 900 kbit/s. Low bit-rate channel is designed for transmission of information with increased reliability, for emergency voice alerting, for example. Bit rate is about 12 kbit/s. Reliable data channel is designed for auxiliary data with high reliability. Bit rate is about 5 kbit/s. The low bit-rate channel and reliable data channel provide higher interference protection and consequently larger coverage and higher stability of reception compared to main service channel.

3.6 The CDR system

Digital terrestrial sound and multimedia broadcasting system Convergent Digital Radio (CDR), has been developed for smoothly switch-off from the currently analogue FM to digital radio. The system was designed to provide vehicular, portable and fixed reception using terrestrial transmitters. During simulcast stage, CDR can make full use the unoccupied spectrum in currently FM channel, provide several additional digital radio services, the system offers improved performance in multipath environments resulting in greater reliability than is offered by existing analogue FM operations. After switch-off is finished, CDR can provide more high quality digital audio services (such as CD quality or

5.1 multichannel services) as well as various data services, and the system also can support the nation-wide coverage by using single frequency network (SFN).

CDR system is designed for the digitalization of the current FM radio, so it is mainly used in FM Band (88~108MHz). To accommodate the different needs during the digital switch-off, CDR system defines several spectrum occupancy modes and three transmission modes. It supports all digital transmission as well as simulcast with currently FM signal.

CDR flexibly provides several spectrum-occupancy modes for different scenarios, the digital signal bandwidth can be 100 kHz or 200 kHz. During the switch-off stage, the digital signal can be simulcast with analogue FM signal, in this case, the digital signal spectrum is divided into two parts, and the spectrum interval is 300 kHz or 200 kHz in which the stereo FM radio or analogue mono FM broadcasting signals can be placed. When the switch-off is finished, the digital signal can be continuous; the signal bandwidth may be 100 kHz or 200 kHz.

CDR supports simultaneous delivery of various digital audio streams and data streams. Various compressed audio services, data services and control information are combined and framed by multiplexing sub-system.

The RF signal will be produced when the output of multiplexing sub-systems are processed by channel coding and modulation sub-system. For each channel, forward error correction, constellation mapping and modulation scheme would be specified independently. The receiving sub-system completes demodulation of the transmitted signal.

The channel coding and OFDM modulation scheme in CDR system are defined as a functional block for adaptation of data from source encoder to transmission channel characteristics. The CDR system allows various levels of QAM modulation and various rates of channel coding in the main service channel, which are used to achieve an optimal balance between bitrate and reliability (interference protection).

The main service channel is designed for audio and multimedia data transmission. Maximum bitrate in this logical channel is about 356.4 Kbit/s. The lower bitrate channel provides higher interference protection and consequently larger coverage and higher stability of reception. The minimum bitrate is about 36 Kbit/s.

4 Completing the transition to digital terrestrial sound and multimedia broadcasting

Studies in ITU-R over the last 30 years coupled with the decisions of World and Regional Radiocommunication Conferences over that time made it possible to digitize almost all radiocommunication services, paving the road to a convergence of services, where appropriate.

However, in order to be successful, it has to be recognized that digital sound broadcasting systems should bring significant benefits to broadcasters and listeners, when compared with analogue systems. In particular, digital sound broadcasting must offer excellent reception on portable and mobile radios, as well as provide additional capacity for extra audio services and/or multimedia services.

At the present time, several terrestrial sound broadcasting services are still in operation that use analogue technologies. The material in this Report is intended to highlight the practical advantages to broadcasters and the benefits to listeners of completing the migration of those remaining analogue sound broadcasting services to digital technologies.

The following considerations have been identified that may be expected to encourage administrations, broadcasters to plan for making further progress in introduction of new digital sound and multimedia broadcasting services and completing the switchover from existing analogue sound broadcasting services, as well as helping listeners to understand the reasons for and the benefits of making the transition:

– means to allocate up to three or four digital sound channels in each current analogue sound broadcasting channel, depending on the digital broadcasting system chosen;
– ability to reduce the emitted power for each sound service;
– ability to improve the audio quality of each sound service;
– means to allow the addition of some ancillary visual information to those sound services (e.g.: the addition of a weather map to a weather sound service);
– opportunities to contribute to a further convergence of digital services, with the attendant market benefits; and
– eventually, to leave the way clear for introducing new frequency plans for the bands allocated to the broadcasting services in order to improve protection from interference while optimizing access to digital sound and multimedia broadcasting services.

Annex 1

Social, regulatory and technical factors involved when considering a transition to the DRM system

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Annex 2

The HD Radio System

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Annex 3

Social, regulatory and technical factors involved when considering a transition to the DAB system

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Annex 4

Consideration of social, regulatory and technical factors on a transition to the ISDB-T multimedia broadcasting systems

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Annex 5

RAVIS System

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Annex 6

Convergent Digital Radio system

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Annex 7

Case studies on the transition to digital sound broadcasting systems

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