ECC Report 177

Possibilities for Future Terrestrial Delivery of Audio Broadcasting Services

April 2012

0   EXECUTIVE SUMMARY

This Report considers the possibilities for continuing Radio Broadcasting into the future. While recognising that technological developments are opening a wide range of potential platforms for the distribution of audio content, it is felt that 'terrestrial' distribution with strategically placed transmitters simultaneously serving a large number of independent receivers will continue. This is particularly true for portable and mobile reception. With this in mind, this document concentrates on terrestrial distribution platforms and especially the relevant digital technologies that exist and are being developed. Radio is now very much a medium which can be, and is, accessed by an audience where a large portion is either mobile or doing something else. The motorist is a good example of this. The report looks at how this audience might be served in the future. While, in the past, conventional terrestrial radio broadcasting was the only viable way to serve this audience, technological convergence and changing habits mean that other platforms such as mobile broadband, satellites and wired infrastructures can now be used under the right circumstances.

In spite of this, terrestrial broadcasting does offer certain advantages and it is felt that this will continue for the foreseeable future.

Terrestrial broadcasting is itself changing with the advent of digital modulation systems. The report goes on to compare and contrast these modulation systems in some detail, looking at the strengths and weaknesses of each one. This is against the background considerations of audience size, geographical concentration and demographics, and how each system is able to exploit the available spectrum.

Looking to the future the available spectrum is clearly going to be limited. Classical analogue based systems, while capable of providing a good quality signal to the listener, provide no easy means for the expansion of facilities.

Particular note should be taken of the following points:

- Terrestrial audio broadcasting is highly effective in reaching very large audiences;
- The strength of terrestrial audio broadcasting is that audio programmes are generally offered free-to-air. This constitutes the main pillar on which the success of radio is built;
- Audio broadcasting may be the only sustainable source of information in emergency situations;
- Migrating from analogue to digital distribution technology offers the opportunity for more services and higher quality services. Thus, digital broadcasting paves the way for more efficient use of spectrum than analogue technologies do;
- The key frequency bands for the introduction of terrestrial digital audio broadcasting are the VHF bands II and III;
- In Band III the necessary regulatory framework for the introduction of digital audio broadcasting is already fully in place. However, there may be a need for Rules of Procedure at ITU level to enable the introduction of digital services in Band II:
- Introduction of digital terrestrial audio broadcasting in the bands currently allocated to it may take advantage of existing broadcasting network infrastructure;
- The evolution of terrestrial digital broadcasting technology needs to take into account the changing habits and expectations of an 'Internet savvy' audience;
- Terrestrial digital broadcasting and IP technologies will have to be used in a complementary way to satisfy the changing demand of listeners. Consequently content will be provided by both linear and nonlinear radio services.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
3GPP	Third Generation Partner Project
AM	Amplitude Modulation
CEPT	European Conference of Postal and Telecommunications Administrations
DAB	Digital Audio Broadcasting
DRM	Digital Radio Mondiale
DTT	Digital Terrestrial Television
DVB-H	Digital Video Broadcasting - Handheld
DVB-NGH	Digital Video Broadcasting - Next Generation Handheld
DVB-T	Digital Video Broadcasting-Terrestrial
DVB-T2	Digital Video Broadcasting – Terrestrial 2
FM	Frequency Modulation
GSM	Global System for Mobile
HD Radio	Hybrid Digital Radio
HF	High Frequency
ITU	International Telecommunication Union
IMB	Integrated Mobile Broadcast
IMDA	Internet Media Device Alliance
IP	Internet Protocol
IPR	Intellectual Property Rights
ITU	International Telecommunication Union
LF	Low Frequency
LTE	Long Term Evolution
MBMS	Multimedia Broadcast/Multicast Services
MF	Medium Frequency
OFDM	Orthogonal Frequency Division Multiplex
NGH	Next Generation Handheld
NGN	Next generation networks
OIRT	The International Radio and Television Organisation (official name in French: Organisation Internationale de Radiodiffusion et de Télévision)
PC	Personal Computer
QoS	Quality of Service
RAVIS	Realtime AudioVisual Information System
RSPG	Radio Spectrum Policy Group
TDD	Time Division Duplex
SDR	Satellite Digital Radio
VHF	Very high frequency

1   INTRODUCTION

The term audio broadcasting is taken to be the distribution of content consisting of an independent audio signal which optionally can also contain text, pictures or even movie clips. Commonly known as radio it can reach any location at all times. The continuing success of radio has been built on its mobility and accessibility.

Along with the printed press, television and the Internet, radio constitutes one of the mass media to guarantee freedom of information.   Freedom of Information is defined as the universal right to access information held by public bodies[1].

Radio wakes people up in the morning and accompanies people around the house - in the bedroom, in the shower, in the kitchen - entertaining and informing everyone. It helps people get to work, advising on traffic problems and calming the nerves of those that commute in a car or on public transport. For others, at work and at home it is a readily available source of information, and companionship; entertaining and making people think. At the end of the working day it helps people get home again. Only then does television take over people's attention.

Radio has been around for over 80 years and, despite the arrival of new technologies, from television to computers and the Internet, radio still plays a major role in people's lives.

The audience's relationship with radio is different from that with television. In Europe radio is a secondary and personal medium; usually listened to while people are doing other things - getting ready to go out, commuting or even working. Radio is also a medium which many feel very passionately about and also have a strong affinity with the stations they listen to. Furthermore, in all countries sound broadcasting services are part of the actions for the development of population with an expectation that these services will be available with freedom of expression.

In recognising the economies of scale, in a pan European market it must be recognised that there is the potential for a much larger market or audience in other regions and continents. The 'FM band', for example, is essentially available on a worldwide basis.

Radio is changing; the advent of digital technology means that not only are there more stations than ever to choose from, but they can be accessed in new ways - via television, on the Internet, on mobile phones, etc. - as well as on the more traditional portable sets, hi-fis, and car radios. The services digital radio can offer could change the medium forever; already digital radio offers:

- much easier navigation between stations;
- the ability to pause and rewind live radio;
- the opportunity to listen at a time of an individual's choice;
- access to programmes that have been missed;
- the ability to download and store songs on personal players;
- access to supplementary data regarding the current track or programme; and
- the possible economies of broadcasting several services from one transmitter.

Future services could include video clips and much enhanced text services. With these possibilities, radio will be at the forefront of the media and technology convergence.

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[1]   Article 19 of the Universal Declaration of Human Rights, which states: "Everyone has the right to freedom of opinion and expression; this right includes freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media and regardless of frontiers

Wherever the development of radio might lead it should at least offer the following targets:

- free access (meaning without a subscription or registration);
- universal availability in time and location;
- instant access to live programming (e.g. news and sport);
- wide functionality and flexibility in the use of radios (e.g. electronic programme guides, associated programme information, recording facilities, etc.);
- the ability to find different programmes easily (e.g. by automatic tuning) and
- a wide variety of radio channels.

Looking to the future the available spectrum is clearly going to be limited. Classical analogue based systems, while capable of providing a good quality signal to the listener, provide no easy means for the expansion of facilities. The potential long term advantages of 'going digital' are that an expansion in the number of services and secondary data information can be made available to an 'Internet savvy' digital consumer.

This Report provides an overview of the conceivable distribution platforms that could be employed in the future to meet these targets. It must be noted that the primary focus is on terrestrial distribution. Other distribution mechanisms are addressed here to the extent necessary to put future opportunities for terrestrial distribution of radio in an appropriate context.

The RSPG has undertaken complementary work in this same area and its initial study report - "The Future of Radio Broadcasting in Europe" - identified needs, opportunities and possible ways forward [1]. Supplementary information, including all the responses to the associated questionnaire which was circulated during this study, is also available [2].

2   THE CHANGING RADIO ENVIRONMENT

In the past people would typically sit down in their living room to listen to a radio programme as a dedicated activity. This is now generally atypical. Today people listen while doing something else; working, doing homework, in the gym or travelling.

Most audiences listen to a relatively limited number of radio stations which are all present on terrestrial platforms. Listening to Internet radio and continuing to listen with 'podcasting' is increasing in many European countries. This does not change the listening behaviour drastically; even via the Internet the majority of listeners tune in to the most popular radio stations.

The Internet is gradually changing the listener's behaviour. It offers today's audiences the possibility to influence what information they get, as well as where and when they get it. They are now accustomed to being able to choose from a large selection of content, formats and channels, whether it be television, radio, printed media or the Internet. Young people listen to and use traditional media less and less, to the benefit of social media.

Radio broadcasters are responding to the changing media environment by introducing thematic radio stations, multimedia content and sharply defined formats all of which serve specific audiences. This is only the beginning; radio must offer the possibility of further development to satisfy the changing needs of listeners.

The opportunity should be provided for new and existing content providers to increase and diversify the overall offer (e.g. using their archives, thematic channels, etc.) so that listeners can choose from a larger number of programmes and supplementary services. These might include surround sound, text, pictures and video. Content on demand or time shifting will need to be offered. All of this calls for digital production and distribution and may require a return channel.

Even with all these changes it is likely that the 'listening-while-doing-something-else' character of radio will remain dominant in the foreseeable future. It is also likely that the majority of the audiences will still listen to a limited number of radio stations.

It is expected that broadcasters will continue to use terrestrial broadcasting platforms to serve the majority of their listeners; and these listeners will expect most of the extra functionality that the Internet offers. Only digital platforms will be capable of offering supplementary services like text, pictures, video and interactivity.

Besides the traditional terrestrial distribution of radio content a new distribution mechanism is currently emerging. Hence, broadcasters face two fundamental approaches to radio distribution with somewhat different characteristics, namely;

1) Broadcast

- Access to listeners is direct and not though a third party;
- Strict regulation of content and access to distribution mechanisms;
- One to many delivery - highly efficient for large audiences;
- Free to air for the listener;
- Defined quality of service;
- Access to spectrum is crucial.

2) Broadband

- Flexibility and interactivity;
- Potential for worldwide coverage via the Internet;
- Subscription needed for reception (Internet provider needed, not free to air);
- 'Gatekeeper' can exercise absolute control;
- Best effort quality of service – dependant on traffic.

Broadcasters are now operating in a hybrid environment producing and distributing content for conventional broadcasting distribution and for the Internet. This presents challenges for the broadcaster and their regulators to:
- Keep radio simple for the user;
- Keep down the costs of receivers;
- Place constraints on standards choice;
- Deal with technological replacement cycles faster than take-up rates and imposes certain requirements such as
  - Open standardisation;
  - Assuring compatibility with CEPT and ITU spectrum regulation;
  - System harmonisation.

Furthermore, broadcasters need to minimise technology license costs.

3   COVERAGE REQUIREMENT CONSIDERATIONS

Broadcasters target specific groups of listeners in a defined geographical area, or by a particular type of content. Within the target groups, broadcasters wish to serve as many people as possible with the greatest efficiency. Clearly, there are different needs when comparing national and regional services or public and commercial services.

Public service broadcasters in Europe have to cover all, or large parts of, their national territory while commercial broadcasters are usually interested only in serving highly populated areas or traffic routes. There are also broadcasters who are serving areas which are significantly larger than their national territories. Furthermore, there are a large number of community broadcasters in Europe providing services in small areas such as individual towns and cities.

Coverage requirements may differ between and within different countries. Broadcasting services are planned for fixed, portable outdoor / indoor or mobile (e.g. car) reception at different quality of service (QoS) levels. Even within a given country the target reception modes can be different in different parts of a country; portable indoor in big cities, mobile along the main traffic routes and fixed in rural areas, etc. Furthermore, geographic and topographic conditions – dense urban places, rural areas, mountainous or woody areas and the presence of large water spaces– have a critical impact on the coverage to be taken account of in the planning. This is reflected in the way that broadcast networks are planned for different location probabilities in different areas.

Some broadcasters provide a single programme only while others offer a range of programmes. Some of the programmes may need to be delivered throughout a whole country to a high proportion of the population (for a public service typically more than 98%) while others can be confined to administrative, cultural or linguistic regions or even parts of them.

Aligning programme variety with geographical coverage is just one aspect of broadcaster's requirements. The ability to allocate transmission capacity for the delivery of particular programmes and enhanced services in a flexible manner is also a crucial freedom for broadcasters.

Finally, free-to-air distribution of radio programmes is essential for public service broadcasters as well as for commercial broadcasters.

4   DELIVERY SYSTEM REQUIREMENTS

The following questions should be considered when comparing different distribution platforms:

a)   How well does the technology satisfy the needs of broadcasters and listeners?

    i)   What **functionality** can be expected?
      (e.g. reception mode, mono, stereo, data services)

    ii)   What **coverage** can be achieved?
      (e.g. nationwide/regional/local[2])

    iii) What quality of service (**QoS**) can be achieved?

    iv)   What is the **availability of equipment**, i.e. transmitters and receivers?

    v)   What **costs** will arise - for broadcasters and for listeners?

    vi)   What **capacity** can be achieved? (e.g. bit rate per program, number of programmes in a multiplex, overall limits)?

    vii) What **flexibility** is offered in terms of multiplex configuration, control over QoS parameters, the possibility to increase the range of programmes and the development and implementation of new functions?

Specifically for terrestrial and satellite delivery there are additional issues to be taken into consideration:

b)   Is the technology ready to be implemented?

    viii) Are the network **planning parameters** available/agreed?

    ix)   Are the **compatibility criteria** established with other users of the same spectrum and in adjacent frequency bands?

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[2]   Radio and television are part of society's warning, alarm and information systems. In times of crisis and catastrophe radio is extremely important for alarms and handling crises, both in terms of spreading information to the public and the general process of decision-making in society. The ability to send important public announcements in extraordinary circumstances depends on how good the conditions are for each technology to reach the entire population.

c) How does the technology fit into the wider European context?

  x) Does it comply with the **international agreements** and frequency plans?

  xi) Is it **standardised** in Europe?

  xii) Is there a wide **support** from broadcasters, manufacturers and regulators?

d) How does the technology utilise the available spectrum?

  xiii) What **frequency band(s)** are available?

  xiv) Are networks deployed in terms of MFN and/or SFN and what is the size of the networks, i.e. what is the **network topology**?

Broadcasters need to employ distribution mechanisms that meet their requirements for coverage, quality of service, variety of content offered and so on. In particular, distribution mechanisms need to be flexible to adapt to changing requirements. Moreover, distribution costs need to be predictable and under the control of broadcasters. Access to distribution platforms should not be hindered by 'gate-keepers' subject to non-broadcasting interests. These are the conditions and constraints against which the suitability of a given distribution platform has to be assessed.

5   TERRESTRIAL DISTRIBUTION

5.1   TERRESTRIAL RADIO BROADCASTING SYSTEMS

In most countries terrestrial radio is by far the most popular way of receiving radio services; most of the audience uses terrestrial as their primary means of reception. Although radio is available on other platforms, they are used only to a limited extent.

Terrestrial distribution of radio offers a combination of many positive characteristics for listeners and broadcasters:

  ▪ potential to provide universal coverage;

  ▪ tailored coverage (local, regional, national);

  ▪ free to air services;

  ▪ fixed, portable (indoor) and mobile reception;

  ▪ receivers which are agile in frequency tuning and simple to use;

  ▪ reliable as a channel of information, especially in crises and catastrophes;

  ▪ an important medium for traffic information, shipping, mountain rescue, etc.;

  ▪ audio quality and multi-media information is independent of the number of simultaneous listeners.

The following sections describe systems and spectrum issues for the terrestrial platform.

5.1.1   Analogue Radio Broadcasting Systems

AM and FM radio are currently the primary means to deliver conventional, ('linear'), audio content. Both can also be used to deliver additional services such as low bit rate radio text and traffic information. These systems have been in use for many years and their strengths and weaknesses are well known – see for example ECC Report 141 [3].

5.1.2   Digital Radio Broadcasting Systems

Four digital radio broadcasting systems are considered:

- **Digital Radio Mondiale DRM**: An open standard digital system for long, medium and shortwave ('DRM30' broadcast configuration) and the VHF bands I, II (FM) and III ('DRM+' broadcast configuration). It usually carries audio and multimedia programme(s) generally of a single broadcaster;

- **Digital Audio Broadcasting DAB** (DAB Classic, DAB+ and DMB audio codecs): An open standard digital system currently introduced in several countries in Europe and Asia. The DAB+ audio codec enables roughly twice the number of services per multiplex compared to the DAB Classic codec;

- **HD Radio**: A proprietary standard developed in the USA which supports simultaneous operation of legacy analogue services (AM-MF and FM), while allowing for gradual transition to digital services. Currently implemented in the USA and in other countries;

- **RAVIS**: An open standard digital terrestrial broadcasting system for VHF bands I and II. It is intended to deliver audio and multimedia (including video) content for fixed, portable and mobile reception through narrowband RF channels (100, 200, 250 kHz bandwidth).

5.1.2.1   Overview of features for the various systems

Most digital systems can operate with more than one programme stream in a multiplex. There can be a trade off between the audio quality of the output and the number of programmes in the multiplex. Importantly, while the potential number of programmes carried in the multiplex can vary, the bandwidth of the multiplex for any given system is fixed. Clearly there are cost / commercial implications here. The cost for each programme goes up as the number of programmes using the multiplex goes down and all programmes sharing the multiplex need to have similar coverage aspirations.

Where more than one programme stream is carried in a multiplex, the effective bandwidth occupied by the programme stream is smaller than the bandwidth of the multiplex. Very simply, it is the multiplex bandwidth divided by the number of programme streams. This will clearly vary because the number of programme streams within the multiplex itself will vary because of quality trade-offs or because it is not possible to find enough programmes to completely fill the multiplex.

All digital systems considered in this document can support single frequency networks (because they use OFDM). While under certain restricted circumstances analogue transmissions can operate on the same frequency, this is not a single frequency network in the accepted sense.

DRM and DAB standards share certain commonality in some modulation schemes, audio codecs and data applications. With respect to the common features they are fully interoperable from a listener's perspective. By providing an automatic two-way service linking DAB and DRM signals can be complimentary. DAB provides an efficient multiplex solution for multiple broadcasters or platform operators sharing the same coverage area, while DRM is rather suitable for individual broadcasters like community stations or single local/regional services but also capable to operate in large area single frequency networks.

With analogue systems the audio quality at the output depends on the quality of the channel and the quality deteriorates gradually as the channel deteriorates. Digital systems retain their quality until the point is reached where channel degradation causes the error correction to fail and the signal to disappear completely. As a general rule, with digital systems, the achievable audio quality for any programme stream depends on the available bit rate. This, in turn, depends on the effective bandwidth available to that programme stream; the higher the effective bandwidth, the higher the bit rate and the higher the bit-rate, the better the potential audio quality. Beyond this, different compression codecs utilise the available bit rate in different ways, some being optimised for different types of audio.

A quick overview about important technical features of the different systems mentioned in section 5.1.2 can be found in Annex 1.

5.2 OTHER TERRESTRIAL BROADCASTING SYSTEMS

Radio services can also be broadcast using digital terrestrial television networks. However, the current business models in Europe favour the use of DTT networks for TV services using the DVB family of standards[3].This may constrain the use of these same networks also for radio broadcasting. The DVB systems that could be used for the delivery of radio content include:

- DVB-T;
- DVB-T2;
- DVB-H and DVB-NGH.

DVB-T networks are not planned for a radio audience. They are often planned for fixed rooftop reception and also for portable reception, consequently DVB-T networks have limited capability to provide mobile reception. In addition, there are very few receivers that support mobile reception of DVB-T. Therefore, using DVB-T in order to deliver radio services is always a suboptimal option. For these reasons DVB-T distribution of radio programmes is currently only a complementary way of broadcasting radio services.

Furthermore, if radio is broadcast using DVB-T or DVB-T2, it has to share the multiplex capacity with TV services. As the capacity requirements for TV services will probably increase in the future (e.g. with introduction of HDTV) it may be increasingly difficult for radio to compete for multiplex capacity with TV channels.

The DVB-T2 standard is an improved variant of DVB-T, providing higher capacity and/or robustness, and can in principle provide mobile reception. However, there are currently no indications that DVB-T2 mobile (handheld) receivers will be available in the foreseeable future.

DVB-NGH (Next Generation Handheld) is still in the early stages of development. It is envisaged that it will be an efficient, flexible and robust system to facilitate rich media content consumption to accompany digital switch over and convergence of fixed and mobile services as well as telecommunication services.

5.3 TERRESTRIAL NON-BROADCASTING SYSTEMS

5.3.1 Multimedia Broadcast/Multicast Services (MBMS)

The Multimedia Broadcast/Multicast Services (MBMS) system has been specified by the Third Generation Partner Project (3GPP). The MBMS system represents a new advanced mode of operation in broadcasting networks providing both broadcasting and multicasting services based on any of the IMT family technologies. A new enhanced version of MBMS and the introduction of the LTE technology platform considerably increase the broadcasting system capacity.

5.3.2 Integrated Mobile Broadcast (IMB)

IMB is an updated standard for multicasting on cellular TDD signals, which was previously addressed by the MBMS standard. The IMB standard has received an agreement by the GSM Association and 3GPP. IMB is part of 3GPP's Release 8 Standard, providing capabilities for Broadcast services, similar to the broadcast element of MBMS, in 3G TDD bands.

5.3.3 Next Generation Networks

Next generation networks (NGN) allow the delivery of services through fixed and mobile convergent networks - NGN is based on packet transmission and uses the Internet Protocol (IP) for carrying different types of traffic (voice, video, data and signalling) with data rates per user greater than 10Mb/sec.

The central theme of the harmonisation towards 'all IP' is that all transmission sub-systems will use a common protocol to deliver its content. The IP multimedia sub-system (IMS) supplies a platform for a transparent access to a variety of fixed and radio access technologies. This expands to the concept of cloud computing and distributed server architectures.

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3 http://www.dvb.org/

6   COMPLEMENTARY DISTRIBUTION PLATFORMS

6.1   WIRED DISTRIBUTION

Radio has been broadcast over wired infrastructure for a long time as cable operators have distributed radio together with television in their products. Wired distribution has the big disadvantage that mobile and portable reception is not supported.

6.1.1   Traditional Cable Distribution

Cable operators generally offer two services: broadcasting (radio and television) and telecommunications (voice, and Internet). In Europe, cable operators normally have agreements with broadcasters to distribute broadcast radio and TV content.

The service area is limited by the connection in the home; mobility at home is made by home networking connected to the cable or wire distribution.

6.1.2   Fixed Internet Access

With the success of the Internet, radio broadcasters have taken the opportunity to provide their content via this medium. This can be considered as a technical extension to wire or cable installations.

Internet radio terminals are dedicated equipment or a PC which allow programmes, including those produced by local radio stations which normally address a limited audience, to be received anywhere in the World.

Projects for connecting radio and Internet have been set up to examine and develop the convergence between the broadcasting sector and IP-delivered services. For example, the project RadioDNS is aimed at providing an efficient and seamless link between broadcast and IP platforms

Radio broadcasters have developed strategies of hybridisation of radio using content delivery through different platforms. Internet is appropriate for an efficient interaction between the radio broadcaster and the audience. The broadcasters are studying standardisation and the Internet Media Device Alliance has announced the creation of guidelines for Internet radio station metadata to define station identity and stream information for the specific station.

The Net neutrality issue is following a double principle, the first one is a principle of granting access to the networks, the second is a principle of equal freedom of choice and access to contents, for all services and applications, including radio.

It is essential that every listener can receive the content which he wishes. It is necessary to avoid the marginalization of certain sources of information which is essential for the freedom of expression.

Quality of service is another aspect. Content must be received with the same quality of service without degradation for the audience.

The question of the neutrality of networks could arise because of the huge increase in uses and the requirements of bandwidth. The forecast of an increase of average traffic per user that doubles every year could create a risk of saturation of networks. Furthermore, access to the content is a key issue under the net neutrality discussion from a broadcaster's point of view. This touches upon the question of gate keeping for a distribution platform that cannot be regulated by national laws. This means there is a risk that international economic interests are in conflict with national coverage obligations.

6.1.3   Fibre Networks

In the future there is the possibility that the copper cable provisions could be replaced by fibre networks that will offer a considerably higher capacity. The infrastructure feeding these fibre interfaces will need considerable enhancement to take advantage of the potential capacity.

6.2 SATELLITE DISTRIBUTION

Sound can be broadcast by satellite and by hybrid or combined satellite and terrestrial systems. Satellite transmission is increasingly the main means of broadcast of services to give full national coverage, compensating for limitations in national terrestrial spectrum or infrastructure availability.

ETSI standards provide information about the standardisation of Satellite Digital Radio (SDR) services. The systems use either broadcasting bands or mobile service bands to reach the users.

A broadcasting satellite service is possible in L-Band while transmissions of multimedia over the mobile satellite service use systems operating in S-Band.

7   REGULATORY BACKGROUND

Across Europe each country has developed its own regulatory framework within which the radio broadcasting services operate. These regulations cover two basic aspects. The first is programme content (not dealt with in this report) and the second is the allocation of spectrum with associated technical characteristics of the transmissions to ensure co-existence of services. The regulation of the allocation of spectrum and technical parameters stems partly from the Radio Regulations and from regional agreements, e.g. Geneva 1984. This results in a set of regulatory processes where administrations have to take into account both their own and neighbouring countries' transmissions when issuing transmission licenses. As far as possible the transmission systems have been harmonised within the regional agreements and standardised through the ETSI organisation. This also ensures a large common market for consumer goods and facilitates easy roaming access for the listeners across Europe.

7.1 CURRENT REGULATION APPLICABLE TO TERRESTRIAL RADIO SERVICES

There are a number of regional ITU Agreements together with CEPT Special Arrangements which cover the broadcasting bands which are summarised in the table below.
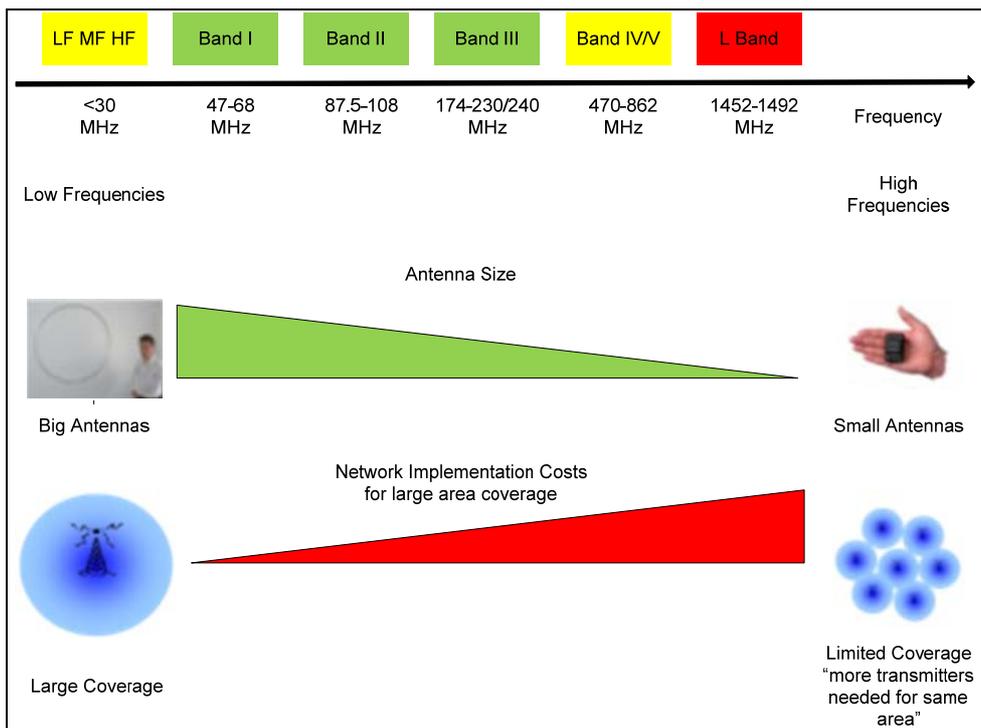
Table 1: Regulation Applicable to Terrestrial Radio Services in Europe

Analogue System	AM	FM	FM	-	-	-
Digital System	DRM HD Radio (MF only)	DRM RAVIS	DRM HD Radio RAVIS	DAB DRM DVB	DVB	DAB Mobile Multimedia Services
Covered by	GE75 [4] (LF/MF only) ITU-R RR [5] §12 for HF	ST61 [6]	GE84 [7]	GE06 [8] WI95revCO07 [9]	GE06 [8]	MA02revCO07 [10] and ECC Decision (03)02 on satellite service [11]

7.2 AVAILABILITY OF FREQUENCY BANDS

7.2.1   General

Several frequency bands are used for radio broadcasting. These frequency bands have different characteristics that make them suitable for different types of radio service. As a general rule, wide area coverage is easier to achieve in the lower frequency bands but the capacity of these bands is restricted. Higher frequency bands have greater capacity but it is more difficult and costly to provide coverage over a wide area.

**Figure 1: Characteristics of frequency for radio broadcasting
antenna size and network costs**

Propagation characteristics vary with frequency and different radio systems have been devised to make best use of them. As a general rule, lower frequencies are better able to cover large areas (countries and even continents) with a single transmitter.

7.2.2   LF / MF / HF

The LF, MF and HF frequency bands between 148.5 kHz and 30 MHz[4] are traditionally used for analogue AM broadcasting. Advanced systems that could be introduced into these bands are DRM and HD Radio AM. The LF and MF bands are primarily used for domestic broadcasting and the HF bands for international broadcasting. Due to changing propagation conditions during the day the coverage in these bands is variable. This can be tolerated by listeners of analogue services but requires extra care in planning digital services to ensure that listeners do not lose their reception.

With a suitable antenna, the 26 MHz HF Band can be made to function in a similar way to the bands above 30 MHz and so could be used for small area coverage.

There are rules of procedure in place to allow DRM transmissions in ITU Region I in the LF/MF bands under Geneva 75 and at HF under the Radio Regulations Article 12 [5].

7.2.3   Band I

Band I covers the frequency range between 47-68 MHz which has mainly been used for analogue television. It is not planned for digital TV. In a few European countries this band is also used for FM services (so called OIRT FM band from 66 to 72/74 MHz). However, most of these countries have ceased using Band I for FM broadcasting services. Consequently, digital terrestrial broadcasting systems such as DRM (using the 'DRM+' configuration) and RAVIS could be introduced in Band I, although no regulatory framework currently exists to facilitate this. Furthermore, in some countries other services operate in Band I.

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[4] LF band: 148.5 - 283.5 kHz; MF band: 526.5 – 1606.5 kHz; HF band: 3 – 30 MHz.

Services in this band are particularly subject to long distance interference (Sporadic E) at certain times of the year and therefore Band I is more suitable for the provision of local services where the wanted signal can be relatively high.

Further information regarding the regulatory conditions in Band I can be found in ECC Report 117 [12].

7.2.4 Band II

Band II, the frequency range between 87.5 and 108 MHz is exclusively used by FM broadcasting. DRM (using the 'DRM+' configuration), HD-Radio and RAVIS are candidate systems for use in Band II in Europe. ECC Report 141 [3] provides a comprehensive overview of the possibilities for introducing digital radio into this Band.

The introduction of digital systems in Band II would have to be considered on a case by case basis. The digital assignments should initially be inserted between existing analogue FM assignments and eventually on free FM assignments where possible. However, there may be a need for some Rules of Procedure in relation to the GE-84 Agreement in order to take into account digital system parameters. The supplement to ECC Report 141 provides the technical elements and parameters needed for the consideration of introduction of digital radio systems in Band II [22].

7.2.5 Band III

Band III, the frequency range between 174 and 230 MHz, comes under the GE06 Agreement and is planned for DAB and DVB-T services. Some countries in Europe have also allocated the band 230 - 240 MHz for digital radio in order to provide sufficient spectrum for sound broadcasting. This frequency band is under the framework of Wi95revCO07 [09].

Band III is the primary spectrum range for the introduction of digital radio broadcasting using the DAB platform which consists of DAB, DAB+ and DMB-Audio. The DAB platform bundles several programs on to a single multiplex which is transmitted within the intended bandwidth of 1.5 MHz. Broadcasters who are not in a position to fill an entire multiplex will need to share a multiplex with others.

Measurements and field trials carried out in various countries have shown that DRM+ performs as predicted in all VHF bands including band III. The use of DRM in VHF band III is approved by ITU (ITU-R Rec. BS.1114 and ITU-R Rec. BS.1660).

GE06, chapter 5.1.3 [8], states that a digital entry in the Plan may also be notified with characteristics different from those appearing in the Plan, for transmissions in the broadcasting service or in *other primary terrestrial services* operating in conformity with the *Radio Regulations*, provided that the peak power density in any 4 kHz of the above-mentioned notified assignments shall not exceed the spectral power density in the same 4 kHz of the digital entry in the Plan. Such use shall not claim more protection than that afforded to the above-mentioned digital entry. DRM+ fulfils these requirements and can therefore be planned in Band III.

Band III is the only frequency band that provides the opportunity for rapid introduction of core digital radio services in most of Europe using the terrestrial broadcasting systems described in this document. Nevertheless, any Band III usage would need to comply with the GE06 framework or, where appropriate, Wi95revCO07 [09].

If different digital radio systems are introduced into Band III appropriate channel rasters must be defined together with the necessary sharing criteria. Where other frequency bands are to be used for the introduction of digital radio, coexistence of different systems should be allowed through appropriate channel rasters and sharing criteria.

7.2.6 Band IV/V

The bands 470 to 790/862 MHz are fully covered by GE06 [8] for use by DTT. The switch from analogue to digital television broadcasting has made spectrum available in Bands IV/V that could be used by other services in the future. This is generally referred to as the Digital Dividend. Currently the only scenarios in Bands IV/V are for radio services to be carried using spare data capacity of a DTT multiplex. Thus, coverage of radio broadcasts using DTT is the same as the coverage of TV services in the same multiplex.

7.2.7   L-Band

In L-Band, the frequency range 1452 to 1479.5 MHz, has been planned for T-DAB and the range 1479.5 to 1492 MHz primarily for satellite. In comparison with Band III the wave propagation conditions are more challenging from a network planning point of view. As a consequence, one of the main issues with L-band is the need for much denser networks to achieve comparable coverage.

The MA02revCO07 [10] provides the regional special arrangement within CEPT for the introduction of DAB and mobile multimedia broadcasting. There is a separate ECC Decision (03)02 on satellite services [11]. Due the lack of take-up of DAB in L-band a CEPT review is currently being carried out considering best possible uses of the band for the CEPT.

7.3   EVOLUTION OF RADIO USES

Broadcasters are aiming to significantly enhance the experience of radio listening using resilient broadcast technology in association with additional information via IP and adapting the radio equipment to these changes. Several systems are standardized, or working towards standardization, by different working groups within collaborative projects involving private and public broadcasters, software companies and consumer electronics manufacturers and supported by other regulatory bodies. We can note for example:

-   Digital receiver profiles aligned by WorldDMB and DRM Consortium;
-   Basic receiver profile for Internet radios defined and harmonised by IMDA - Internet Media Device Alliance;
-   Convergence of radio broadcasting and IP-delivered in the Radio-DNS project;
-   Technical performance standards and normative references for digital receivers.

7.4   EQUIPMENT LICENSING ISSUES

7.4.1   DAB and DRM

The DAB and DRM system share the same licensing models.

Both systems are openly standardised and their specifications are freely and completely available for all to implement encoder/transmitter and receiver equipment; there is no undisclosed or restricted intellectual property rights (IPR) owned by individual companies and organizations. Broadcasters and receiver manufacturers can rely on the current as well as future availability of concurrent and independent implementations.

As with all modern standards, also both the DAB and DRM systems include IPR license cost, to grant revenue from commercial equipment sales to those who originally developed the technology. This cost is taken care of by manufacturers and thus invisible to broadcasters and operators of transmitter equipment and receiver buyers. All license costs are handled in the form of a one-time payment; there are no running IPR royalties for broadcasters and transmitter operators independent of the number of services deployed or system features. License pools have been set up to offer a convenient and reliable one-stop license handling for manufacturers.

7.4.2   HD Radio

iBiquity licenses its IPR to the HD Radio™ community. iBiquity has committed to the National Radio Systems Committee, the Federal Communications Commission and the International Telecommunication Union that it will license its technology on reasonable and non-discriminatory terms.

iBiquity licenses manufacturers of transmission equipment the right to copy iBiquity's HD Radio software in their equipment and the right to manufacture equipment that incorporates iBiquity's patents and other IPR. In return, iBiquity receives a one-time per unit license fee.

In the United States, iBiquity separately licenses broadcasters to use its IPR to transmit a digital signal. The license includes the right to provide a main channel simulcast of analogue programming, additional multicast

channels and datacasting services. Broadcasters pay iBiquity a one-time fee for the main channel simulcast and annual fees for multicasting and datacasting services.

Outside the United States, the license to transmission equipment manufacturers includes the right for broadcasters to offer main channel simulcasting of analogue, multicasting and program associated data; all broadcaster license fees for these services are included in the purchase price of the transmission equipment, and are valid for the life of the products. Broadcasters interested in offering datacasting services would require a separate license with iBiquity and would be required to pay a separate license fee for that service.

iBiquity also licenses semiconductor and receiver manufacturers. For semiconductor manufacturers the license provides the authority to manufacture and sell products that include iBiquity IPR in return for recurring royalties. For receiver manufacturers the license provides authority to use iBiquity's intellectual property in receiver devices. Receiver manufacturers pay a separate royalty for those rights.

8   THE ROLE OF TERRESTRIAL AND INTERNET RADIO

Traditional on-air radio has many strengths and is a vibrant medium. It is likely that it will remain an important mechanism for the delivery of radio content for a quite long time. Terrestrial broadcast radio is free as listeners are not required to pay for access to the services provided. It enables the delivery of services to a mass audience at a guaranteed quality of service to fixed, portable and in particular mobile receivers in a cost effective manner. Furthermore, broadcast radio can provide a local service keeping an audience in touch with what's happening in the community. During emergency situations broadcast radio may be the only reliable means of providing service information and news updates.

Delivery of radio over the Internet is popular because of a virtually non-exhaustive choice of services and potentially worldwide availability. It enables broadcasters to offer a wide range of services, both linear and on-demand, including time-shifted, personalized and interactive services. Internet radio is particularly suitable for serving small audiences at relatively low cost and with sufficient quality. However, as both the delivery costs and the capacity requirements are largely proportional to the number of listeners this may be prohibitive for large audiences.

Broadcasting has major strengths, as has Internet radio. The two technologies can be used in a truly complementary way to enable the delivery of the full range of linear (real-time) and non-linear (e.g. on demand, catch-up, download) radio services.

9   CONCLUSIONS

Radio is now very much a medium which can be, and is, accessed by an audience where a large portion is either mobile or doing something else. The motorist is a good example of this. The report looks at how this audience might be served in the future. While, in the past, conventional terrestrial radio broadcasting was the only viable way to serve this audience, technological convergence and changing habits mean that other platforms such as mobile broadband, satellites and wired infrastructures will impact the future role of terrestrial broadcasting.

Looking to the future the available spectrum is clearly going to be limited. Classical analogue based systems, while capable of providing a good quality signal to the listener, provide no easy means for the expansion of facilities.

Particular note should be taken of the following points:

- Terrestrial audio broadcasting is highly effective in reaching very large audiences;
- The strength of terrestrial audio broadcasting is that audio programmes are generally offered free-to-air. This constitutes the main pillar on which the success of radio is built;
- Audio broadcasting may be the only sustainable source of information in emergency situations;

- Migrating from analogue to digital distribution technology offers the opportunity for more services and higher quality services. Thus, digital broadcasting paves the way for more efficient use of spectrum than analogue technologies do;

- The key frequency bands for the introduction of terrestrial digital audio broadcasting are the VHF bands II and III;

- In Band III the necessary regulatory framework for the introduction of digital audio broadcasting is already fully in place. However, there may be a need for Rules of Procedure at ITU level to enable the introduction of digital services in Band II;

- Introduction of digital terrestrial audio broadcasting in the bands currently allocated to it may take advantage of existing broadcasting network infrastructure;

- The evolutions of terrestrial digital broadcasting technology needs to take into account the changing habits and expectations of an 'Internet savvy' audience;

- Terrestrial digital broadcasting and IP technologies will have to be used in a complementary way to satisfy the changing demand of listeners. Consequently content will be provided by both linear and nonlinear radio services.

ANNEX 1: COMPARISON OF RADIO SYSTEMS

Table 2: Comparison of different radio systems

System	Multiplex Bandwith	Suitable Band(s)	Channel Raster (ITU Region 1)[1]	Status of Standardization
AM	N/A[2]	LF, MF, HF	9 kHz 5 kHz	ITU-R Rec. BS.560 [23]
DRM30 (DRM Mode A-D)	4.5 – 20 kHz[3]	LF, MF, HF	9 kHz 5 kHz	ETSI ES 201 980 [13] ITU-R Rec. BS.1514 [14]
HD Radio AM	10 – 30 kHz[7]	MF	9 kHz	NRSC-5C [15] ITU-R Rec. BS.1514 [14]
FM	N/A[2]	VHF II	100 kHz	ITU-R Rec. BS.450 [16] ITU-R Rec. BS.412-9 [26]
DAB	1.5MHz	VHF III, L-Band	1.75 MHz	ETSI EN 300 401 [17] ITU-R Rec. BS.1114 [25] ITU-R Rec. BS.1660 [24]
DAB+	1.5MHz	VHF III, L-Band	1.75 MHz	ETSI EN 300 401[17] ITU-R Rec. BS.1114 [25] ITU-R Rec. BS.1660 [24] ETSI TS 102 563 [18]
DMB	1.5MHz	VHF III, L-Band	1.75 MHz	ETSI EN 300 401 [17] ITU-R Rec. BS.1114 [25] ITU-R Rec. BS.1660 [24] ETSI TS 102 427 [19] ETSI TS 102 428 [20]
DRM+ (DRM Mode E)	96 kHz	VHF I, VHF II, VHF III	See [4] 100 kHz See [4]	ETSI ES 201 980 [13] ITU-R Rec. BS.1114 [25] ITU-R Rec. BS.1660 [24]
HD Radio FM	70 – 200 kHz	VHF II	100 kHz	NRSC-5C [15] ITU-R Rec. BS.1114 [25]
RAVIS	100 kHz, 200 kHz or 250 kHz	VHF I and II	See [5]	GOST R 54309-2011 [21]

TABLE NOTES

1. Basis of the given channel rasters are the Final Acts of the ITU-R Conferences for the respective broadcasting bands (Final Acts of Geneva 1975 for LF/MF, Final Acts of Geneva 1984 for VHF Band II, Final Acts of Geneva 2006 for VHF Band III).The channel raster is the basic 'grid' on which the frequency allocations for different services are laid out. In VHF Band II in Europe, for example, transmission frequencies (currently for Analogue FM) are usually allocated at 100 kHz intervals. Given that the band occupancy of an analogue FM channel is ±100kHz (200 kHz overall) two services in the same area with a 100 kHz spacing would clearly interfere with one another. Care has to be taken to ensure that through geographical separation and the use of directional transmitting antennas interference is kept within acceptable limits. Particular care has to be taken when introducing different modulation formats where the band occupancy or the energy distribution within the band might be different.
2. With the exception of a very few FM transmissions where high frequency sub-carriers are used to carry additional audio streams, all analogue systems are all single programme per carrier and so the concept of a 'multiplex' does not apply.
3. DRM30 can be configured to carry more than one MPEG 4 AAC audio streams where the transmission bandwidth is greater than 9 kHz.
4. The DRM+ system can operate in any of the VHF Bands I, II and III, each of which has its own channel raster. Currently the channel raster for Band II is 100 kHz and for Band III, 1.75 MHz. No channel raster currently exists for digital radio in Band I. For DRM+ in VHF band III a channel raster of 100 kHz is proposed in the ITU-R Report BS.2214.
5. The RAVIS system can operate in the VHF Bands I and II, each of which has its own channel raster. Currently the channel raster for Band II is 100 kHz. No channel raster currently exists for digital radio in Band I in Europe (30 kHz channel raster is set in Russian Federation for 66-74 MHz radio broadcasting band).
7. The minimum MUX bandwidth exceeds the channel raster.

ANNEX 2: LIST OF REFERENCES

[1] RSPG10-349 : The Future of Radio Broadcasting in Europe - identified needs, opportunities and possible ways forward (http://rspg.groups.eu.int/consultations/consultation_futradio/rspg10_349_report_future_radio_broadcasting.pdf)

[2] RSPG10-349 bis : The Future of Radio Broadcasting in Europe - replies to questionnaires (http://rspg.groups.eu.int/consultations/consultation_futradio/rspg10_349_annex.pdf)

[3] ECC Report 141: Future possibilities for the digitalisation of band II (87.5-108 MHz) (www.cept.org)

[4] GE75: GE75 Agreement, Geneva 1975 (www.itu.int)

[5] ITU RR: Radio Regulations (www.itu.int)

[6] ST61: ST61 Agreement, revised Geneva 2006 (www.itu.int)

[7] GE84: GE84 Agreement, Geneva 1984 (www.itu.int)

[8] GE06: GE06 Agreement, Geneva 2006 (www.itu.int)

[9] WI95revCO07: WI95revCO07 Special Arrangement (www.cept.org)

[10] MA02revCO07: MA02revCO07 Special Arrangement (www.cept.org)

[11] ECC Decision (03)02: Designation of 1479.5-1492 MHz for use by Satellite Digital Audio Broadcasting systems (www.cept.org)

[12] ECC Report 117: Digital Sound Broadcasting in the bands below 80 MHz (www.cept.org)

[13] ETSI ES 201 980: Digital Radio Mondiale (DRM); System Specification (www.etsi.org)

[14] ITU-R Rec.BS.1514: System for digital sound broadcasting in the broadcasting bands below 30 MHz (www.itu.int)

[15] HD Radio NRSC-5B and NRSC-5C: In-band/on-channel Digital Radio Broadcasting Standard

[16] ITU-R Rec. BS.450: Transmission standards for FM sound broadcasting at VHF (www.itu.int)

[17] ETSI EN 300 401: Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers (www.etsi.org)

[18] ETSI TS 102 563: Digital Audio Broadcasting (DAB);Transport of Advanced Audio Coding (AAC) audio (www.etsi.org)

[19] ETSI TS 102 427: Digital Audio Broadcasting (DAB);Data Broadcasting - MPEG-2 TS streaming (www.etsi.org)

[20] ETSI TS 102 428: Digital Audio Broadcasting (DAB);DMB video service; User application specification (www.etsi.org)

[21] Russian Federation National Standard GOST R 54309-2011: Real time audiovisual information system (RAVIS). Framing structure, channel coding and modulation for digital terrestrial narrowband broadcasting system for VHF band. Technical specification

[22] Technical Supplement To ECC Report 141 Future Possibilities For The Digitalisation of Band II (87.5 – 108 MHz) (www.cept.org).

[23] ITU-R Rec. BS.560-4: Radio-frequency protection ratios in LF, MF and HF broadcasting (www.itu.int)

[24] ITU-R Rec. BS.1660-5: Technical basis for planning of terrestrial digital sound broadcasting in the VHF band (www.itu.int)

[25] ITU-R Rec. BS.1114-7: Systems for terrestrial digital sound broadcasting to vehicular, portable and fixed receivers in the frequency range 30-3 000 MHz (www.itu.int)

[26] ITU-R Rec. BS.412-9: Planning standards for terrestrial FM sound broadcasting at VHF (www.itu.int)