Digital Audio Broadcasting
– coming out of the tunnel

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The roll-out of Digital Audio Broadcasting (DAB) in Europe is at an advanced stage – but is much slower than expected. This article attempts to analyze the principal economic, technological, regulatory and frequency management reasons for this slow progress. Thanks to the concerted efforts of the members of the World DAB Forum, which brings together the main players, the introduction of DAB is now running smoother that it would have been if WorldDAB did not exist.

The article confirms that Eureka-147 DAB is the right technology to take Radio into the 21st century.

Introduction

Radio will only survive as an independent medium in the long run – if it goes digital. Radio broadcasting would probably be marginalized in a multimedia environment, losing its vital role and its independence as a medium, if it remained analogue. In particular, its role at local level would be highly endangered. The digital future thus opens up new possibilities for Radio but its two principal features – namely its ubiquity and friendliness – should remain.

The Eureka-147 DAB system [10] is *the* right technology to bring digital radio to the market-place. But it is not just the technology that matters. The success of digital radio will depend on many non-technical factors, such as:

- how aware the potential listeners are of DAB and its advantages compared to analogue radio services;
- how attractive and appealing the DAB programmes are to the listeners;
- how well a country is covered with DAB signals;
- what is an affordable price for a DAB receiver;
- how DAB will help public broadcasters to enhance their national cultural, social and political mission;
- what new business opportunities DAB will offer to the private broadcasting sector;
- what revenue DAB will generate for receiver manufacturers;

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- ⇨ what the incremental value of a new car, fitted with a DAB receiver, will be;

- ⇨ what the spectrum savings would be in the long term, due to the migration of FM to DAB.

Of course, DAB is not the only pipe that can convey digital radio programmes to the listener. It is but one piece in a large jigsaw of potential FM-substitute or competitor systems. Other technologies that will allow us to access digital radio include: the Internet; various DVB channels (satellite, cable, terrestrial); different storage devices; DRM; WorldSpace; ADR, etc. This being said, the Eureka-147 DAB system is probably the strongest candidate to carry future digital radio services. In 1999, it can safely be said that there is no serious alternative system to Eureka-147 for delivering digital radio terrestrially across Europe – particularly in the mobile environment where much radio listening takes place.

While DAB satisfies all the requirements of public and commercial broadcasters – in terms of audio quality, service performance, spectrum efficiency, network costs, operational flexibility, scalability, interoperability and future extensibility – we must nurture it, if it is to succeed in the marketplace. The interest in DAB, as well as the economic, cultural and regulatory circumstances surrounding it, vary considerably from country to country. The introduction of DAB thus requires a concerted and synchronized action by all its major players, at both the national and international levels.

Investments in DAB

The economic aspects of the introduction of new DAB technology have so far been rather neglected and, indeed, underestimated. But the fact is that the public broadcasters and manufacturers in Europe have invested significant money in the making of DAB and, fortunately, the point of "no return" has been reached; otherwise, these investments would have been lost.

Sceptics will say that the current DAB coverage in Europe is still patchy. The current and/or near-future DAB coverage in three major European countries is shown in *Fig. 1*. In reality, the population penetration of DAB in different European countries has reached a significant proportion of the total population in less than four years. *Table 1* (on the next page) shows the projected coverage of DAB in certain European countries, by the end of 1999. By then, more than 180 million people will be within reach of DAB in Western Europe alone. Experimental DAB services are also being conducted in Austria, Croatia, Hungary, Poland, Slovenia and other countries.

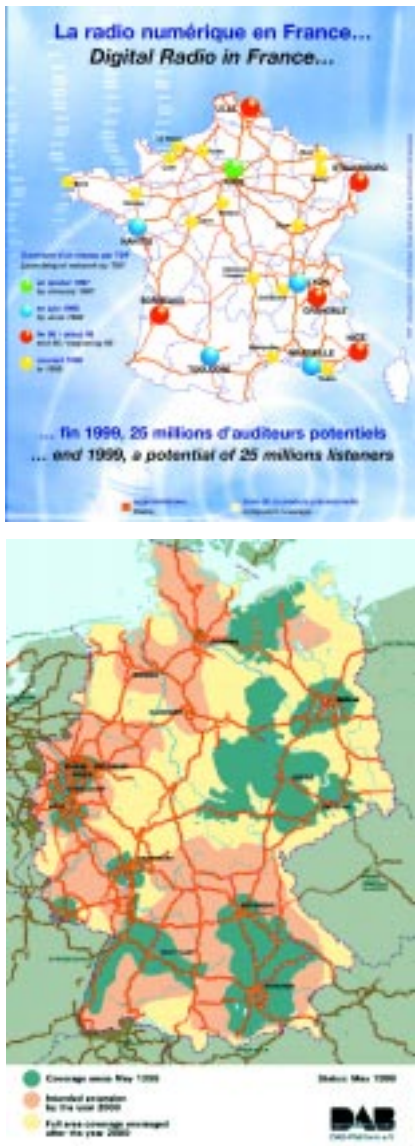

Figure 1
Current/near-future DAB coverage in France, Germany and the UK.

The coverage of any new terrestrial broadcasting service inevitably grows slowly but steadily, as the transmitter infrastructure is developed – and terrestrial DAB coverage is no exception. The key issue here is the lack of money. Investments in the infrastructure have to be funded from the normal annual budget of broadcasting stations. In order to minimize these investments, the strategy is to use existing transmitter sites where possible.

It has been estimated by Prognos [11] that some five hundred million Euro (€500m) have been spent over the last 12 years on DAB:

- some €250m have been invested at the national

Country	Percentage of population	Approx. number of people (in millions)
Belgium	80%	8.16
Denmark	25%	1.30
Germany	50%	40.80
Finland	20%	1.02
France	43%	25.00
Italy	60%	34.38
Netherlands	45%	6.97
Norway	35%	1.54
Portugal	20%	1.80
Spain	25%	10.00
Sweden	85%	7.48
Switzerland	50%	3.50
UK	70%	41.16
TOTAL		183.11

Table 1
Projected DAB population coverage in various European countries, by the end of 1999.

Abbreviations

ADR	Astra Digital Radio
AM	Amplitude modulation
CEPT	European Conference of Postal and Telecommunications Administrations
DAB	Digital Audio Broadcasting
DRM	Digital Radio Mondiale
DVB	Digital Video Broadcasting
DVB-T	DVB - Terrestrial
DVD	Digital video (versatile) disc
EC	European Commission
EPG	Electronic programme guide
FM	Frequency modulation
GPS	Global positioning system
GSM	Global system for mobile communications
HMI	Human-machine interface
IEC	International Electrotechnical Commission
ISDN	Integrated services digital network
ISO	International Organization for Standardization
ITS	Intelligent transport system
ITU	International Telecommunication Union
MOT	Multimedia object transfer
MPEG	(ISO/IEC) Moving Picture Experts Group
OFDM	Orthogonal frequency division multiplex
PDA	Personal digital assistant
TDMA	Time-division multiple access
TMC	Traffic message channel
TPEG	Transport Protocol Experts Group
UMTS	Universal mobile telecommunicaton system
VHF	Very high frequency
VM	Virtual machine
WARC	(ITU) World Administrative Radio Conference

level (radio broadcasters, experiments, trials, network costs and national subsidies for these activities);

- ⇨ some €200m have been invested by equipment manufacturers, on radio receivers and transmission network equipment (including national subsidies);
- ⇨ Some €50m have been spent on supranational co-ordination and by professional bodies.

However, it may well be that the real investments are much higher. In particular, the estimates attributed to the manufacturers may be rather low, given that many did not respond to the Prognos questionnaire. Futhermore, the modernization of digital studios and production facilities, archiving facilities and staffing costs have not been taken into account in these estimates.

Digitalization affects both the radio broadcasting and the retail markets. The former is confronted with additional costs during a rather long period of simulcasting and uncertain prospects of enhanced business services. The receiver manufacturers and retailers, on the other hand, can expect a strong resurgence of consumer demand for receiving equipment. Other sectors of the audio/radio industry are also likely to flourish in this new business environment. At the end of the day, the radio industry should grow faster due to digitalization.

A new business model

Radio in Europe has traditionally been a conglomeration of individual companies, under different ownership, meeting local needs. This pluralism, allied to the principle of "free-to-air" services, has driven the growth of Radio in the past decade, particularly at the regional and local levels.

In terrestrial broadcasting, the vertical structure of the industry that has served Radio well for decades is now being replaced by a horizontal value chain. A vertical structure, however, still applies to the satellite and cable operators. In the horizontal value chain, several players must work together harmoniously in order to put digital radio on the map. These players are as follows (see *Fig. 2*):

- ⇨ content providers (i.e. producers of radio programmes, data and multimedia content);
- ⇨ service providers (i.e. service packagers);
- ⇨ multiplex providers and transmission/network providers;

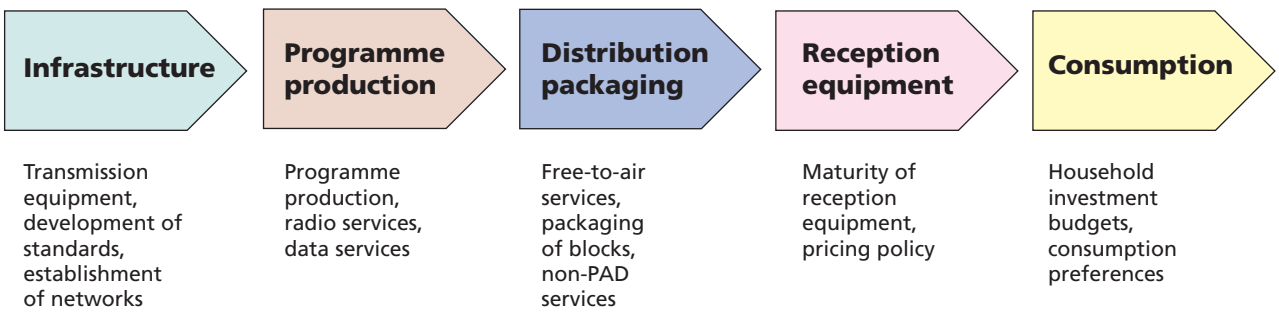

Figure 2
Value chain of digital radio *(courtesy of Prognos)*.

⇨ manufacturers.

This structure, although a significant change for Radio, nevertheless presents major opportunities. There are no multinationals – with large shareholder finance – willing to risk capital in new technology or to subsidize the receivers. Instead, this business model allows the radio sector to create new partnerships across the industry, and leads to much greater competition in the internal market. It is therefore a dynamic business model, with important implications for European content provision, employment and the long-term viability of the radio industry.

Currently there is a lack of incentive for the commercial sector to migrate to DAB. Initially, DAB will not enable commercial radio stations to have a wider reach: in fact, their coverage area may initially decrease. This will automatically increase the competition between the commercial players, who may even have to share a multiplex. It is also true to say that the commercial sector will have to be prepared to take the risk of having little return on their investments over a short period of broadcasting on DAB but, once they have acquired a hardcore of listeners, the potential for financial gain will be enormous. The fear of taking a risk may seem daunting to broadcasters but it will present a real challenge and those who do not plunge into the water now may never learn to swim.

Manufacturer	Car	Hi-Fi	Portable	PC Card	Chips	Module
Aiwa		*				
Alpine	**					
Arcam		****				
AVI		****				
Bang & Olufsen		**				
Becker	**					
Blaupunkt	*****					
Bosch			**	*****		*****
Clarion	*****					
Connaught Elec.				*		
Cymbol Electronics		****				
Daewoo						
Delphi Delco	**					
Fraunhofer				*		
Fujitsu Ten	**					
Grundig	*****	**				*****
Hitachi			**		*****	
JVC	***					
Kenwood	*****	**				
Mannesmann (VDO)	**					
Marantz		*				
Meridian		****				
Mission		***				
Mitsubishi	**					
Panasonic	***					
Philips					*****	
Pioneer	*****					
Radioscape				***		
Roberts			*			
Roke Manor						****
Sharp		**				
Sony	***	***				
Tag McLaren Audio		***				
Teac		**				
Technics		***				
TechnoTrend				****		
Temic					*****	
Terratec				***		

Table 2
Manufacturers of DAB equipment and components.

* = study / development
** = prototype
*** = pre-production
**** = production, limited distribution
***** = production, internationally available

Figure 3
A selection of readily-available DAB radios for the car and the home.

DAB receivers

At the present stage of DAB roll-out, the biggest "missing link" is insufficient sales of DAB receivers. There are several reasons for this:

- ⇨ lack of consumer awareness and / or interest;
- ⇨ the distraction effect of other electronic products, e.g. mobile phones, digital TV, DVD, etc.;
- ⇨ high initial prices for DAB receivers;
- ⇨ less-than-universal coverage.

DAB receivers are intended to become mass-market products. Already, a variety of consumer products is available in the shops and more will come. Some examples of consumer receivers are given in *Fig. 3* (top of this page). While the majority of manufacturers produce only car radios (for the moment using a separate add-on DAB box with a separate antenna), there are currently four manufacturers who are producing hi-fi DAB tuners for the home.

On the previous page, *Table 2* (courtesy of WorldDAB) summarizes the availability of DAB consumer equipment in Europe [1]. Two conclusions may be drawn from this table:

1. The WorldDAB Roll-out Support Programme (RSP) is currently in the process of collecting data from manufacturers, and this table may be revised in future as new data become available.

- several manufacturers are already involved in the production of consumer DAB receivers, and a potentially larger number have plans to do so;
- there are several types of DAB receivers already on the market and more will arrive soon, in particular portable and "walkman-type" receivers, as new generation of integrated circuits begin to appear.

Table 3 gives the retail prices (in DM) of some receivers that were available at the time of writing (May 1999). As DAB is no different from other new consumer products, it is expected that the prices of DAB receivers will come down rapidly, and the market will then grow steadily. Some predictions for the growth of DAB are given in *Fig. 4*.

Manufacturer	Unit	Type	Price (DM)
Blaupunkt	D-Fire 01	Box	1990
Clarion	DAB 9475 R	(DIN)	2200
Grundig	DCR 200	Box	1299
Kenwood	KTC-959 DAB	Box	2999
Pioneer	GEX-O 900 DAB	Box	1399
Sony	XT 100 DAB	Box	2000

Table 3
The retail prices (in DM) of DAB receivers available at May 1999.

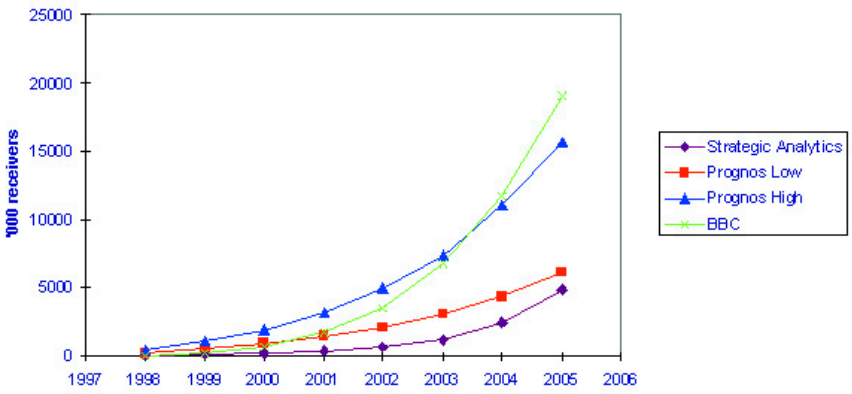

Figure 4
Predicted growth of DAB in Europe up until 2005.

It should be noted that PC cards are now a very popular form of DAB receiver. These cards help many people who already own a PC to experience DAB services (audio and data) before integrated DAB receivers come to the market.

It is important that the technical and operational features of DAB receivers match the features that are transmitted. WorldDAB has made considerable effort in bringing together the broadcasters and manufacturers in order to agree on a minimum set of mandatory and optional characteristics for the first-generation consumer receivers, and hence avoid introducing a mismatch. On the next page, *Table 4* shows the principal features of the DAB receivers now available on the market. It should be noted that not all these features may be supported in the receiver itself; some may initially be implemented in a separate decoder, in which case an interface is provided in the receiver. Some of these features will be implemented in second-generation receivers. There will be a wide range of different levels of implementations, and correspondingly different price levels.

An important aspect of DAB is user-friendliness and simplicity of handling. DAB receivers tend to be highly sophisticated and complex, but attempts have been made by the HuMIDAB Project [12] to simplify considerably the access to DAB services and their selection.

Further effort should be made to include DAB as a standard feature in the car dashboard as part of the car telematic system. For example, a DAB receiver in the car could be combined with a GSM telephone and a GPS navigation system.

Table 4
Principal DAB receiver features.

Transmission-provider-related functionalities
Transmission modes
Mode I
Mode II
Mode III
Mode IV
Service Access – Technical
TII / Regional coding
Alternative services
Service trigger
FIC overflow
Mux reconfiguration with no interrupt
Content-provider-related functionalities
Audio
Audio 8 - 24 kbit/s
Audio 32 - 256 kbit/s
Audio 320 & 384 kbit/s
Half sampling rate
Multi-channel sound
Error concealment in the receiver
Storage of 10*2*16 character blocks
Storage of 10 min. audio

National Features
Language
Country Identifier
Time and Date (UTC)
Local Time Offset (LTO)
Receiver Display Related
≥ 2 * 16 characters
≥ 1/4 VGA
Labels
National Character Sets
Programme Type - Selection Mode
International set
Full coarse set
Download
Fine codes
Programme Type - Watch-Mode
International set
Full coarse set
Download
Fine codes
Programme Type - Preview
International set
Full coarse set

Download
Fine codes
Programme Type Downloading
Announcements
Alarm
Programme delivery control
Features
X-PAD Applications
X-PAD table of contents download
Dynamic label segment
Closed user group data: a:) Stream mode b:) Packet channel
F-PAD Applications
Dynamic range control
Music/Speech switch
Data-provider-related functionalities
Other Data Services
Paging
TMC (Traffic Message Channel)
Multimedia and hypertext
Still pictures
Conditional access
Receiver Data Interface (RDI)

The advent of software (or virtual) receivers may revolutionize receiver designs in the future. In the longer run, all future DAB receivers – even the smallest "walkman" type – may use conventional computer-processing chips, rather than dedicated DAB chip-sets. In addition, powerful computer memories will allow the local storage of thousands of internet-like pages, pictures, graphics, maps and other information. This will lead to an extremely flexible broadcasting system in which DAB will be used as a transparent data pipeline. Radio will no longer be only an audio medium, but a multimedia medium. Applications will be implemented in software, downloadable off-air by the receiver, and updateable and upgradeable on the fly.

Technology

A stable technology is an essential foundation on which the future of radio broadcasting should be based. Eureka-147 DAB is certainly one such system. But it is no longer the only

one. Many alternative technologies have emerged in recent years, with different advantages and disadvantages. For a public broadcaster, it is important to understand the pros and cons of these different technologies and their commercial, economic and operational implications, so that sound decisions can be made. Broadcasters will always aim to use the best possible means to reach the audience in the most effective way.

Apart from the EU-147 system, the following digital technologies can readily be used for sound broadcasting in Europe:

- DVB;
- the Internet;
- satellite (ADR, WorldSpace).

In the future, the Digital Radio Mondiale (DRM) system will also be available.

It may be interesting to note that the Eureka system has been vastly improved in terms of its multimedia applications in last two or three years; its competitive edge to deliver multimedia applications has been considerably sharpened. However, in order to make DAB happen now and not delay its introduction, it is important to arrest any further improvements to the existing standard. It is necessary to freeze all the characteristics of the specification, implement them in DAB receivers in their present state and bring the system to the market as soon as possible. Module 1 of the World DAB Forum has suggested that the DAB standard should not be "improved" for at least two to three years. During this time, studies should continue with a view to developing: (i) backwards-compatible refinements, as appropriate; (ii) a full-software "virtual" receiver, and (iii) further multimedia applications that the market will require. In this way, multiple receiver generations will be avoided. Such a highly-sophisticated receiver could be ready by no later than 2002.

Some refinements are already underway in the Eureka-147 Consortium to integrate the DAB system with other technologies, such as the Internet, mobile telephony (GSM, UMTS) and GPS. DAB must become interoperable with other technologies and not remain an isolated technology island. Efforts should continue to oversee a convergence between the two key new broadcasting technologies: DVB and DAB. An interesting further development will be to provide for an appropriate return channel in order to allow future interactive applications (e.g. purchasing, transactions, voting, etc). Some additional work will be conducted on the conditional access and the transactional models used with these developments.

Multimedia Object Transfer Protocol (MOT)

Using MOT in DAB, it is possible to implement a wide range of different multimedia user applications. These applications will no doubt boost the attractiveness of DAB from the beginning of the commercial phase. The principal MOT user applications are:

- asynchronous slide show;
- timed slide show;
- broadcast website;
- traffic information slide show:
- interactive news service;
- video clips;
- differential GPS service.

Virtual machine (VM)

In order to realize the data-service applications independently from the native programming environment of the hardware platform, a "Virtual Machine" (VM) for executing the applications will be specified. A new application could be broadcast and executed by the data terminal after reception of the VM. Expected services using VM are:

- electronic programme guides (EPGs);
- dynamic content (e.g. stock exchange, slide shows via the broadcaster's website);
- new programme presentations (e.g. service label, etc.);
- intelligent transport services (such as traffic information, departure times, etc.);
- new human-machine interface (HMI) solutions;
- advertising;
- games;
- software updates (e.g. new audio decoder schemes).

Software receiver

RadioScape (UK) has implemented in software the entire DAB chain, on both the transmission and receiver sides. On the receiver side, the software covers all the signal processing, channel decoding and source decoding required of a DAB receiver. RadioScape has built up a large database of digital signal processing (DSP) libraries, routines and metrics. The code is first implemented as a mathematical model, which is transferred into C++ and finally into architecture-specific code.

Transport Protocol Experts Group (TPEG)

Now recognized as a very robust delivery system – with increasing coverage and availability across Europe – DAB is likely to become a major carrier of traffic, travel, tourism and telematics services in the future [13]. The European market forecast for advanced traveller information services, such as in-car navigation and traffic information, is estimated at €26bn per annum. To this end, DAB-based ITS services are being promoted extensively by ERTICO [2] and will be instrumental in the creation of the DIAMOND [3] project, to be co-funded by the 5th Framework of the European Union's Information Society Technologies (IST) programme.

Traffic information is at present being conveyed to the general public by using RDS-TMC (Traffic Message Channel). Many EBU broadcasters have developed an infrastructure to broadcast it, many road traffic data centres have been established and some TMC decoders are starting to appear on the market. In order to protect all these investments, the DAB system has recently been adjusted to be able to carry TMC. Later, it will be able to carry efficiently the entirely new protocol denoted "TPEG". During a certain transition period, both TMC and TPEG will be carried in parallel by DAB.

2. Intelligent Transport Systems – Europe
   http://www.ertico.com
3. Delivery of ITS Applications with Multimedia Over Networks using DAB.

TPEG is a new protocol for traffic and travel information, for use in the multimedia broadcasting environment [14], and is being developed by EBU Project Group B/TPEG. It is a byte-oriented stream format which may be carried on almost any digital bearer with an appropriate adaptation layer. An adaptation layer for DAB is under development. The BBC performed a demonstration of TPEG to WorldDAB Module 1 in London during March 1999.

The TPEG Road Traffic Message application supports a wide range of receiver types, from sophisticated agent receivers (to serve navigation systems), through to simple receivers only able to decode "top-level" information. Some of the possibilities include digital map-based receivers, GPS receivers without digital maps, and receivers without either GPS or digital maps. Road traffic messages may be presented to the user in many different ways, including text, synthesized speech and graphically, or they may be used in route calculations.

New emerging technologies

Digital radio services will be available to the user through different digital delivery mechanisms. Some of those are now briefly described.

Digital Radio Mondiale (DRM)

Probably one of the most promising new technologies to carry sound radio services is DRM [15]. This technology is designed to complement and indeed replace analogue radio services in today's AM bands below 30 MHz (i.e. long wave, medium wave and short wave). Due to the propagation conditions in these bands, the DRM system will be particularly suitable for international and national broadcasting. Digital technology is expected to improve significantly the audio quality and service ruggedness, compared with the present analogue services.

The DRM system is being developed within the DRM Consortium. The aim is to agree on a single world-wide system for "Digital AM". At the time of writing, the DRM system specification has not yet been completed. However, an agreement has been reached to use a multi-carrier OFDM system, multi-level coding and multi-modes. Two system proposals are currently being considered: Thomcast and Deutsche Telekom. The audio coding is likely to be based on the MPEG-4 [16] Advanced Audio Coding (AAC) scheme.

The DRM system, when fully developed and tested in both the laboratory and the field, will become a useful complement to the DAB system which is used on VHF and L-Band. Both systems target different markets and both will be needed. The DRM system will require a new digital receiver design. However, due to similarities with DAB, it should be possible to develop a common DAB/DRM receiver, should the market require it. Later, it may even be viable to develop common DAB/DRM integrated circuits. The advantages – from the user point of view – of such a common receiver/chip are evident. The user does not mind about the technology used; he/she is only interested in the services received, and the cost. In designing the Service Information (SI) and data broadcasting features, it would be advantageous for DRM to use those already standardized in DAB, as appropriate. Similar or identical SI would simplify the production of radio programmes for DAB and DRM, and would enhance the interoperability of the two systems.

DVB-T as the radio carrier

DVB-T is a new digital television broadcasting system [17], developed for terrestrial broadcasting. Recent studies have shown that DVB-T can be used, under certain conditions, not just for stationary and portable reception but also for mobile reception. Consequently, some broadcasters consider DVB-T as a possible carrier of digital radio services, thus avoiding the need to develop separate infrastructure for DAB. The EBU Technical Committee has agreed [18] that Radio is a specific medium with its own characteristics and that it is vital for Radio to be able to develop its own digital platform and not be relegated as an "add-on" service within other platforms. The conclusions that have been adopted by the EBU are given in *Panel 1*.

Panel 1
EBU statement on DAB and DVB

DAB and DVB are two different, yet complementary, broadcasting systems that have been designed for different objectives and different markets. In many EBU member countries, DAB has been implemented already on a pre-operational or regular operational basis, and DVB-T has already been introduced in a few countries with others expected to follow shortly.

The EBU encourages its members to develop both DAB and DVB-T systems to serve the radio and television communities, respectively. As the technology migrates from analogue to digital, the integrity of the radio medium should be preserved and the expectations of the radio listeners should be met.

The assumption that DVB-T can replace DAB, and that DAB is no longer needed, is not correct and should not be pursued by EBU members. Radio is a mobile and portable medium, and the best technology for it is DAB.

DVB-T can, technically, provide for mobile services, but few broadcasters will be able to implement a low programme-capacity variant of it, initially for the reasons of spectrum scarcity and economics. DVB-T will be able to carry radio services to *stationary* receivers (e.g. using TV set-top antennas), but this activity may represent only a minority market and is not a future-proof solution for the radio medium.

Both systems will be used for the delivery of mobile broadcast interactive multimedia in the future. DAB will be used where mobility is the prime requirement. DVB-T will be used where large data capacity of the forward channel is required.

Efforts should be made to bring the DAB and DVB technologies closer together in terms of common system features, data protocols and service information (SI), in order to facilitate production, distribution and broadcasting, using both technologies.

Internet Radio

The Internet is an increasingly popular means of conveying audio, in particular music, to PC-equipped members of the general public. Although internet audio streaming is in its infancy, there are signs of big interest in it among public broadcasters. Practically all EBU broadcasting organizations have their own website. In total more than 6000 stations are present on the Internet. Many (some 1000) are offering audio streaming. However, at the moment, this activity is not cheap. In Germany, the cost of a 16 kbit/s stream (i.e. *per listener*) is about 1.2 DM an hour. Large broadcasters are investing heavily in the Internet since they consider it a powerful medium. For example, the BBC invested more than £20m on its public-service internet activities during its 1998-99 financial year.

At the present level of development, a major drawback of Internet Radio is its relatively poor and inconsistent sound quality, and the fact that only a very limited number of listeners, typically no more than 1000 to 2000, can listen to a given radio programme simultaneously [4]. The Internet is not a mobile medium, which is an important issue as a lot of radio listening is done

4. Compared to the millions of simultaneous listeners on FM/AM, Internet Radio hardly deserves the term "broadcasting".

on the move. Several audio compression schemes are used on the Internet; perhaps the most popular scheme is MPEG Layer III, now known as MP3.

In addition to audio streaming – which allows for real-time listening to news and music at low quality – the audio-on-demand business is flourishing. By this means, a music track coded in MP3 is downloaded via a PC and recorded on a small and light portable recorder called Diamond Rio PMP300 which contains a solid-state memory chip. You can carry this device around with you, rather like a mini "walkman".

Synergy with GSM, UMTS

The Universal Mobile Telecommunication Service (UMTS) is the third-generation mobile telecommunications service. It is a successor to the GSM system which already has 30 million users in over 100 countries. UMTS will offer new services to mobile users, such as high-speed internet access, mobile video-phones and fast data file transfer to and from portable computers and personal digital assistants (PDAs). These services will be enabled by a transmission capacity ranging from a basic rate of 144 kbit/s to primary rate ISDN at 2 Mbit/s. In the early days of UMTS, however, a capacity in excess of 384 kbit/s is unlikely.

UMTS may have a significant impact on broadcast services. For example, it will be able to provide world-wide "dial-in" access to radio and television services. The UMTS Forum sees great potential for co-operation and synergies with DAB, as shown in *Panel 2*.

Panel 2
UMTS statement on DAB

Co-operation with broadcasting companies could to some extent change the technical prerequisites for wideband communications. Such co-operation could, for instance, include the use of high-power Digital Audio Broadcasting (DAB) transmitters as part of the overall UMTS service with the possibility of providing high-speed downlink data services in certain areas. This potential need for asymmetry in terms of high data-rates on the downlink has already been identified in other UMTS studies. Another possibility would be Digital Video Broadcasting (DVB), also called digital TV, currently discussed in many countries.

A similar possible development is that mobile UMTS operators could adopt the DAB technology for broadcasting-/narrowcasting-type services, possibly even in the 800 MHz band. The realism of this development is difficult to assess at the present stage. However, in general there has been separation between the regulatory environments for broadcasting and mobile telecommunications and there is therefore a need for interaction between the regulatory regimes to be carefully considered. The regulation of broadcasting content should be kept separate from the regulation of transmission in order to enable such an interaction.

The EBU is in the process of assessing the potential of the DAB/UMTS synergy for mobile multimedia services. An interesting possibility would be to investigate the concept of combined DAB/UMTS user terminals. This may well provide a means for UMTS to subsidize the cost of the combined terminal which will already include a display, an HMI and audio/video output, thus providing an economy of scale.

New attractive programmes

DAB will help to increase the programme choice significantly. As in digital television, "digital" is becoming a synonym for thematic, specialized and niche programmes. DAB will also offer tremendous possibilities for creative people to explore new challenges in Radio. There seem to be two paths of exploration: firstly, by adding a visual component to the primary

component which remains audio and, secondly, by providing new interactive forms of programmes. Content providers have often been criticized that they lack imagination in producing new attractive radio programmes that would encourage people to subscribe to new services, and to buy new DAB receivers. This should all change with the advent of DAB.

The World DAB Forum has recently decided to form a new Module 5 to bring together all creative ideas on DAB programming, and it held its first workshop in Baden Baden, Germany, on 11 March 1999. Although some receivers will be sold on the basis of DAB's robust reception and excellent sound quality, the most important and powerful sales tool will be the better content and more imaginative programmes which will be broadcast on DAB. Many broadcasters and content providers are already carrying out experimental productions of multimedia applications which are targeted at their particular markets. Module 5 intends to hold more workshops in mid-1999, during which creative programming ideas will be exchanged amongst members of the World DAB Forum.

Regulatory aspects

The regulatory aspects of DAB are perhaps the most important area but are also the most complex. Regulatory aspects are a matter of national concern and, therefore, they normally reflect the national political, cultural, economic and legal environment of a country. It is certain that digital radio needs some political support from national governments but it would be advantageous to receive some guidance from the European institutions as well. Digital radio cannot roll out merely as commercial merchandise. Radio needs agreed and stable regulatory arrangements in order to exploit fully the opportunities of digital technology. These arrangements should be able to offer fair and equitable opportunities to all the players involved. Disparities between certain aspects of market entry, licensing and operating conditions between various countries, should be minimized. Across Europe there are some examples of valuable experiences that can be shared and used as common best-practice recommendations.

In the UK, the first commercial franchise for digital radio was awarded last autumn. The licensing process for commercial radio in the UK combines two types of licences: one for "digital sound programme services" and one for "the multiplex". For the purpose of this status overview, this distinction is not made here since it does not affect the conclusions on aspects such as coverage and network build-up.

The basic policy of the UK Radio Authority is to invite applicants to submit proposals which detail the numbers and types of services, numbers of sites and transmitters, the bit-rate allocations, roll-out plans, etc. When submitted, these proposals – if accepted – become part of either the mandatory licence conditions (e.g. the number of services) or the indicative provisions (such as the network roll-out timetable beyond the launch). In view of the infancy of digital radio, and allowing for new developments, the Radio Authority claims to be open to consider revisions of the mandatory conditions. The application fee for the national multiplex was £50,000 and the Radio Authority is charging an annual licence fee of £10,000. By taking up broadcasting licences on the national commercial multiplex, the existing three national commercial radio stations have received an automatic extension of their analogue licences for a further eight years.

As the multiplex is peculiar to digital broadcasting, one of the critical questions is how it is organized and who is responsible for its operations. One possibility is that the multiplex operator becomes a new licensed entity, as in the UK commercial sector. Another possibility is

applied in Italy where the multiplex operator will not be licensed; the licences will be only given to content providers who will form a kind of multiplex consortium.

Another regulatory matter which has been the subject of hot debate recently is the proportion of the multiplex allowed to be allocated to non-audio (data) applications. The current regulatory arrangements in the UK allow 20% of the multiplex to be used for non-audio data applications, but regulations in other countries may be different. Many countries encourage the broadcasting of a variety of data applications in order to make DAB different from FM, and to attract new audiences and data service providers to launch different business applications.

The European Commission, in particular DG X, has been very supportive to the radio community and has organized two workshops. The most recent one titled "Principles for the implementation of Digital Radio" was held on 5 March 1999 in Brussels and drew up the following set of principles:

- recognition of radio's specificity;
- need for more frequencies;
- need for a co-ordinated switch-off strategy for FM radio;
- encouraging co-operation between public and private broadcasters;
- affordable prices for DAB receivers;
- need for a legal framework in European countries;
- more political and institutional support.

The European Commission has introduced digital radio in its 1999 Work Plan. The Commission is planning to prepare a Communication to the European Parliament and the Council. The purpose of this Communication is to trace Radio's forthcoming transition to digital, to identify possible barriers and recommend possible ways of overcoming them. Thanks to significant efforts carried out by the World DAB Forum, the Commission recognized that (a) Radio has its own cultural identity and is a particularly important issue for consideration, and (b) Radio will be addressed in a separate Communication, in a very distinguished manner.

Frequency spectrum

The lack of frequency spectrum available for DAB is perceived as a major barrier. The DAB system is a terrestrial broadcasting system and it requires a dedicated spectrum range. Depending on the network scenario and the frequency band used, DAB is three to ten times more spectrum-efficient than FM. Frequencies *are* available for the startup of DAB simulcast services in parts of the VHF band and L-Band (i.e. from 176 to 230 MHz and from 1452 to 1467.5 MHz).

According to the international frequency plan established for CEPT countries at Wiesbaden in 1995, each country has obtained at least one frequency block (ensemble) for nation-wide coverage. In many cases, this provision is not sufficient to accommodate all the existing radio services which use analogue technology in the FM and AM bands and thereby allow them to migrate to digital. In particular, there is a lack of frequencies available for small local radio stations. This constitutes a significant barrier to business development. It is very important that there is enough spectrum for both the public and commercial sector as the audience is often different.

In December 1998, the European Commission published a Green Paper on spectrum issues and invited interested parties to contribute their comments on whether the present political and legal base, as well as the practical implementation of Community radio spectrum policy, requires adaptation in the light of technological, market and regulatory developments.

The World DAB Forum, in their response, emphasized that the spectrum resource, which is finite, should be shared among different radiocommunication services in such a manner as to maximize the public benefits and interests. Sufficient spectrum should be allocated to those services that offer the greatest good to the greatest number of people. Digital radio is such a service: it will satisfy public interests in terms of promoting cultural values for national, regional and local communities, serving the specific interests of minorities (largely ignored by other media), providing news, information, education, knowledge and entertainment. Digital radio will ensure the availability of free-to-air services to all citizens at all times.

Although international co-ordination through the EC, ITU and CEPT is needed, the ultimate decision about all spectrum allocation issues should be left to the discretion of the administrations of the different states. They are best placed to decide on their spectrum needs in the light of national circumstances, providing these principles comply with international market and competition objectives.

Recently, economic efficiency and the cost of spectrum has been invoked in CEPT circles as a possible criterion for spectrum allocation. It is difficult to compare directly telephone services and broadcasting services. It may well be that, in some cases, the economic viability of phone services may be greater. But the nature of these personal (one-to-one) services is fundamentally different to broadcasting services which provide services to many millions of people at all times.

For WorldDAB, the public interest is in part secured by a mix of commercial and non-commercial players in the market. Beyond this, for the industry as a whole, we see merit in DAB being judged against a set of criteria which value the economic worth of spectrum. These would include the creation of new services and employment, technological innovation and European competitiveness, production of consumer electronic products as well as economic growth.

While spectrum auctioning may be suitable for telecom services, charging for the spectrum needed to sustain existing broadcasting services or to develop new DAB services would be highly counter-productive. It could stifle the introduction of new broadcasting technologies, such as DAB and DVB.

It is now essential that spectrum is made available for a broad implementation of DAB. Radio services which are currently broadcast in analogue also need to be simulcast on DAB. These include the existing public and commercial AM and FM broadcasters that are operating national, regional, local and community services. There must also be provision for satisfying the need for new radio programmes – produced by both existing and new broadcasters – which cannot be accommodated on AM or FM today, because of the lack of spare frequencies in these bands. There must also be appropriate allocations for new data and multimedia services. These are essential to stimulate the sale of new receivers and to create opportunities for new revenue streams for broadcasters.

Switch-off time table

It is recognized that it is difficult to set a date that is common to all European countries for the analogue switch off. However, it is necessary to elaborate a common strategy for a relatively

quick and smooth approach to digital radio implementation. An early announcement by administrations about the timetable for ending simulcasting seems an essential measure to support the shift to digital technology, allowing a more efficient use of broadcasting spectrum in the longer term.

Germany has set an example, having fixed the year 2003 for the publication of the timetable for the replacement of FM by digital radio. The French "Radio Numerique DAB" believes that this date is well chosen and would allow the formulation of relevant decisions at the European level.

The concept of analogue switch-off should be studied in detail but it seems to be beneficial for everybody:

- **Broadcasters** would reduce the cost of transmission which is almost doubled due to simulcasting;
- Provided that the majority of FM stations would be able to migrate to the DAB bands, **administrations** would be able to use parts of the current FM band for other services;
- **Customers** and **users** would be encouraged to buy new digital radios (assuming reasonable prices for DAB radios);
- **Manufacturers** would sell more DAB radios and the prices would come down further. Rather than combined FM/DAB receivers, DAB-only receivers could be manufactured, leading to a further, albeit slight, reduction in the cost of receivers.

Suitability of L-band for DAB

At WARC 92 in Torremolinos, Spain, the band 1452 to 1492 MHz (i.e. L-Band) was allocated to digital sound broadcasting (satellite and complementary terrestrial). This band can accommodate 23 DAB blocks. However, in many countries, parts of this band cannot be used before 2007 due to its current use by other radiocommunication services, such as fixed point-to-point services. The lower part of this band (i.e. nine blocks occupying about 13.5 MHz) was planned by the 1995 CEPT Planning Meeting in Wiesbaden. There is already an initiative by CEPT to plan an additional seven blocks for terrestrial DAB services. The World DAB Forum has expressed its position that, due to the current shortage of spectrum used for local, commercial and community services, all the available blocks in L-Band should be used for terrestrial DAB. It is pointless to reserve spectrum for future *satellite* DAB services since there is little or no commercial interest in pan-European DAB services over the foreseeable future. It should be pointed out that, for large-area coverage using a Single Frequency Network (SFN), VHF is more appropriate than L-Band. The latter seems to be technically more suitable for small-coverage zones, e.g. for small local and community broadcasters.

Suitability for small local broadcasters

"Community" broadcasters, operating small low-power FM or AM stations, are numerous in many countries. They can be found in a variety of different localities and they serve different purposes; for example, a student station covering a campus, or a small station covering a village, etc. In many countries, such small stations are becoming increasingly popular among certain categories of listeners; they represent a low-cost solution to providing news and information of local interest.

It is important for these small broadcasters that they have the same opportunities to migrate to digital radio as any other broadcaster. A fundamental requirement for them is that the same DAB system is used for their transmissions and that the users are able to use commonly-available DAB receivers. However, it should be realized that community radio stations have some specific requirements, such as an independent location, small coverage area and low installation costs.

Although the Eureka-147 DAB system has been designed and optimized to carry a multiplex of several radio services, it can in principle carry only one stereophonic service. It would be sensible, where geographically possible, to use a dedicated ensemble for a stereo service, with the highest possible audio bit-rate (i.e. 384 kbit/s) and protection level (1/3). This configuration would allow high audio quality and low transmitter power, thus minimizing the installation costs. It would also allow us to shape the coverage of the multiplex, as required by the market. The remaining data capacity in the multiplex could be devoted to data or multimedia services as appropriate, and/or shared with other national/regional/local services. In the latter case, agreement should be reached about an acceptable coverage area, among all the service providers sharing the same multiplex.

EBU Project Group B/DAC has investigated the possibility of using DAB in a TDMA mode to allow for local opt-out services. The group found that such a solution is probably technically possible (subject to the successful resolution of transmitter filtering and synchronization in the receiver) but would be operationally complex, with reduced coverage (mush areas) and reduced bit capacity. Therefore such a solution could not be recommended for DAB community services.

As a trivial solution, these community services could remain on FM for a sufficiently long time (until the switch-off deadline) or, if part of the 87.5 - 108 MHz band continued to be available for broadcasting, they could stay there indefinately.

Current DAB services in major European countries

In order to illustrate the situation concerning DAB in Europe, it may be instructive to give examples of actual services and regulatory arrangements in three major European countries; France, Germany and the UK. However, it should be noted that the situation is evolving rapidly and this brief overview could rapidly become out of date.

A complete updated review of DAB services world-wide is given at:

http://www.worlddab.org

France

Three multiplexes were licensed in the Paris region in 1996. Coverage there today reaches about 10 million people who can receive 19 regular programmes. Further licences were granted in October 1998 and April 1999, for the cities of Lyon, Marseilles, Nantes and Toulouse (three multiplexes in each city). The multiplexes that were licensed in October 1998 commenced very shortly afterwards in November 1998.

Further DAB licences to be announced in 1999 will cover another five major cities and 14 medium-size cities, and will provide for coverage along major highways. The number of peo-

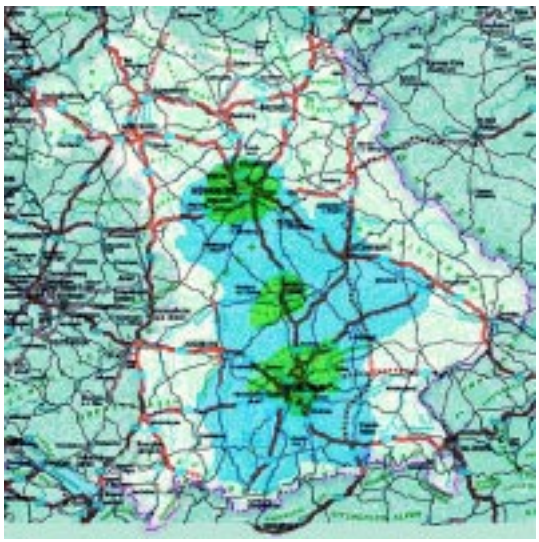

Figure 5
Projected DAB coverage in Grenoble, France, and Bavaria, Germany.

ple reached by the end of 1999 will be 25 million. The number of services provided will be 19 in Paris, 17 in Lyon, 22 in Marseilles, 20 in Nantes and 20 in Toulouse.

The projected DAB coverage in the Grenoble area is shown in *Fig. 5*.

Germany

One obstacle in rolling out DAB in Europe, and one often quoted by receiver manufacturers, is the situation in Germany – by far the biggest consumer electronics market in Europe. The position appears to be unclear because there is still no formal commitment from German public broadcasters to introduce DAB, and commercial broadcasters seem to be concerned by the lack of funds and frequencies. But in fact, the situation in Germany is very encouraging.

In August 1998, the German Cabinet took important decisions on the migration from analogue to digital broadcasting; it adopted DAB as the official standard for digital radio in Germany. It has now set up a clear licensing process for DAB. In April 1999, Saxony Anhalt was the first German Länder to launch regular digital radio services; it launched its DAB services with an initial coverage area of more than 95%. Then, on 10 May 1999, operational digital radio services started in Bavaria, Germany's largest Länder. DAB frequencies have also been assigned to other Länder, including Brandenburg, Saxony and Thuringia.

Within five years there will be 90% DAB coverage of Germany and the plan is to increase this figure to 95% within eight years. In Bavaria, with 22 programme slots available to commercial broadcasters, the Bavarian media authority received over 50 applications. In other Länder, the demand for digital transmission capacities has been similar – broadcasters want to go digital.

The projected DAB coverage in the Munich area is shown in *Fig. 5*.

The United Kingdom

BBC Digital Radio started in 1995 and had reached 60% of the population by the end of 1998. Currently, BBC Digital Radio offers five national and various regional and local radio services. Subject to approval, it hope to offer a further four services in the near future.

On 12 October 1998, the first national commercial DAB multiplex was licensed to the Digital One consortium. They will start services – based on 69% population coverage – in October 1999. Digital One will offer ten programmes (three existing national stations, and seven new ones).

Existing commercial radio stations that bid for a DAB multiplex channel were given a free eight-year extension of their existing FM licences. The UK Radio Authority has now started the licensing process for additional (local and regional) multiplexes at the rate of one per month, and seven such licences are planned to be awarded by the end of 1999 (Birmingham, Manchester, Greater London 1, Glasgow, South Yorkshire, Tyne & Wear and Cardiff / Newport). The number of people expected to be reached by the end of 1999 will be 39 million. The number of services on-air by the end of 1999 will be around 19 national, plus eight or nine regional / local.

The World DAB Forum

The World DAB Forum was established in October 1995 – at the initiative of the EBU – to become a major international facilitator of DAB. It now includes more than 100 members worldwide. It is a collective of private and public broadcasting organizations, data content providers, manufacturers, network pro-

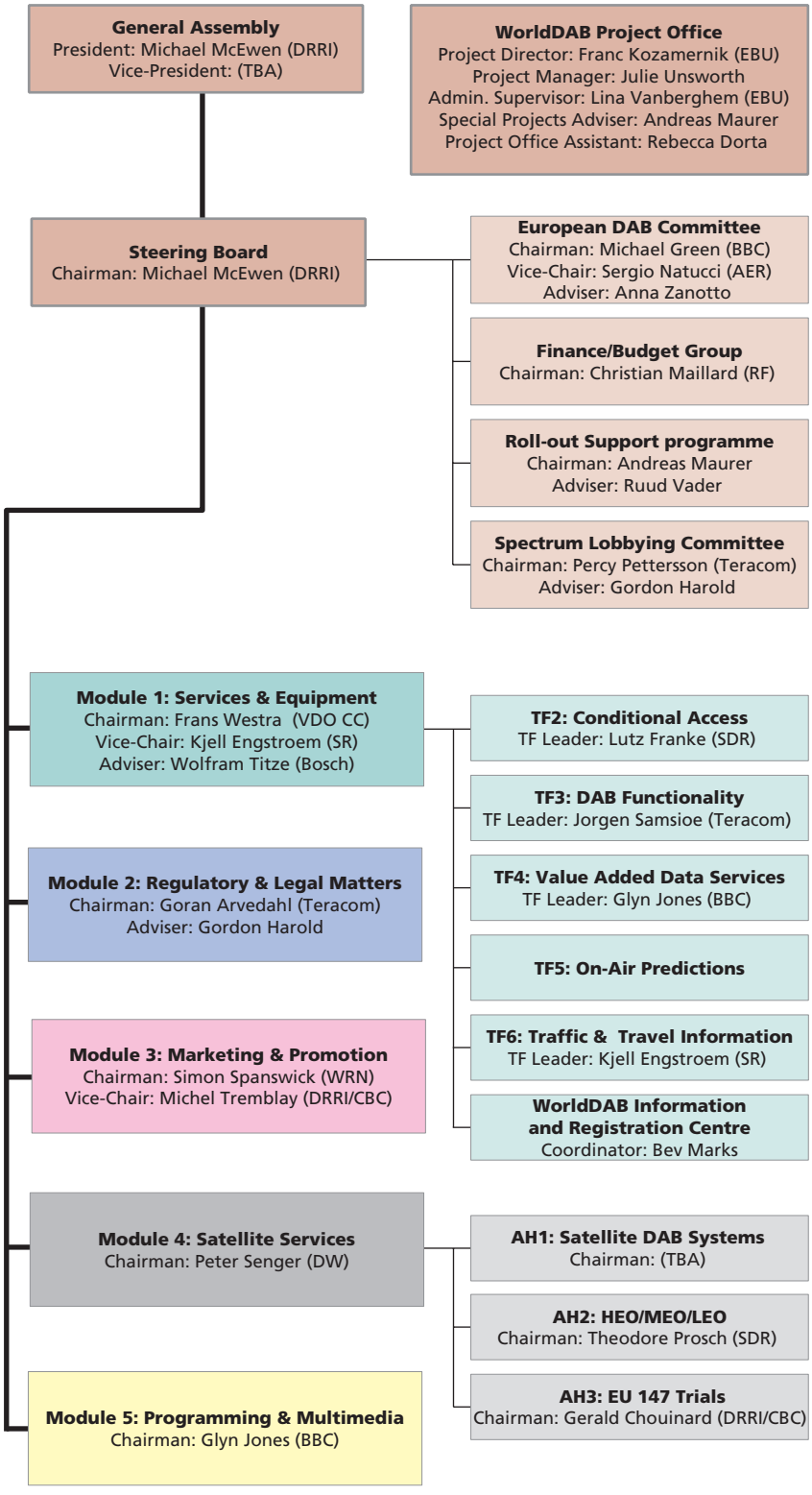

Figure 6
Organigram of the World DAB Forum.

viders, regulators, research institutes and other organizations, with a common interest in developing Digital Audio Broadcasting (DAB) services and introducing them on the consumer market. The Forum is dedicated to encouraging international co-operation in Radio, and to making DAB a world-wide commercial marketing success – to the lasting economic and social benefit of all concerned. The organigram of the World DAB Forum is shown in *Fig. 6.*

The Forum will continue to strive to make the private and public sectors work together in conjunction with the policy makers. Generally, the industry feels that the regulatory framework is acceptable, and the leadership of the public sector is seen as positive. However, the public broadcasters must take on the challenge of involving the private broadcasters in DAB. The example of Digital One in the UK, which will start its commercial services in October 1999, is very encouraging.

It is probably true to say that the international consensus process, which was opted for in the case of DAB, has been very long, perhaps even too long. By way of comparison, the DVB process was significantly shorter. But any such process whose objective is to agree a new broadcasting standard is, by its nature, very complex since it involves many parties, e.g. public and commercial broadcasters, content providers, receiver, transmitter and IC manufacturers, network providers, regulators, research institutes and many others. It takes time to agree on a common approach. The author strongly believes, however, that such a process is, in the long run, the only way to achieve a stable, future-proof, internationally-agreed and market-driven standard.

Conclusions

There is a general consensus among broadcasters that the Eureka-147 technology is the right choice for digital radio. We know that it works well and we are convinced that there are tremendous potential programming and business opportunities offered by DAB. Today, we have a good idea of where these opportunities lie, but one thing that is certain is that different markets will develop very diverse applications. The more imaginative they are, the better the business return for the broadcaster.

What really matters now is to put DAB technology on to the consumer market, and to allow those who have invested huge amounts in the infrastructure to get back a return on their investments as soon as possible. Those who are involved in the production of radio programmes and data services should regard DAB as a potential source of large revenue.

With the market forces starting to develop, the whole process is now unstoppable.

The EU-147 system is future-proof. Future DAB receivers, including the smallest "walkman" type, may use computer processing chips and memories. This will lead to an extremely flexible broadcasting system in which all multimedia applications will be implemented in software. Applications will be down-loadable to the receiver off-air, and could be changed on the fly.

But today, DAB is primarily a modern radio. Its strengths are clarity of sound, mobility, small size and weight and, soon to be, its low cost.

The author believes that, in spite of all the barriers encountered along the way, DAB in Europe has definitely come out of the tunnel. The rest of the world will follow soon.

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