Digital Audio Broadcasting®

DAB progress report – 1997

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August 1997 saw the official launch of consumer DAB equipment at the IFA exhibition in Berlin.

In this article, the Author reviews the world-wide progress of DAB, and offers his personal views on how it should be developed over the years to come. In particular, he suggests that an augmented version of the DAB system should be used to replace the current analogue TV transmissions in Band III with digital multimedia transmissions for Europe, which are equally well received at home or on the move.

1. Introduction

Developments in microelectronics are continuing at a very fast pace (*Fig. 1*). When compared with analogue transmission systems, the costs to set up and operate a digital system – such as Digital Audio Broadcasting (DAB) and Digital Video Broadcasting (DVB) – are becoming substantially less expensive and so, too, are the costs of the receiving equipment. Analogue transmission systems will thus progressively retreat to the background, while digital systems will flourish.

The Eureka-147 DAB system [1] offers many advantages over the existing FM analogue radio system:

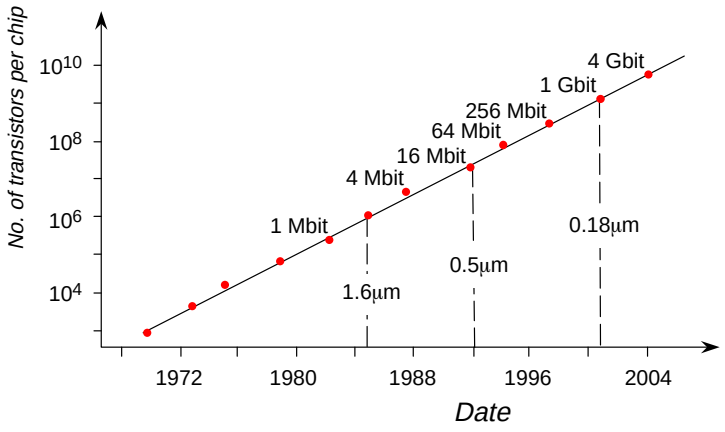

Figure 1
Developments in chip structures, 1970 – 2004
(courtesy of DAB Plattform e.V.).

- the receiving equipment will be less expensive and smaller;
- the sound quality is superior;
- the reception quality is very stable, particularly in mobile environments;
- simple programme-selection tools are provided that are very convenient to operate;
- services can contain a mixture of audio programmes and information (data) services, transmitted at different data-rates.
- more efficient use is made of the frequency spectrum by multiplexing several audio/data services within a single transmission channel, and through the use of single-frequency networks (SFNs);

– less transmission power is required to cover a given area, leading to substantially lower capital investment and running costs.

The Eureka-147 DAB system has passed all the technical tests carried out on it so far, and is internationally standardized. It has put its features to the test in a great number of field trials, specifically for mobile reception. Among all the digital transmission systems already in use or announced (e.g. DSR, ADR), it is DAB alone which is able to reach *all* the receivers within a service area (for stationary, portable *and* mobile reception). In addition to conventional radio programming, DAB offers a very stable platform for new data services such as updates to the navigation systems used in vehicles, up-to-date information on stock exchange prices, etc. Furthermore, it is now possible to transmit high-quality moving images via DAB, to the viewer at home or in a fast-moving vehicle.

Abbreviations

ACTS	Advanced Communications Technologies and Services
ADR	Astra digital radio
CEMA	Consumer and Electronics Manufacturers Association (USA)
DMB	Digital multimedia broadcasting
DRC	Dynamic range control
DSR	Digital satellite radio
GSM	Global system for mobile communications
FCC	Federal Communications Commission (USA)
HTML	Hyper-text markup language
ISO	International Organization for Standardization
M/S	Mono/stereo
MEMO	(ACTS) Multimedia Environment for Mobiles
MOT	Multimedia object transfer
MPEG	(ISO) Moving Picture Experts Group
NAB	National Association of Broadcasters (USA)
PAD	Programme-associated data
PTY	Programme type
QAM	Quadradure amplitude modulation
QPSK	Quadrature (quaternary) phase-shift keying
SFN	Single-frequency network

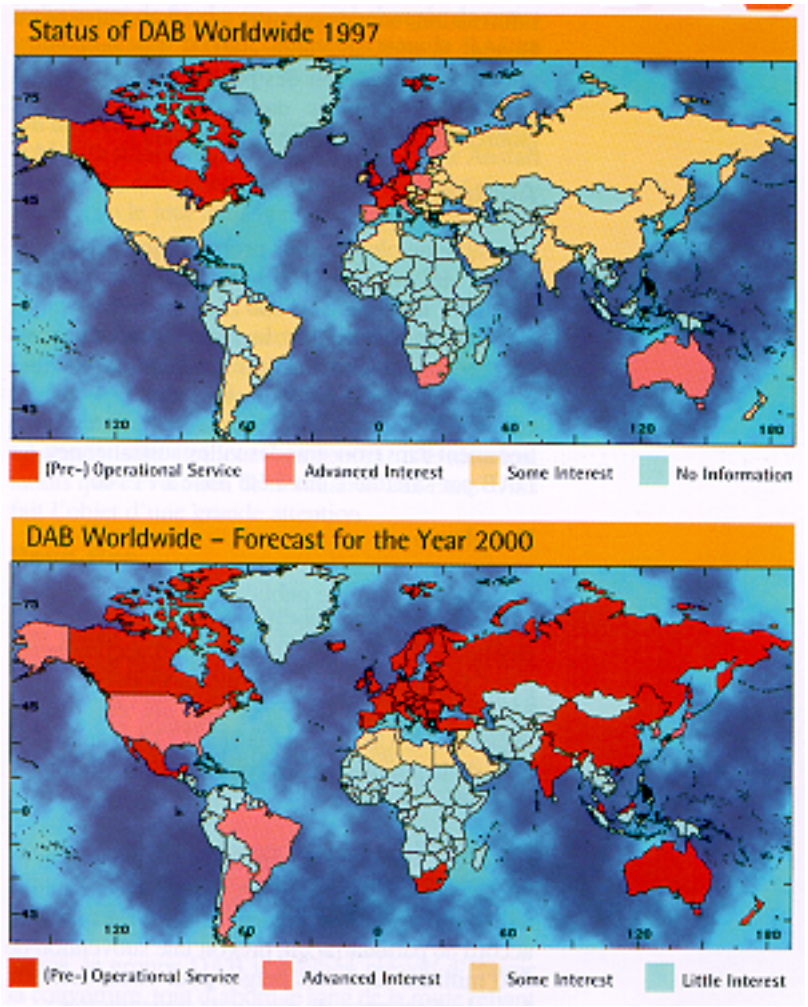

Figure 2
World-wide status of DAB in 1997 and the year 2000 *(from the "BBC Guide to Digital Radio", courtesy of the BBC).*

2. DAB progress report

At the *Internationale Funkausstellung* (IFA 97) exhibition in Berlin during late August, the European consumer equipment industry presented a great multitude of DAB chipsets and equipment for mobile and stationary DAB reception; these units will be commercially available by the end of 1997 or in spring/early summer of 1998. PC cards are already available for receiving and processing DAB data services on a personal computer.

DAB-related activities are going on in many European and non-European countries. Transmitter network structures are being established and DAB services are being prepared. With more than a dozen countries active, it means that in Europe alone we are on target to bring DAB to within reach of 100 million people by the end of 1997. As shown in *Fig. 2*, take-up of the DAB system by the year 2000 will be almost global in the developed world – with the obvious exception of the USA (more about that later).

The remainder of this section presents a country-by-country report on the world-wide progress of DAB, courtesy of the WorldDab Forum (August 1997). *Table 1*, at the end of the section, shows the country-by-country distribution of DAB audio programmes and data services (also courtesy of the WorldDab Forum, August 1997).

Australia

It is looking increasingly likely that the Eureka-147 DAB system will be adopted in Australia. Last year, the Government-appointed *Digital Radio Advisory Committee* expressed support for Eureka-147 as the appropriate delivery system for Australia. Pilot services are operating in three major Australian cities. Tests have also been carried out with satellite-delivered DAB.

Belgium

BRTN, the public broadcasting company for the Flemish community in Belgium, has bought 14 DAB transmitters and associated equipment. Operational services with 11 transmitters started on 12 September 1997. An SFN operating on channel 12A covers 80% of the population; full coverage will be reached in 1998.

RTBF, the public broadcaster for the French-speaking population, has signed a partnership agreement with the Walloon Ministry of Equipment and Transport, under which the Ministry will contribute 160m Belgian francs towards the start-up costs of the transmission network.

Canada

Canada has remained at the forefront of Eureka-147 developments and, in November 1996, commercial radio and CBC announced their plans for initial DAB services. A group of Toronto commercial broadcasters will establish full-time transmitters on Toronto's CN Tower in late 1997 to carry the programming of 15 radio stations. At the same time, CBC announced that it would bring DAB to 75% of the population over the next five years, starting in late 1997 in the Toronto and Montreal areas.

China

China has been assessing digital radio for some time and announced in December 1996 the inauguration of a three-station Eureka-147 network in Guangdong Province, the area near Hong Kong which is growing both industrially and economically. The three sites are at Foshan, Guangzhou (formerly known as Canton) and Zhongshan, and are transmitting a single ensemble of up to seven audio programmes on 85 MHz. The project is the result of a co-operative agreement between the European Commission and China. Some idea of its significance can be gathered from the official Chinese news agency's description of DAB: it described the start of DAB transmissions as *"a watershed in the development of China's radio broadcasting system"*.

Denmark

Denmark is committed to the introduction of DAB, and the transmitter network is progressively being built up. In the first few months of 1997, under a project set up by Danish Radio with government support, 500 test receivers manufactured by Bang & Olufsen were distributed to consumers for market research purposes. While the receiver itself has a large graphic display, the normal remote unit has been replaced by an Apple Newton Message Pad which can be used to access information and to carry out control functions.

Finland

In Finland, DAB frequency blocks for national and regional networks have been agreed. The public broadcaster, YLE, will build up the transmitter network and rent the facilities and channels to private broadcasters. There were 32 applications for national and regional DAB licences when the deadline was reached in February 1997.

France

In France there has been a new spurt of interest in DAB with the decision to license three multiplexes in the greater Paris area for a period of five years. A fourth one may be added. With Band III already taken up by other services, these three multiplexes are in the L Band. Among the groups involved are Radio France, the commercial stations RTL and Europe 1, and the transmission provider, TDF. A pilot project during the Paris Motor Show in October 1996 received the accolade of the French President; *"le DAB, c'est formi**dab**le"*. One could hardly ask for a better marketing slogan!

Germany

Germany is an important country for the success of DAB because of the size of its potential market. The first pilots started in 1995, and now pilot services are running in 10 of the Federal states (Länder). Typically these involve both private and public broadcasters; they are in both Band III (for SFNs over large areas) and L Band (within

cities); they provide various audio and data services, and they are accompanied by associated market research programmes.

Some 120 audio services are currently being transmitted in Germany of which 30 are unique to DAB. In addition there are more than 50 data services. Approximately 37% of the population (around 30 million people) will be covered by late 1997. Network operators estimate that they could cover 80 to 90% of the population by the end of the year 2000.

Hungary

The public Hungarian broadcaster, Magyar Radio, started experimental DAB transmissions in Budapest on 1 December 1995 on its 70th anniversary. A 250 W transmitter operating in Channel 13A is used. The multiplex contains three main domestic programmes and one special high-quality programme: it is within reach of three million people. In the near future, some data services will be included and a second transmitter will be installed.

India

India is another vast nation which is looking to Eureka-147 DAB as the future of radio. The public broadcaster, All India Radio, started preliminary studies and experiments some time ago and set up a test transmission system in Delhi. Over the past year or so, work has been oriented towards DAB service planning, satellite distribution of a DAB ensemble and its re-transmission by local relay transmitters in major cities.

Israel

Bezeq, the Israeli Telecommunications Corporation, has been piloting DAB transmissions since 1996, using Band III. There are currently two transmitters, covering about 70% of the population, and a third one is being planned. Bezeq sponsored an international conference in Tel Aviv in May 1997 to communicate the benefits of DAB to governmental and business organizations.

Italy

The Italian Parliament recently approved a new Telecommunications / Broadcasting law which, among other things, provides the basic regulatory framework for the introduction of DAB.

Licences will be given out freely during a ten-year period, in order to promote the development of DAB. The public broadcaster, RAI, which has been carrying out DAB test transmissions for several years, is to provide 172 transmitters by 1999, reaching some 60% of the population. The main private broadcasters, after forming the Club DAB Italia, have set up a corporation to build up the private network, and are collaborating with RAI on delivery and research.

A new pilot, which will ultimately involve seven transmitters, has started in the Alto Adige region (Aosta Valley) as a joint venture between RAI and the regional station RAS (Rundfunk Anstalt Suedtirol).

Japan

No decision has yet been taken by the Japanese Ministry of Posts and Telecommunications on which digital radio system to adopt – either Eureka-147 (favoured by manufacturers) or an NHK in-band alternative. Evaluation of these two systems is continuing, with an “eagle eye” being kept on what may happen in the USA.

The Netherlands

A single national multiplex, operated by the Dutch DAB Pilot Association, is reaching 45% of the population via three transmitters. It carries eight audio channels plus a 24-hour datacast of news, weather, stock market information etc.

Norway

Three transmitters cover the Oslo area, reaching about 32% of the Norwegian population of 4.2 million. The government is expected to announce the future policy framework for DAB by the end of 1997. In the meantime, the Norwegian DAB Group plans further coverage, first along the road between Oslo and Trondheim, and then along the coast from Oslo to Bergen, thus reaching 60% of the population by the end of 1998.

Poland

In April 1996, Polish Radio started transmitting four audio programmes in the Warsaw area. 8% of the population is covered.

Portugal

The Portuguese government and the Portuguese Communications Institute have finally given the management of DAB in their country to Portuguese National Radio (RDP). In 1998, RDP will start to install transmitters to carry the 6 national radio services (3 commercial and 3 governmental)

on a single national frequency. By the time of Expo '98 in Lisbon (May – September 1998), visitors to the exhibition should be able to listen to DAB in kiosks. After the year 2000, local and regional radio stations may start up DAB services.

Singapore

DAB was demonstrated at Asia Telecom 97 by the Singapore Broadcasting Authority in association with Deutsche Telekom. Regular services in L Band and on VHF will start in October 1997.

Slovenia

The public broadcaster, RTV SLO, will carry out experimental transmissions from October 1997 to cover the capital city of Ljubljana (300 000 inhabitants).

South Africa

In South Africa, a seminar on DAB was organized in August 1996 by the South African Broadcasting Corporation and Sentech, the transmission provider. This led to the formation of a South African DAB Association. Sentech plans to set up a test facility in Johannesburg in 1997 to serve as a pilot and development system.

South Korea

Tests and evaluations of the Eureka-147 system have been carried out, and the Ministry of Information and Culture has announced that the system will be adopted in South Korea over the next five years.

Spain

A DAB Association has been formed, involving both private and commercial broadcasters. Test transmissions were due to be set up in Barcelona during mid-1997. Earlier in the year, a successful three-week trial was conducted in and around Pamplona by Cadena SER and Bosch.

Sweden

Swedish Radio and Teracom began DAB transmissions in Stockholm simultaneously with the BBC in September 1995. By the end of 1996, the national ensemble (multiplex) was reaching 45% of the population and the regional services, 35%. A total of 17 transmitters were in use. By early 1998, the national ensemble will reach 75% of the population and the regional services, 55%. There will be both private and public services in the regional ensembles.

The Swedish government recently approved a Swedish Radio project to provide a Finnish language service on DAB from 1 January 1998.

Switzerland

In Switzerland, public and private broadcasters, other content providers and Swiss Telecom (now Swisscom) are co-operating in a number of pilots. In the project "Bernese Oberland", the area is covered by three Band III and twelve L-Band DAB transmitters. About 200 receivers are being supplied to participants from the general public for market research, and more will follow. A further pilot was set up at the end of 1996 in the Basle area, and a special DAB service was provided during the Geneva Motor Show in March 1997.

United Kingdom

The Government set up the framework for the development of DAB in the UK in the 1996 Broadcasting Act.

The BBC began an operational DAB service in September 1995 in the Greater London area and is now building up its transmitter network so that 60% of the UK population will be covered by mid-1998. It has carried out extensive trials to gather experience prior to the introduction of new DAB services.

The regulatory body for commercial radio, the Radio Authority, has announced a "fast burn" approach to the licensing of private radio multiplexes, both national and local, starting in early 1998. A number of pilots involving private stations are now operating.

USA

While the Eureka-147 system has emerged as clearly superior in laboratory and field tests carried out by CEMA, the NAB opposes the adoption of this system in the USA. Their opposition is based on: lack of new spectrum; dislike of sharing services within a multiplex, and concerns that DAB would introduce new competition. Efforts are being made to develop a more limited in-band digital radio solution, although some experts doubt whether this will ever be effective.

The FCC has recently approved two licences for satellite-delivered digital radio in the S Band. These transmissions will inevitably have limited penetration in cities and will be very poorly received in moving vehicles.

Country	Audio services	Data services	Comments
Australia	Pilot services in three major Australian cities.	–	Terrestrial L-band transmitters. Tests have been carried out with satellite DAB.
Belgium	BRTN: National ensemble with 5 radio networks and a new audio service “DAB Klassik” as well as a message channel for traffic and info. 32–224 kbit/s.	Announcements, PTY and PAD with Dynamic Label. Data services to be decided at 32–64 kbit/s.	14 transmitters in Band III serving 80% of the population. RTBF will build a network with financial contribution from the Walloon Ministry of Equipment and Transport
Canada	Private Broadcasters: 15 services in Toronto, 10 in Montreal and 5 in Vancouver. 128–224 kbit/s. CBC: Toronto, Montreal and Vancouver with 5 audio services. 64–224 kbit/s	PAD is currently being defined. Dynamic Label and MOT will most likely be used. Applications for data channels are being studied.	Toronto: 4 blocks covering 3.9 million people. Montreal: 3 blocks covering 3.3 million. Vancouver: 2 blocks covering 1.7 million. All transmitters in L Band.
China	Test in Guangdong Province with 7 audio programmes in one ensemble in Foshan, Guangzhou and Zhongshan.	–	3 transmitters on 85 MHz.
Denmark	DR: National ensemble with 5–8 audio services and a message channel for traffic and info. 32–256 kbit/s.	Announcements, PTY including language code and PAD with Dynamic Label, MOT and DRC. Data services in 64 kbit/s Packet Mode/MOT. Programme number.	3 transmitters in Band III covering 25% of population. 500 hi-fi DAB receivers manufactured by Bang & Olufsen distributed to consumers for market research.
Finland	YLE: National Ensemble with 4–5 audio services. 128–256 kbit/s.	Not decided	3 transmitters covering 20% of the population.
France	Pilot projects in the Paris region with 3 ensembles. Decision to license 3 ensembles for 5 years. Radio France, RTL, Europe 1 and TDF are involved.	Different tests with PAD and dedicated data channels.	4 transmitters in L Band covering 10 million people, i.e. 17% of the population.
Germany	Extensive pilot projects in Baden-Wuerttemberg, Bavaria, Berlin/Brandenburg, Hesse, North Rhine-West-phalia, Saarland, Saxony, Saxony-Anhalt and Thuringia with some 120 audio services from both public and private broadcasters, of which 30 are unique to DAB.	More than 50 different tests and pilot data transmitters in Band III and L band. Both PAD and dedicated data channels. Many different information and network providers are involved in the different projects.	Covering 50% of the population in the pilot areas, which is 37% of the total German population, i.e. 30 million people. NDR has decided to cover 80–90% of its service area during the next two years.
Hungary	Public broadcaster, Magyar Radio (MR), began experimental DAB transmissions in Budapest on 1 December 95. The multiplex contains 3 domestic programmes and 1 special high-quality programme by MR.	Some data services to take place in the near future and a second transmitter will shortly be installed.	A 250W transmitter operating in Channel 13A is used to cover a population of 3 million.
India	Test transmissions in Delhi.	–	Planning for satellite DAB and terrestrial relays in major cities.
Israel	Pilot project run by Beseq, the Israeli Telecommunications Corp.	–	2 transmitters in Band III covering 70% of the population, and a third transmitter is planned.
Italy	RAI: a pilot project in the Aosta Valley with 6 audio services. 64–256 kbit/s. Pilot services from RAI, in co-operation with Club DAB Italia, will start as soon as the spectrum question can be resolved, with two ensembles in Turin & Milan.	–	4 transmitters in Band III in the Aosta Valley will cover 10% of the population. A new law will give DAB licences to existing FM operators. RAI is committed by the Ministry of Posts and Telecomm. to cover 60% of the population by 1999.
Japan	No decision has yet been taken by the Ministry of Posts and Telecommunications on which system to adopt.	–	Several manufacturers have developed DAB receivers for Eureka-147.

Table 1
Distribution of DAB audio programmes and data services *(WorldDab Forum, August 1997)*.

Country	Audio services	Data services	Comments
Mexico	Terrestrial and satellite experiments.	–	L Band.
Netherlands	A single national multiplex operated by the Dutch DAB Pilot Association. 8 audio services, both public and private. 64–192 kbit/s.	PAD with Dynamic Label. NOZEMA datacasting with weather, news, stock exchange information. 64 kbit/s Packet Mode/MOT.	3 transmitters and gap fillers in Band III covering 45% of the population.
Norway	National Ensemble with 5 services from the public broadcaster, NRK, and one service from P4, the private national broadcaster. 64–256 kbit/s.	Announcements from a message channel within the ensemble. PAD with Dynamic Label and MOT.	4 transmitters in Band III covering 35% of the population.
Poland	Polish Radio: national ensemble with 4 audio services. 256 kbit/s.	–	8% of the population is covered by one transmitter.
Singapore	Demonstrations during Asia Telecom 97 by Singapore Broadcasting Authority in association with Deutsche Telecom.	–	Further trials in L Band and on VHF are planned during 1997.
South Africa	Plans for a pilot project during 1997.	–	The South African DAB Association was formed during 1996.
South Korea	Tests and evaluations have been carried out.	–	The Ministry of Information and Culture has announced that Eureka-147 will be adopted in South Korea over the next five years.
Spain	Test transmissions during 1997.		A DAB Association has been formed.
Sweden	SR: A national ensemble with 5–6 audio services and a message channel for traffic and info. Regional services from SR in three regions with 5 audio services (32–256 kbit/s).	Announcements, PTY including language code and PAD with Dynamic Label, MOT and DRC. Data services in 64 kbit/s Packet Mode/MOT. Programme number.	11 transmitters for the national ensemble (covering 45% of the population) and 6 for the regional ensembles (covering 35%), all in Band III. Teracom plans for 75% national and 55% regional coverage with another 56 transmitters by early 1998.
Switzerland	Pilot Projects in Bernese Oberland, Basle and Geneva with 4 regional ensembles comprising, in total, 25 public and private audio services. 96–224 kbit/s.	Data services within each ensemble of 24–64 kbit/s, comprising traffic news, public transportation info. etc.	Bernese Oberland: 3 transmitters in Band III and 12 in L Band. Basle: 12 transmitters in L Band. Geneva: 1 transmitter in Band III. Total coverage: 2 million people.
United Kingdom	BBC: National ensemble with 5–12 audio services. 48–192 kbit/s. London Experimental Multiplex with 5 private audio services, an NTL Multimedia service and a message/announcement channel. 64–192 kbit/s.	Announcements, PTY and PAD with Dynamic Label, MOT, DRC and M/S. Data services from BBC with teletext in HTML format at 12–24 kbit/s and travel/traffic info. at 8 kbit/s. Private services: PAD with Dynamic Label, MOT, DRC and M/S.	BBC: 27 transmitters in Band III covering 60% of the population by early 1998. NTL runs the London Experimental Multiplex in Band III. Radio Authority will start licensing private radio multiplexes, both national and local, in early 1998.
United States	CEMA tests found Eureka-147 to be the superior system. NAB opposes the adoption of Eureka-147 in the USA.	–	The FCC has recently approved two licences for satellite Digital Radio in S Band.

Table 1 *(continued)* Distribution of DAB audio programmes and data services *(WorldDab Forum, August 1997).*

3. *Pan-European market research study*

In 1996, the WorldDab Forum sponsored a market research study in six European countries (France, Germany, Italy, The Netherlands, Sweden and the UK). Interviews were carried out on a representative panel of 750 adults, between the ages of 15 and 65 years, in each of the six nations. The views given by this panel can be extrapolated to represent the views of roughly 190 million adults or some 90 million households in the six countries.

37% of the interviewed persons were highly interested in DAB, particularly the audio and reception enhancements it could offer them. DAB may therefore expect a substantial market in these countries, if not throughout the whole of Europe.

3.1. DAB's market potential amongst "early adopters"

From the study, 33 million families have been identified as prospective "early adopters" of DAB. They comprise 37% of the 88 million (non-pensioner) households in these six countries. For *in-car* DAB reception, an early market potential of 18 million receivers has been established (21% of the families were very interested in DAB for use in the car, which represents 35% of car drivers in the six countries). For *in-home* DAB reception, an early market potential of at least 25 million receivers has been established.

These results are summarized in *Table 2*.

3.2. Reception, sound quality and ease of tuning, as marketing "drivers" for DAB

Problems with the quality of reception, quality of sound and the ease of tuning are experienced by significant minorities, particularly in the case of FM car radios and portables. A greater degree of concern was expressed about reception and tuning difficulties, than about the quality of the sound. DAB's interference-free reception is therefore probably a more powerful marketing platform than its near CD-quality sound. Ease of tuning is also a major selling point for DAB car radios (this is also true of RDS).

Table 3 summarizes the results of this aspect of the market research survey.

3.3. Audio enhancement vs. audio-related and information services

At the moment, it is the audio enhancement features of DAB, rather than audio-related and information services, that attract the highest interest among potential listeners (see *Table 4*).

The main attractions of DAB are:

– interference-free reception;

– near CD-quality sound;

– no re-tuning necessary when on the move.

3.4. Information and data services as the "drivers" for DAB

Of the additional data services that could be provided by DAB, there is a substantial demand for *local information* that could be met by local DAB services:

– *local* news;

– *local* traffic conditions and parking;

– *local* weather.

In general the *information and data applications* of DAB seem to be more powerful "drivers" for DAB than *programme-related data services* such as: where to find similar stations, name of the tuned station, the current artist or composer, etc.

A number of niche markets have been identified as good candidates for *DAB subscription services*. The most obvious one is financial and stock market news**.**

3.5. The demographics of early adopters

As is the case for most new consumer electronic products, the demographics of those most interested in taking up DAB are:

– men rather than women;

– young rather than older people;

– those with higher incomes**;**

– frequent radio listeners.

Across all six countries	Millions	%
Total number of families	88	100
Number "very interested" in acquiring DAB for use in/at:		
– Car or home	33	37
– Car	18	21
(amongst car drivers)	(31)	(35)
– Home	25	28

Table 2
DAB's market potential amongst early adopters.

Across all six countries	Car (%)	Hi-fi (%)	Portable (%)
Use of FM	91	94	90
Amongst FM users, problems experienced often or sometimes with:			
– reception	45	23	37
– fair/poor sound quality	17	7	21
– ease of tuning	31	18	34

Table 3
FM reception – sound and tuning problems.

Across all six countries	Car drivers (%)	Families at home (%)
Total number of families	88	100
% very interested in buying a DAB radio in order to obtain:		
– audio enhancement	29	21
– audio-related features	19	13
– screen-based info.	10	7

Table 4
FM features and functions.

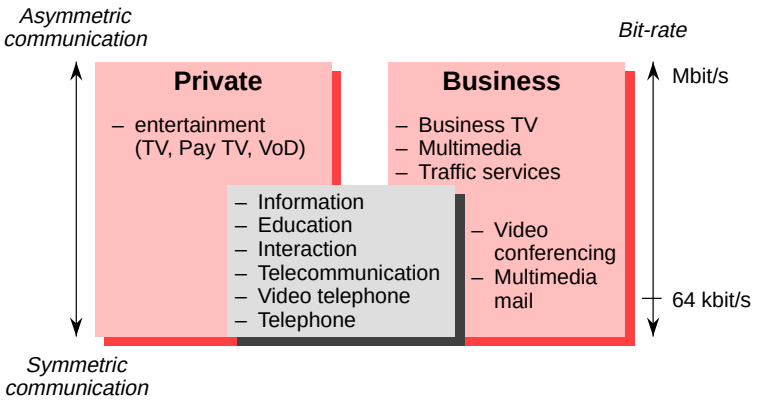

Figure 3
Segmentation of multimedia services. For the majority of multimedia applications, asymmetric data flows are required!

4. DAB – as the future terrestrial, mobile, multimedia transmission system

The DAB transmission system is a data-transparent system that is capable of carrying datastreams at different rates (n x 8 kbit/s) and which is independent of the content (audio programmes, data services, moving images, etc.)

Future multimedia services will result in an asymmetrical flow of data (*Fig. 3*). Many applications will require a wide high-speed data channel in the direction of the subscriber for the "downloading" of text, images, graphics, audio and video sequences. The bandwidth of the "control channel" in this system, however, will be comparatively narrow.

4.1. ACTS MEMO project

The DAB transmission system has the potential to offer a range of multimedia services. Within the framework of the ACTS Programme of the European Commission, the MEMO project aims to develop and demonstrate an interactive multimedia platform for mobile and portable reception using DAB in conjunction with GSM.

DAB offers extremely good mobile reception at any location within the service area. Every user may have simultaneous access to the information which will have an "on-line" element. The users will have the option to select certain services which can then be "downloaded" to them, whether at home or on the move.

4.2. Multimedia object transfer protocol (MOT)

The DAB transmission mode which was defined for the transmission of audio programmes is not suitable for transmitting major blocks of *text*, and certainly not for transmitting *video data*. Such applications demand a transmission standard close to the ftp (File Transfer Protocol) format used on computer networks. This is the reason why a specific data transmission standard has more recently been designed for DAB: the *Multimedia Object Transfer* (MOT) protocol.

Bosch has developed a DAB enhancement called *Digital Multimedia Broadcasting* (DMB) which incorporates the MOT protocol: it enables the services provided by DAB to be extended considerably Developed and presented during summer 1996 (in co-operation with Deutsche Telekom AG), the Bosch system utilizes standardized source coding techniques (MPEG-1 or MPEG-2) for video frame compression, and combines them with the standard DAB transmission system in a manner which allows stable fixed and mobile reception of the pictures.

DMB is hence the first system to offer the opportunity of real-time reception of topical information with moving pictures in mobile environments (e.g. in trains, buses, lorries, motor cars, etc.).

The transmission of an MPEG datastream for mobile reception is governed by the following parameters:

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Frank Müller-Römer was Technical Director of Bayerischer Rundfunk *from 1975 until the end of 1994. As a participant in a number of working groups organized by the broadcasting stations under public law in the Federal Republic of Germany, he has always worked actively for the continuing development of radio and television. He is author of a number of articles and monographs published throughout Europe.*

In 1990, Prof. Dr-Ing. Müller-Römer became President of the National DAB Platform of the Federal Republic of Germany. At the end of 1991, he became Chairman of DAB Plattform e.V. which was established to co-ordinate and control the introduction of Digital Audio Broadcasting in the German marketplace.

– without “external error protection”, a code-rate of $^1/_2$ must be selected. This furnishes a useful data-rate of 1.152 Mbit/s.

– with “external error protection” (Reed-Solomon Code), an MPEG data-rate of 1.504 Mbit/s (with a code-rate of $^4/_6$) can be provided.

4.3. MPEG-4

In the future, a further enhancement of the delivered video quality may be expected from the MPEG-4 coding standards. Within the framework of MPEG-4 standardization, a broadcast mode will permit a distinct data-rate reduction compared to MPEG-2.

Fig. 4 indicates the picture-quality improvements offered by successive source coding standards such as the MPEG series. It can be seen that a data-rate of 1.152 MHz (code rate $^1/_2$) is not sufficient with today’s coding techniques (MPEG-2) to provide good stationary reception (PAL quality) on a large TV screen – unless an external directional antenna is used to improve the received S/N ratio.

If the use of an external directional antenna is assumed for high-quality home viewing, the application of *hierarchical modulation* to DAB (as for DVB-T) would permit a substantial improvement in the picture quality received via DAB. This idea is now explained in some more detail.

4.4. Hierarchical modulation

Trouble-free reception in portable and mobile conditions demands the selection of a simple modulation system such as QPSK. On the other hand, in order to serve users in mobile and portable environments, the bandwidth needed is larger than that required to serve the user at home (using an external directional antenna).

The hierarchical modulation technique aims to split each HF (1.75 MHz) terrestrial DAB block into two separate parts:

– Part 1 permits the transmission of comparatively low data-rates in a way that they may still be received at small signal-to-noise ratios without impairment of the picture quality, even in mobile environments;

– Part 2 permits the parallel transmission of substantially greater data volumes. It involves, however, higher demands in terms of the signal-to-noise ratio.

Using the hierarchical modulation technique, it is possible to transmit the *two* required datastreams *at the same time*: one datastream undergoes QPSK modulation and presents a lower code rate (e.g. $^1/_2$ of the internal error protection system) whilst the other datastream is modulated with either 16-QAM or 64-QAM and is provided with a higher code rate (e.g. $^5/_6$ of the internal error protection system). By means of a modulation multiplexer, each isolated carrier of the transmission frame can then transmit two data words simultaneously – one for high-quality home reception, the other for stable mobile reception of video images.

The user data-rates for mobile and home reception can be derived from *Table 5*. For example, a mobile user could receive the high-priority QPSK datastream at 1.15 Mbit/s (with a code rate of $^1/_2$) while the home viewer (with an external directional antenna) could receive a low-priority 16-QAM datastream at 3.64 Mbit/s (with a code rate of $^4/_5$).

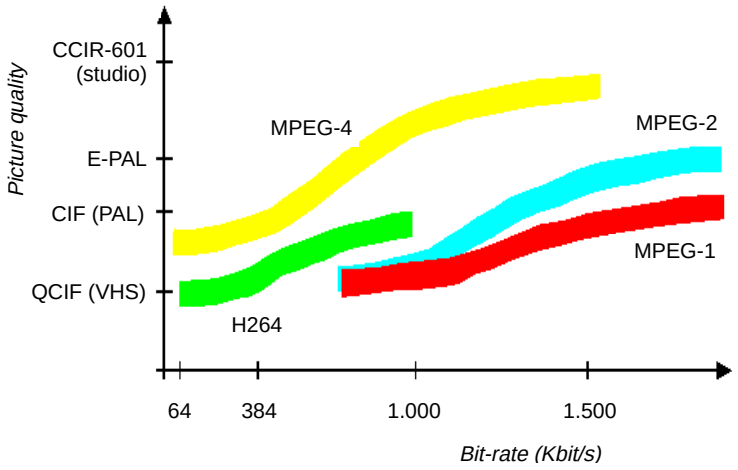
Code rate	QPSK (Mbit/s)	16-QAM (Mbit/s)	64-QAM (Mbit/s)
$^1/_2$	1.15	2.30	3.45
$^2/_3$	1.54	3.08	4.62
$^3/_4$	1.73	3.46	5.19
$^4/_5$	1.82	3.64	5.46

Table 5
User data with non-hierarchical modulation.

In the near future, it is reasonable to assume that it will be possible to transmit a television signal at a data-rate of 3 Mbit/s using MPEG-4 coding, with approximately the same picture quality that is currently possible with MPEG-2 at a data-rate of 6 Mbit/s. The *Institut für theoretische Nachrichtentechnik und Informationsverarbeitung*[1] has submitted a proposal to the Eureka-147 consor-

1. The Institute for the Theory of Communications Engineering and Information Processing, at the Technical University of Hannover, headed by Dr-Ing. Hans-Georg Musman.

Figure 4
Picture quality of various source-coding techniques.



tium for a dual broadcasting layer in DAB, based on hierarchical modulation and the use of MPEG-4 coding in the additional layer.

When hierarchical modulation is applied to DAB – which will require (i) only slight (modulation) modifications at the transmitters, (ii) a higher transmission power (+3.2 dB) and (iii) future DMB-compatible receivers for moving pictures – it will be possible to broadcast a moving picture of restricted quality via one DAB frequency block for reception on portable and mobile receivers. The same programme may be received within the same frequency block at home – *with very good quality* if an external directional antenna is used.

The DAB multimedia system just described could, in principle, be employed as the successor to the current terrestrial analogue TV system, at the same time offering *mobile, portable* and *fixed* reception of DAB multimedia services.

5. Conclusions

The Eureka-147 DAB system is now at the stage of service implementation in a growing number of countries around the world. Via extensive pilot trials and pre-operational services, it has proven to be an extremely robust carrier of digital audio and narrowband data services to the user, whether at home or on the move. It is now decisive that we accelerate and support the adoption of this system on a global basis.

Additional frequency blocks should be vigorously pursued in order to augment DAB with comprehensive multimedia services. Through the application of *hierarchical modulation* techniques, the frequency assignments which comply with the Wiesbaden 1995 Band III DAB plan [2] could simultaneously be used to carry parallel digital transmissions via DAB of the existing analogue TV transmissions in Band III. With such a scheme, these parallel digital TV transmissions could commence soon, resulting in the complete shutdown of the terrestrial Band III analogue TV networks after 10 to 15 years. These released frequencies would then permit Band III in Europe to be used for further DAB multimedia services.

The universal multimedia DAB system oulined here is surely the system of the future.

Bibliography

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