Better Passenger Information through Digital Broadcasting

Passenger information is a key issue for modern transportation. FM radio and stored videos do not fulfil the increasing requirements. Digital broadcasting not only supports better audio quality but is also able to bring real-time multimedia contents into high-speed trains.

1 Introduction

Today, people want to be well informed even they are travelling. Modern trains – like the German ICE – are equipped with audio/video systems. Audio information is received from local FM\(^1\) radio stations. Video information, in contrast, today only comes from local storage media and is therefore not up-to-date.

The FM system was developed for stationary reception so that critical reception conditions are likely to occur through:
- fading: the receiver is in the “shadow” of a building or mountain
- multipath interference: time delayed (double) reception of the reflected signal
- Doppler interference: due to the moving receiver in mobile reception

A moving receiver has to deal with these continuously varying reception conditions in a split of a second. As a result, audio-quality is subject to noise and distortion and cannot meet the requirements of growing mobility and CD-like quality. As the coverage area of a specific FM transmitter is relatively small, in-train receivers have to be retuned in short time intervals, interrupting the service.

For the TV services the above mentioned conditions are much more critical, because the analogue TV system highly depends on undisturbed signals. Therefore, reception of analogue TV services in trains is not possible in technical terms. The additional problems for reception of analogue signals in tunnels are not discussed here.

2 Digital Audio Broadcasting

A new digital transmission scheme was sought for sound broadcasting in the 1980s to overcome the quality limits of FM radio for mobile reception. The Eureka-147 consortium developed the Digital Audio Broadcast (DAB) system in 1992. DAB, developed in Europe and standardised within ITU\(^2\), ETSI\(^3\), and EBU\(^4\), is implemented on all continents in the meantime. DAB, originally developed for sound broadcasting to mobile and portable receivers, is well suited to carry also any kind of digital data.

The key features of the DAB system include [ALAR]:
- CD-comparable audio quality
- high data rate of 1.7 Mbit/s
- reliable transmission for all terrestrial speeds
- frequency economy with the possibility to operate Single Frequency Networks (SFNs)
- Low field strength of radiation (< FM)

\(^1\) FM: Frequency Modulation
\(^2\) ITU: International Telecommunication Union
\(^3\) ETSI: European Telecommunication Standards Institute
\(^4\) EBU: European Broadcasting Union
2.1 **CD-like Quality**

DAB provides crystal clear sound that is comparable to CD quality which serves as the standard for audio transmission. As the data rate for CDs (about 1.4 Mbit/s) is very high, it was reduced without diminishing the quality. Using MPEG Audio Layer 2 (MUSICAM\(^5\)) data reduction, the DAB data rate is lowered to about 192 kBit/s in order to reduce the bandwidth of the audio signals. This does not reduce the audio quality.

2.2 **Frequency Economy**

DAB makes use of a relatively large bandwidth of 1.536 MHz, but it is used simultaneously for six to eight programme services which are transmitted in a so called “ensemble”. DAB services should be available primarily for high coverage mobile reception, which requires a special network infrastructure. DAB networks are designed as “Single Frequency Networks” (SFNs) and have numerous advantages compared to “Multiple Frequency Networks” (MFNs) as required for analogue FM radio.

2.2.1 **Single Frequency Networks**

In an SFN, all transmitters are synchronised and transmit exactly the same signal at the same time and at the same frequency. Due to its COFDM\(^6\) modulation process it is possible to build SFNs. During modulation, a time guard interval is added to the signal which helps to prevent the problem of multipath interference; this capability is the cornerstone for SFNs. Consequently, the receiver does not need to change the frequency within an SFN. Therefore, SFNs are more economic than FM networks with the same transmitter power. Another advantage is that fewer frequencies are required by DAB, which is especially important in large networks.

2.2.2 **Gap Filling**

Gap filling is used to close gaps in coverage areas. Gap fillers receive the signals from the main transmitters, amplify them and retransmit them at the same frequency to provide coverage in an area where the main transmission signal is not received satisfactorily.

As gap fillers need not to be synchronised in time (as long as time delays stay within the time guard interval), they can have a very simple design. The gap filling concept is useful both for terrestrial and satellite broadcasting systems.

2.3 **Additional Services and Multimedia Broadcasting**

In principle, any type of information can be transmitted by DAB, provided that it is available in digital form. Therefore, the DAB system is not reduced to simple audio transmission but can also transmit other data, for

\(^{5}\) MUSICAM: Masking pattern Universal Sub-band Integrated Coding And Multiplexing  
\(^{6}\) COFDM: Coded Orthogonal Frequency Division Multiplex
example still pictures or texts accompanying radio programmes, digitised traffic messages, electronic newspapers, www-content (html-files) or animated videos [KLI1].

Consequently, since 1991 Bosch have developed Digital Multimedia Broadcast (DMB®) which permits high-quality transmission of text and even moving pictures to trains, busses, passenger cars and other means of transport. This system uses standardised source-coding techniques to compress video images (MPEG-2 or MPEG-4) combined with the DAB mobile transmission. DMB is the first system which allows mobile users to receive video information in real-time even while travelling at high speed [GRU]. Furthermore, TV programmes can be supplemented and embellished as required with special information such as current stock-exchange figures and moving pictures from weather satellites.

Comparison PAL and DMB in Mobile Reception

### 3 Status of Digital Multimedia Broadcast

Bosch have already developed and demonstrated DMB together with Deutsche Telekom AG since 1995. Starting in October 1997, Deutsche Bahn AG have operated a DMB service delivered by Bosch on the long distance track between Frankfurt am Main, Mainz and Saarbrücken. During the trip, passengers can watch the programmes broadcast by n-tv, a German TV station. Up-to-date information on train schedules, connecting trains or the train’s exit side at the next station are displayed on the video screens installed in the train cars [BRI1]. Also since October 1997 Teracom (Swedish broadcaster) and the Swedish Railways (SJ) have been operating a DMB service in Sweden on the Uppsala-Stockholm commuter trains. A demonstration by Bosch in June 1998 showed that reliable TV reception using DMB is even possible in the German Transrapid (up to 430km/h). Even error free transmission from aeroplanes is possible, as shown by Bosch and DLR whilst the sun eclipse in 1999.

Since EXPO 2000, ÜSTRA AG (public transportation operator in Hanover) runs a public transport information system based on DMB with 144 ÜSTRA city transportation vehicles and stationary posts as bus stops, equipped with information displays. Similar system are installed in Berlin and even in busses in Leipzig.

### 4 Passenger Information for Long-Distance Railway Services

Railway services for inter-city connections are in competition with air and automotive transport. Cost, travel time and comfort are main criteria for customers’ choice. For comfort the railway system has a big advantage, as it can provide up-to-date information and entertainment in a quality not possible for the competing systems. Using Digital Broadcast and especially DMB the passengers can hear live radio-programmes in CD-quality, they can watch live TV programmes and receive actual information associated to there journey about e.g. connecting trains.

#### 4.1 Passenger Information on the Nahe Valley Interregio

Deutsche Bahn AG and Robert Bosch Multimedia-Systeme have operated a DMB system on the Interregio-line between Frankfurt am Main, Mainz and Saarbrücken in the valley of the river Nahe. The VT611 tilting-technology-train occasionally attains speeds of up to 160 km/h. Every train is equipped with eight colour dis-

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MPEG: moving Picture Experts Group. MPEG-2 today used standard for Digital TV, MPEG-4 modern enhancement to MPEG-2 with better coding efficiency: needs only half of the data-rate compared to MPEG-2.
plays based on plasma technology, measuring 51 centimetres diagonally. During the journey the passengers can watch the German news broadcaster n-tv. In addition screen subtitles continuously supply updated information on train schedules, connecting trains and the platform side at the next stop. The travel information in the subtitles does not require any audio output. Passengers who want to listen to the television program can do so with the help of headphones connectable to a socket in the armrest of each seat.

Display in Train

For Deutsche Bahn it is a decisive step towards providing train passengers with information relevant to their route.
The 221-km railroad line between Frankfurt and Saarbrücken is equipped with the most modern wireless communications system in the German rail network. Eight main transmitters and 27 signal boosters - or repeaters - operating at a transmission frequency of around 1,500 MHz supply trains along the entire route with information. Moreover, they do so reliably and without interference. The flow of data remains uninterrupted, even when the trains pass through gorges or one of the 18 tunnels along this stretch. Even the 2.2-km airport tunnel just outside of Frankfurt cannot stop the information flow.

![DMB— for a World on the Move](image)

Configuration DMB Nahe-Valley

A data studio in Frankfurt am Main (1) digitises and compresses both the video data of the television program and the supplementary information. These signals are then transmitted to a satellite (2). From here, the signals are transmitted to a DMB network set up specially for this purpose. A total of eight main transmitting stations and 27 smaller repeaters (gap fillers) ensure continuous reception onboard the trains (3). Having reached a train, the data is decompressed and reproduced in the form of high-quality video and audio signals.

5 Passenger Information for Public Transport Services

Travel time in public transport is relatively short, therefore information should not only be up-to-date but also concise highlighting news, sports and e.g. yellow press headlines. A combination with advertising is a good opportunity for cost sharing. Of main interest of course is up-to-date information about the journey such as next stations, next connections etc. This information should reflect the current situation, not transport schedules from static time-tables.

5.1 Public Transport Passenger Information in Hanover

Since EXPO 2000 in Hanover’s urban transit system, travellers are offered a glimpse into the future of passenger information systems.

A total of 144 urban transit trains from the operating company ÜSTRA have been equipped with six double display screens per coach, on which passengers can check out current train schedules, events information and advertising spots. Integrated into an attractive information environment, passengers receive real-time information on:
- connecting busses and trams
- changes in the timetable
- delays
- special runs
- current information on the transport system and daily news
Displays in Üstra-Train

The DMB service is supplied to the Hanover metropolitan area by three master stations, each with 200 watts of transmission power, operating a DAB-SFN. Thirteen repeaters provide links to the underground track sections and stations.
All of the traffic data converge in the video and data studios of the operating company. A DMB multiplexer combines these data with other information, such as advertising spots, to form a 1.5 Mbit/s data stream which is then broadcast to all the transit coaches. From this data stream, the DMB receiver in each coach selects those data that are relevant to its track section.

It is even possible to show an advertise relative to the current train position, e.g. shortly before the train reaches the relevant stop.

Double Display
In the region around Hanover too, where no fixed data lines are available, DMB fully demonstrates its capabilities. The EXPO city’s broadcasting infrastructure supplies display columns at train stations and bus stops with consolidated information about the schedules of ÜSTRA trains and of the RegioBus regional bus system. By providing static and dynamic information about both train and bus schedules, this service is making an important contribution to better acceptance of public transit in metropolitan Hanover.
6 Other Technologies – A Comparison

6.1 Digital Video Broadcasting (DVB)

DVB was originally developed for satellite (DVB-S) and cable (DVB-C). Both protocols allow data rates of up to 38 Mbit/s at a bandwidth of 7 MHz respectively 8 MHz.

Of interest for mobile users is only the terrestrial DVB system (DVB-T). DVB-T can be operated in different modes related to the reception conditions, the system is used for. For stationary reception with an outdoor antenna datarates up to 30 Mbit/s are possible. For portable reception with a rod antenna the maximal datarate is 15 Mbit/s and for mobile reception about 5 Mbit/s all in a 7 MHz respectively 8 MHz channel. In the same channel 4 DAB/DMB ensembles each with 1.5 Mbit/s can be transmitted and therefore 8 MPEG-4 coded TV-programmes can be transmitted. The size of a SNF is much smaller than in DAB/DMB. The field strength of radiation is much higher compared to DAB/DMB (DVB-T: 85 dBµV/M; DAB/DMB: 67 dBµV/m).

DVB-T can only guaranty reliable mobile reception for speeds up to 110 km/h and line-of-sight between transmitter and receiver, even a tree or a passing train will interrupt the reception.

6.2 Mobile Telecommunication Systems

While a broadcast service can reach all users in a given area at the same time, mobile systems are mainly point-to-point oriented. Broadcast features like cell broadcast are not very common. The costs for broadcasting using mobile phone services are very much higher than for Digital Broadcasting.
6.2.1 GSM and EDGE

The current 2nd generation mobile phone system GSM\(^6\) is mostly used for point-to-point voice communication. Point-to-point data communication in the voice channel is possible at data rates of 9.6 kBit/s. EDGE\(^7\), a data communication service offered by some mobile operators supports higher data rates up to 384 kBit/s by combining multiple GSM channels.

GSM can be used for speeds of up to 250 km/h, but the effective data rate decreases dramatically with increasing speed, caused by packet repetition due to a rising bit error rate.

6.2.2 GPRS

GPRS\(^8\) is an extension to GSM for data services. It is a data packet oriented connection-less system opposite to the switched GSM and EDGE. GPRS has just started operation. Data rates of up to 115 kBit/s are planned with a later increase to 384 kBit/s. While in GSM and EDGE charging is based on connection time, GPRS costs are calculated based on the number of data packets multiplied by the data rate used.

As GPRS uses GSM technology and infrastructure it has mainly the same restriction regarding the speed of mobile users.

6.2.3 UMTS

The future 3rd generation mobile telecommunication system UMTS\(^9\) generates a lot of expectations related to high data rates. As a matter of fact, 2 Mbit/s are only available for the speed of a pedestrian. For applications in public transport and in high-speed trains, the data rate will not be higher than today with GPRS or EDGE. Furthermore, due to the small cell-size a lot of overhead for horizontal handover is needed when travelling at higher speeds, which can reduce the effective data rate to nearly zero.

7 Conclusion

Passenger information is a key issue for modern transportation. Current analogue broadcasting services and “canned” video do no longer fulfil the travellers’ expectations.

Digital Audio Broadcast (DAB) is specially designed for mobile reception. Digital Radio Services using DAB technology are available in most highly developed countries around the world. To make this service available only installations in trains are necessary respectively the replacement of the receivers for analogue FM-Radio by ones for DAB. On the infrastructure side some gap-fillers (repeater) might be necessary especially in tunnels, but this is much simpler and cheaper than today’s leakage cable antennas.

Digital Multimedia Broadcasting (DMB) supports high quality transmission of audio, data and live-TV to trains, busses, passenger cars and any other means of terrestrial transport. Due to the use of DAB technology, transmission is reliable at any terrestrial speed.

DMB is the ideal solution for any up-to-date information on long-distance railway and public transport services. It can provide CD-comparable audio, live-TV, updated travel information etc. in real time. In combination with advertising spots cost sharing is possible.

DVB-T, the terrestrial digital TV-system is not useable for passenger information services, among others, due to its unreliability at higher speeds.

Mobile telecommunication systems are mainly used for point-to-point communications. Broadcasting is the only solution to reaching a big audience in large areas at affordable costs. Furthermore the data rates available for train speeds are too low for an acceptable service.

First installations on long-distance railway lines and public transport systems in metropolitans have demonstrated and proven the capability of DMB for a better passenger information.

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\(^6\) GSM: Global System for Mobile Telecommunications
\(^7\) EDGE: Enhanced Data rates for GSM Evolution
\(^8\) GPRS: General Packet Radio Service.
\(^9\) UMTS: Universal Mobile Telephone System


