Switchover

— the German approach

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The analogue-to-digital transition in the delivery of TV programmes to the home is a major challenge. Many requirements have to be met. Germany provides an interesting case study as the approaches taken for satellite, terrestrial and cable delivery differ significantly.

In this article, after a brief review of TV coverage in Germany, the analogue-to-digital transition is detailed for the three distribution platforms – including issues on picture quality, HDTV and interactive programming based on MHP.

TV reception in Germany

Television in Germany can be received via the satellite, terrestrial and cable delivery platforms. According to the *Astra Satellite Monitor*, at the end of 2003 around 40% of the total of 36.2 million TV households in Germany received television channels via satellite *(see Fig. 1)*. Compared to the previous year, this is an increase in direct-to-home satellite reception of 650,000 to a total of about 14.5 million TV households.

Direct-to-home satellite reception requires a parabolic reflector antenna to be precisely aligned with a satellite in space. The construction design of a house or flat, such as the lack of a south-facing balcony, can hinder direct alignment or even make it completely impossible. In particular, there may be further restrictions on installing a satellite reception system for those in rented accommodation or flat-owners. Thus, it may not be easy in every household to put up a satellite dish and to wire it up for in-house distribution.

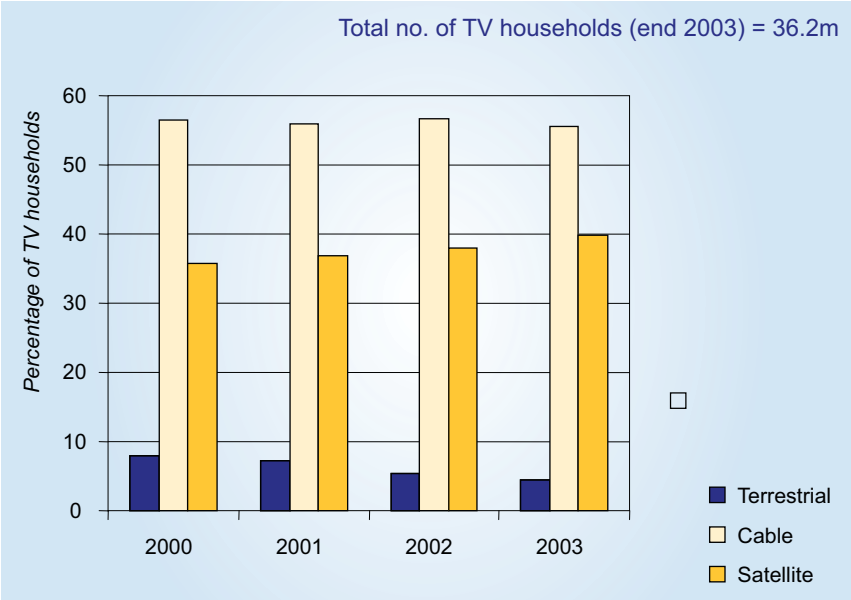

Figure 1
TV reception in Germany (end 2003)
(Sources: SES Astra, German Satellite Monitor, TNS Infratest)

Analogue terrestrial reception of television channels has

continually been on the decline, amounting to only around 5% in Germany as a whole, at the end of 2003. This development can primarily be attributed to the small number of programme channels available, typically around three to five. Additionally, for analogue terrestrial reception, a roof-top aerial has to be installed. Thus the incentive to install new analogue terrestrial reception systems is very low indeed.

At the end of 2003, more than 55% of all TV households used cable to receive television channels, making cable the most widespread means of television delivery. In Germany the construction of cable networks has mainly been concentrated in urban areas, with cities such as Hamburg and Berlin having over 80% of reception via cable. Yet cable reception is not universally available. In more sparsely populated areas of Germany, cable networks often do not exist at all.

In Germany, analogue television is transmitted as free-to-air TV in an unencrypted signal format. Digital television is both unencrypted (free TV) and encrypted (pay TV). One requirement carried over from analogue-to-digital reception is that television viewers can reasonably expect to be able to view TV programme channels from a range of content providers on one piece of equipment. Content providers also have an interest in being able to present their programme offerings on all reception equipment in a fair and undiscriminating framework. The key prerequisite for this is to create a horizontal market on the basis of open standards. Maintaining open standards guarantees all parties – not least of all the viewers – the required investment security.

The analogue-to-digital transition in Germany

As part of a governmental initiative on digital broadcasting, Germany intends to fully complete the transition from analogue to digital transmission of television signals by the year 2010. For analysis, it makes sense to examine the analogue-to-digital transition separately for satellite, terrestrial and cable, as they differ in terms of both the required transition strategies and the processes involved.

Satellite

The analogue and digital TV programme channels for Germany are broadcast via the Astra satellite system from an orbital position of 19.2 degrees east. Digital satellite television is transmitted according to the DVB-S standard and free-TV signals are unencrypted.

At the end of 2003 around 81% of all satellite households were still receiving the analogue TV signals. However, recent years have seen a rapid increase in digital satellite reception of free TV. One reason for this is the wider range of channels. Since 1997 the public service broadcasting organizations ARD [1] and ZDF [2] have broadcast their digital programme bouquets *ARD Digital* and *ZDFvision* respectively. The bouquets contain extra TV programme channels which can only be received digitally. For viewers, the shift from analogue to digital satellite reception means gaining extra free TV channels and new interactive programme offerings, thus creating a clear added value incentive.

In addition, brand-name manufacturers have stopped producing analogue satellite receivers, and are now completely concentrating on producing DVB-S receivers, especially for the free-TV market. This product policy means that satellite households are almost automatically provided with digital receivers if they buy new or replacement equipment. A wide variety of reception devices with differing ranges of features is available on the retail market. Low-end DVB-S receivers, for instance, can be bought for less than €100.

1. **A**rbeitsgemeinschaft der öffentlich-rechtlichen **R**undfunkanstalten der Bundesrepublik **D**eutschland: Association of nine autonomous and independent public service broadcasting organizations in Germany.
2. **Z**weites **D**eutsches **F**ernsehen: Second public service broadcasting organization for television in Germany alongside ARD, based in Mainz.

Viewers can access and select channels with the help of additionally broadcast service information which describes the channels and individual programmes. This service information is also based on the DVB standard and is transmitted as so-called SI data parallel to the programme channels. This data can be read by all satellite receivers, whether they are designed for free-TV or pay-TV. Television viewers can access this data either in the specific manufacturer's navigator or in an electronic programme guide (EPG) provided by the broadcaster. For example, the digital satellite multiplexes of ARD contain an EPG programmed in MHP for presenting the choice of available programmes and interactive services – in the layout of the bouquet *ARD Digital* – to the viewers.

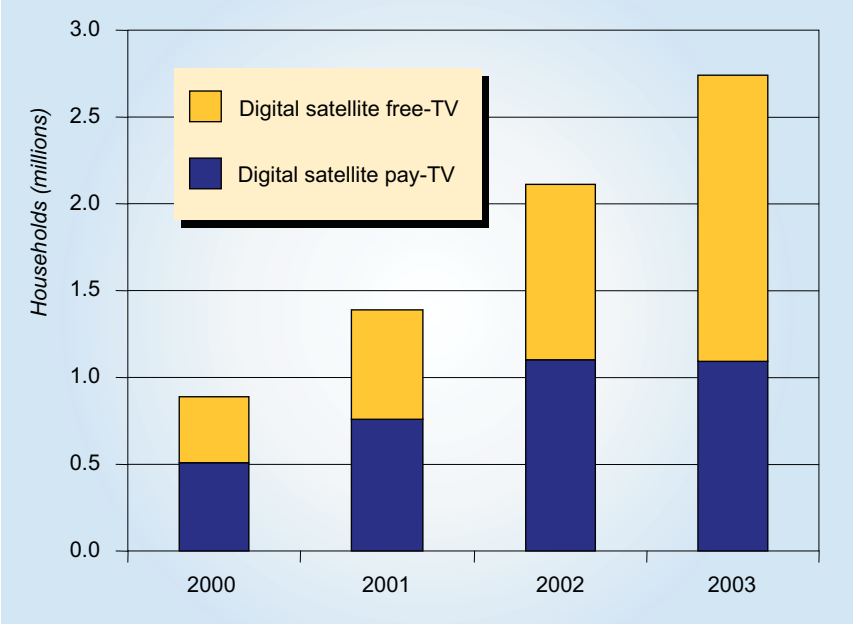

Figure 2
Digital satellite reception in Germany (end 2003)
(Sources: SES Astra, German Satellite Monitor, TNS Infratest)

As *Fig. 2* shows, the number of digital pay-TV households doubled between the end of 2000 and the end of 2003. Yet, during the same period, the number of digital free-TV households increased four-fold, equivalent to a constant annual growth rate of about 60%. In contrast, after initial growth, the pay-TV sector stagnated between the end of 2002 and the end of 2003. These figures highlight the key importance of the free-TV market for the analogue-to-digital transition.

Alongside the extended range of TV programme channels, digital satellite transmission technology also provides improved picture quality by avoiding typical PAL artefacts. At the same time, digital transmission can better compensate transmission errors due to channel distortion, which also adds to the received picture quality.

ARD has developed a concept for the gradual expansion of digital satellite transmission in preparation for the envisaged analogue switch-off in the year 2010. The shutdown of analogue transponders would terminate the simulcast operation and be a major contribution to reducing transmission costs.

Until recently, ARD's DVB-S signals were broadcast via two transponders. However, this transmission capacity was not enough to broadcast all the local programmes produced by WDR [3] simultaneously via satellite. Until the end of 2003, reception of the correct regional programme was only guaranteed via cable or terrestrial transmission. The first stage of the satellite broadcasting concept thus envisaged the launch of a third satellite transponder from the beginning of 2004 onwards, thus removing the previous restriction on the range of regional programming available.

The shutdown of the analogue transponders also affects the analogue satellite radio and ADR [4] services transmitted on the subcarriers of analogue television signals. Thus the second stage envisages the launch of a fourth DVB-S transponder from 2005 onwards, which will allow digital transmission of ARD's radio stations via DVB-S. This will provide a simulcast of radio stations and ensure a sufficiently long transition period for satellite radio listeners to move from analogue and ADR to DVB-

3. **W**est**d**eutscher **R**undfunk, Cologne: public service broadcasting organization for North Rhine-Westphalia, one of the nine members of ARD.
4. **A**stra **D**igital **R**adio: digital radio services on Astra, broadcast on the subcarriers of the analogue transponders.

S reception. The transition to DVB-S includes the provision of transmission capacity for advanced and future signal formats such as multichannel audio and surround sound. The remaining capacity will be used for regional TV programming that, up to now, is only available via terrestrial and cable reception.

The prerequisite for increased distribution quality is an SDTV signal of the best possible quality in the studio, in accordance with the ITU-R BT.601 standard. The objective behind digitizing studio production is to maintain this level of quality throughout the production chain. The resulting picture quality should also be transmitted to viewers with as little loss as possible. One measure for meeting this requirement is increasing the bitrate for MPEG-2 video for DVB-S transmission.

Large displays in particular place high demands on picture quality. Market analyses have shown that large displays will achieve significant market penetration in years to come. With this in mind, ARD is planning to launch a fifth DVB-S transponder from 2008 as a further stage of its satellite concept. The additional transmission capacity will then be available for improving the picture quality of television broadcasts.

The transition from the 4:3 to 16:9 picture formats parallels the analogue-to-digital transition. Although 4:3 displays dominate the households in Germany at present, the number of 16:9 displays is constantly increasing. As the ability to produce in 16:9 format increases, many programmes – especially period pieces, documentaries and reports – are being produced and broadcast in wide-screen format. The exchange of programmes at an international level is also increasingly oriented towards the 16:9 format.

Alongside the analogue-to-digital transition, there is renewed debate on the transmission of HDTV signals. Being able to provide HDTV is not only dependent on having the required transmission capacity. Viewers also have to be able to receive HDTV signals, and there has to be equipment that can display the signal in the desired HDTV resolution and quality. As yet, the required HDTV receiving equipment and displays with HDTV resolution of e.g. 1920 pixels per line x 1080 lines is virtually unavailable in the retail sector in Germany. Additionally, there is the question of how quickly the prices for that kind of equipment will fall to penetrate a substantial number of households.

Seen solely from a financial perspective, the transmission of digital HDTV programme channels will not be feasible until the shutdown of analogue television broadcasting. The simulcasts during the analogue-to-digital transition are a major additional financial burden. Additional funding for HDTV is not available to the public service broadcasting organizations.

Yet costs do not only arise for programme distribution to the homes. Considerable advance investment in production equipment and training of staff is also necessary. Nevertheless, there are possibilities for using HDTV equipment at an earlier stage, such as for providing repertoire material as a replacement for 16/35 mm film productions.

Yet before major investment is made in HDTV, there are unresolved issues that have to be clarified. One question concerns the method used for source coding. The debate revolves primarily around the two standards, MPEG-2 and H.264/MPEG-4 AVC. There are also different options available for satellite transmission, with both DVB-S and DVB-S2 as possible transmission standards. A desir-

Abbreviations

16-QAM	16-state Quadrature Amplitude Modulation	**DVB-T**	DVB - Terrestrial
API	Application Programming Interface	**EPG**	Electronic Programme Guide
AVC	(MPEG-4) Advanced Video Coding	**HDTV**	High-Definition Television
CI	Common Interface	**HH**	Households
COFDM	Coded Orthogonal Frequency Division Multiplex	**MHP**	(DVB) Multimedia Home Platform
		SDTV	Standard-Definition Television
DVB	Digital Video Broadcasting	**SFN**	Single-Frequency Network
DVB-C	DVB - Cable	**SI**	(DVB) Service Information
DVB-S	DVB - Satellite	**UHF**	Ultra High Frequency
DVB-S2	DVB - Satellite, version 2	**WSS**	Wide-Screen Signalling

able measure would be for the industry to agree on a common or at least preferred HDTV picture format. A confusing variety of formats, as is the case in the US, should be avoided.

Terrestrial

In Germany only about 5% of the households still receive their television channels via analogue terrestrial broadcasting networks. The decreasing acceptance of terrestrial broadcasting means that the analogue-to-digital transition called for in the digital broadcasting initiative must be pushed forward. The objective is to make terrestrial reception generally more attractive to television viewers. At the same time, the figure of 5% suggests that there is a realistic chance in Germany of being able to conclude the transition to digital transmission quickly and thus to shut down analogue transmission completely after a very short simulcast period.

Figure 3
DVB-T starup regions in Germany
(Sources: DVB-T Project Office, North Rhine-Westphalia)

In Germany, DVB-T is being introduced step by step, starting with urban areas. The scheme was launched in the Berlin/Potsdam conurbation on 1 November 2002. Since 4 August 2003, free-to-air television has been broadcast solely in digital form, with a current total of 27 free-TV programme channels. During the nine-month transition period, over 170,000 households decided to buy a DVB-T receiver, successfully concluding the world's first wide-scale change in terrestrial broadcasting in an urban area. As the next stage, DVB-T was given the green light in the regions of Cologne/Bonn, Hanover/Braunschweig and Bremen/Unterweser in May 2004. October 2004 will see the start of the change in the Rhine/Main region, November for the Düsseldorf and Ruhr areas, and from 2005 onwards, other regions in Bavaria, and in north, central and southwest Germany will join. *Fig. 3* shows the DVB-T startup regions in Germany.

In Germany, DVB-T is used for distributing free-TV. Pay-TV providers have as yet shown no interest in distributing their content using digital terrestrial technology.

As an example, the Cologne/Bonn region is considered in the following to further detail the launch of DVB-T in Germany. The start of DVB-T transmissions on 24 May 2004 in that region is the first stage of the transition in the federal state North Rhine-Westphalia (NRW) as a whole. The DVB-T multiplexes are transmitted in UHF channels. Reception can either be **fixed** via a roof-top aerial, **portable indoor** *(see Fig. 4)* or **portable outdoor** via a small rod antenna, or **mobile** e.g. in cars.

The DVB-T parameter setting of 16-QAM modulation, 8k mode, 2/3 error protection ratio and a guard interval length of ¼ of the useful COFDM symbol duration provides a data rate of 13.27 Mbit/s for each multiplex carried in a UHF channel. There are six DVB-T multiplexes in total, each containing four TV programme channels. Three of the multiplexes are allocated to the public service broadcasters ARD/WDR and ZDF, and three to the commercial free-TV broadcasters. Each DVB-T multiplex is distributed via a single-frequency network (SFN) operated jointly by the Deutsche Telekom subsidiary, T-Systems, and WDR using radio towers of both organizations.

Figure 4
"Portable indoor" DVB-T reception

A short simulcast, in which the television channels are broadcast in both analogue and digital form, has been agreed for the public service broadcasters and the commercial free-TV providers. The simulcast for the Cologne/Bonn region will end on 8 November 2004, from when on channels will only be available digitally.

The introduction of DVB-T in the Cologne/Bonn region was accompanied by a viewer information campaign. A DVB-T project office has been set up, which oversees the introduction process and bundles all further information for viewers. There have been information commercials and tickers on the analogue terrestrial television channels, informing the public about the launch of DVB-T and the analogue switch-off. Printed material is available in the form of leaflets and information folders containing maps showing the predicted reception in the NRW region. Additionally, viewers can access information on the introduction of DVB-T via the internet, at **http://www.nrw.ueberall-fernsehen.de**, and via a telephone hotline.

Interest among viewers has been high. In the first week after the launch of DVB-T in the Cologne/Bonn region, around 5,500 viewers rang the hotline. Between the beginning of April 2004 and the end of June 2004, a total of 13,000 viewers called. They had questions concerning receiving equipment, antennas, availability, and connecting the DVB-T set-top box with their television set or asked for general information on DVB-T in NRW. The feedback was generally very positive. Many viewers find the possibility of portable outdoor reception especially attractive, such as for sports programmes in the summer.

General criticism of, or dissatisfaction with, DVB-T was restricted to isolated cases only. There were hardly any complaints from so-called digital refuseniks affected by the planned shutdown of analogue terrestrial transmission. Coverage predictions have proved to be realistic. DVB-T can even be received in places that were not listed on the maps. Individual DVB-T reception problems could often be solved quickly and did not fundamentally put the viability of DVB-T into question. In places where old antennas had been installed, the amplifiers were often designed for reception up to channel 60 (786 MHz). In single cases this led to difficulties in receiving the DVB-T multiplexes that are broadcast on UHF channels 65 and 66.

Sales of DVB-T receivers in the Cologne/Bonn region are high, as had been the case in Berlin. Over 100,000 receivers were sold in the first four weeks after the launch of DVB-T alone. The main factor behind this positive trend is the free retail market for DVB-T. The cheapest DVB-T receivers already cost less than €100.

A list of minimum requirements for DVB-T receivers is available. Features that must be supported include two-channel sound, teletext, and wide-screen signalling (WSS). Ideally, the receivers should also generate a VPS [5] signal so that they can allow programmes to be recorded using an analogue VHS recorder. The complete list of minimum requirements is available on the Internet (in English) at **http://www.tv-plattform.de/download/DVB-T/MinAnfo/MinAn-V11e.pdf**.

Following the launch of DVB-T in the Cologne/Bonn region, DVB-T transmissions will begin in the Düsseldorf/Ruhr area on 8 November 2004. After a short simulcast period, the transition to DVB-T

5. **V**ideo **P**rogrammier **S**ystem: a technology developed for the German market for pre-programmed video recording of television broadcasts.

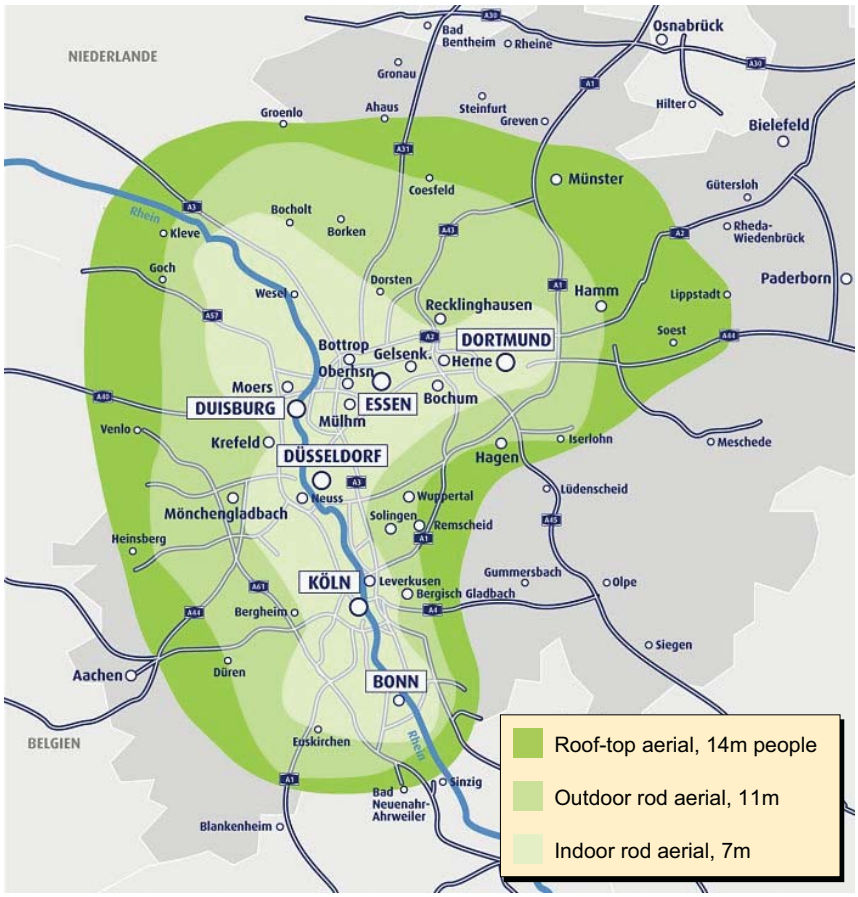

Figure 5
DVB-T startup region in North Rhine-Westphalia

is scheduled to be completed on 4 April 2005, when up to 14 million people in NRW will be able to receive six DVB-T multiplexes. *Fig. 5* shows the predicted DVB-T coverage in NRW as a function of fixed roof-top, portable outdoor and portable indoor reception. The date for providing DVB-T for the remaining three million inhabitants in other areas of NRW can be planned when the results of the Regional Radiocommunication Conference 2006 (RRC 06) in Geneva are available.

Cable

In Germany, the distribution of cable TV is conducted by a number of network operators at different network levels. *Fig. 6* shows the cable network operators and the number of households reached. There are a total of four network levels, with

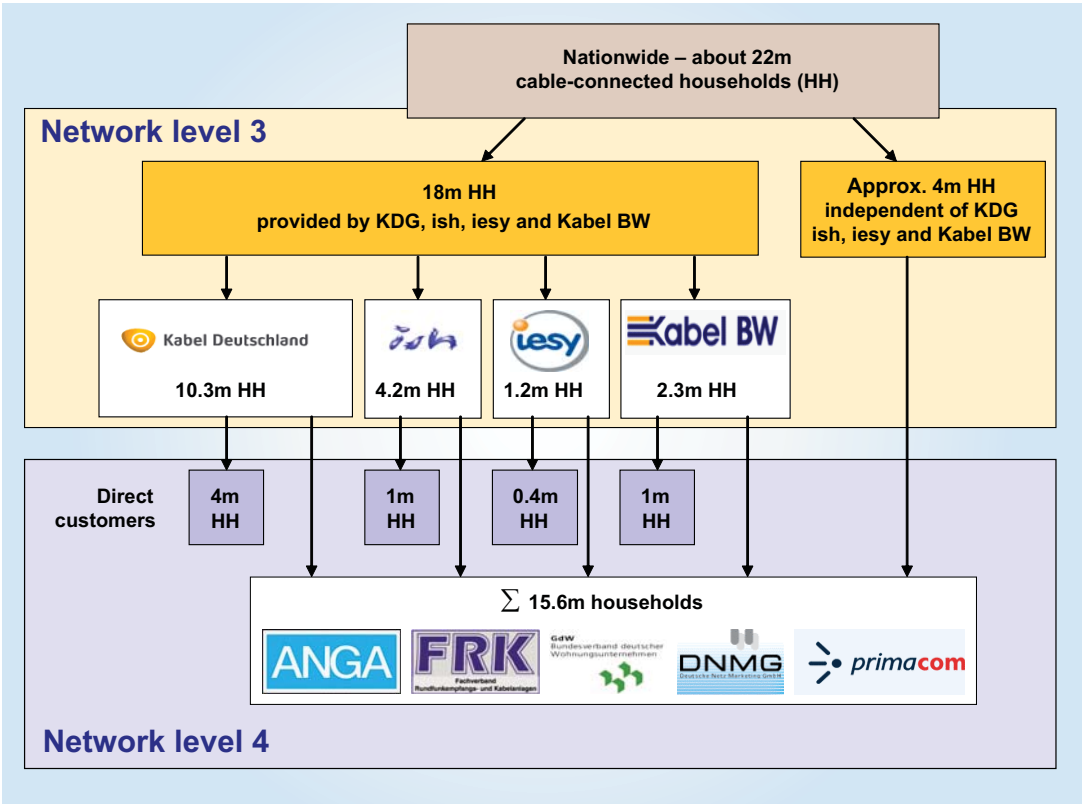

Figure 6
Level 3 and level 4 cable network operators in Germany
(Sources: ANGA, FRK, WIK 2002 and business information)

levels 1 and 2 ensuring the distribution of TV signals from the content provider to the cable head-ends. Network level 3 comprises the cable head-ends and the networks for carrying the signals up to a final handover point to network level 4. Lastly, operators at network level 4 are responsible for supplying cable households.

Around 22 million households are connected to the cable network. In mid-2004 there were three independent network level 3 operators running their own cable networks in three federal states: "ish" in NRW, "iesy" in Hessen and "Kabel BW" in Baden-Württemberg. In all the remaining federal states, the networks have been taken over by KDG [6]. These four network operators serve a total of about 18 million households either directly or indirectly via network level 4. The remaining 4 million households are supplied by independent network operators.

Since January 2004, KDG has been attempting to buy the "ish", "iesy" and "Kabel BW" networks. This points to a Germany-wide consolidation of network level 3. The assessment of such a takeover was expected by autumn 2004 from the German cartel office but, very recently, KDG announced that it has decided to withdraw its takeover bid.

Public service broadcasters ARD and ZDF maintain DVB-C transmissions in parallel with analogue cable transmissions. They have reached an agreement with KDG on the technical aspects for the 1:1 cable retransmission of their bouquets, *ARD Digital* and *ZDFvision*. DVB-S satellite multiplexes are transcoded to DVB-C multiplexes at the cable head-ends, leaving the relevant transport streams of the bouquets unchanged and unencrypted for delivery to the cable households. The TV programme channels of the bouquets can thus be received by any device complying with the DVB-C standard. There was a steady increase in the number of households using digital cable TV from the first DVB-C transmissions in 1997 to 1.4 million households in 2000.

As *Fig. 7* shows, growth has since stagnated at an overall low level. By the end of 2003, the number of cable households with DVB-C receivers had only increased to around 1.9 million. So far, digital cable in Germany is primarily oriented towards pay-TV. For this reason, the growth of digital cable households can be interpreted as a measure of the penetration of pay-TV receivers. The receivers have to pass a proprietary certification process specified by the pay-TV operator Premiere.

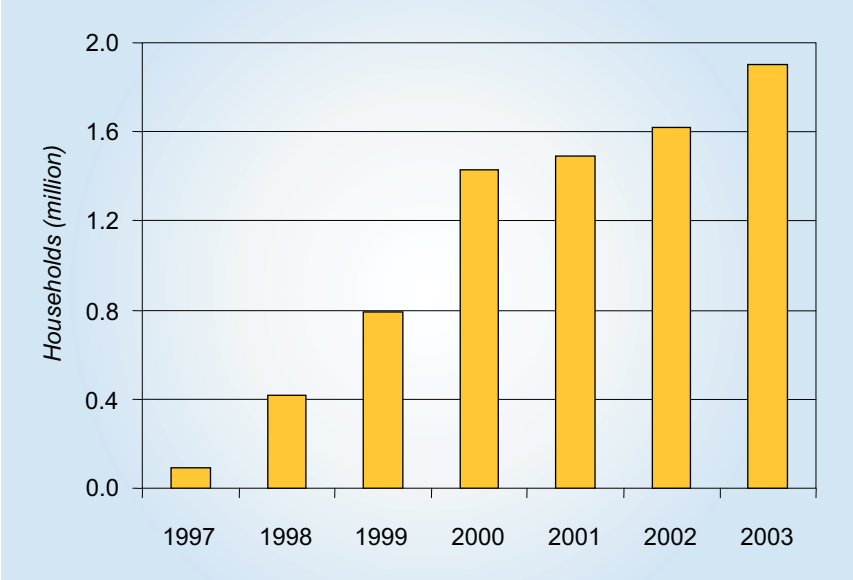

Figure 7
Digital cable reception in Germany (end 2003)
(Sources: SES Astra, German Satellite Monitor, TNS Infratest)

Terms for the reception of free-TV have been agreed that will allow a free market for DVB-C receivers. Cable customers will have a free choice of which equipment to buy and use with their cable connection. The manufacturers can equip the devices with different features according to their own wishes. For example, the devices may range from simple "zapping boxes" to ones with Common Interface (CI), MHP-API and an integrated hard-disk drive. The free-TV receivers do not need to be certified by KDG, which means that the receiver is not an integral part of the cable network.

However, DVB-C free-TV receivers are virtually non-existent. As yet, the content of commercial free-TV broadcasters is only available on analogue cable. For the sake of the development of digital

6. **K**abel **D**eutschland Vertrieb und Service **G**mbH & Co. KG: The company that has taken over the majority of the cable television network from Deutsche Telekom AG

cable, it is hoped that the commercial free-TV broadcasters will reach an agreement with the cable network operators and that the consumer electronics manufacturers will put a range of DVB-C receivers on the market to equal the success stories of free-TV on the DVB-S and DVB-T platforms.

Interactive television based on MHP

Interactive Television gives an add-on value for digital TV in comparison to analogue. The express intention of the "Berlin Declaration" of 18 February 2004 is to continue to push forward the Multimedia Home Platform (MHP) as the open standard for interactive television as part of a new initiative. The declaration was ratified by the public service and commercial free-TV broadcasters (ARD, ZDF, RTL Group and ProSiebenSat1-Media AG), as well as by the media authorities and the German Consumer Electronics Manufacturers Association (ZVEI). All parties agree that only joint efforts can lead to the success of interactive television. To achieve this aim, the broadcasters are required to continue their involvement at a programming level in order to make further attractive applications available. The consumer electronics industry is called upon to provide MHP receivers at acceptable prices. The media authorities will foster all activities by the consumer electronics manufacturers and broadcasters in support of MHP. In a second stage of the "Berlin Declaration", an agreement was reached with KDG on the support and acceptance of MHP in the cable networks.

In order to make audiences and the trade aware of MHP, ARD has been broadcasting an MHP promotion channel via DVB-S, which transmits various MHP applications in a 35-minute loop. Each application is accompanied by a video demonstration which presents the MHP application as a video signal, thus making it visible to all viewers with a DVB-S receiver. Viewers with an MHP receiver are also able to launch the actual application itself and test all its functions.

All parties have agreed to foster the development of MHP. In the first quarter of 2005, an assessment will be conducted of the extent to which the objectives of the "Berlin Declaration" have been achieved.

Conclusions

The preliminary results for digital satellite (DVB-S) and digital terrestrial (DVB-T) transmission in Germany show that a horizontal market based upon open technical standards is a key prerequisite for the successful analogue-to-digital transition. In particular, the combination of attractive free-TV programming with a free retail market for a wide range of TV receivers is a major driver. Vertical structures geared towards pay-TV, including a proprietary certification process for receivers, have led to stagnation in the digital cable (DVB-C) market and failed to generate a comparable and steady rate of increase in digital households.

The length of the obligatory simulcast period is an additional financial burden to the broadcast operation, thus the shorter it is the cheaper it will be. However, keeping the audience happy and not losing but gaining additional viewers is paramount to the broadcast business. Therefore, the number of households affected by the analogue-to-digital transition has to be carefully taken into account and balanced against the benefit of going digital and switching off the analogue transmissions.

Specifically, DVB-T is being introduced on an island-by-island basis in areas with dense population and with a very short simulcast period in the order of 6 months: on average, only 5% of all TV households rely on analogue terrestrial transmissions in Germany. The parameter setting for portable indoor and mobile reception distinguishes DVB-T from satellite and cable delivery, which have the larger number of TV programme channels as a plus.

Market figures show that the number of digital satellite households is increasing every year at the rate of about 60%. Therefore, it seems quite realistic to switch off the analogue satellite transmissions by 2010, after 13 years of simulcast operation. This long simulcast period takes into account

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Since 2000, Dr Werner has served as Chief Engineer at WDR in Cologne in the field of new technologies and training of technical staff.

Alfred Riedel studied electrical engineering at the University of Dortmund, Germany. After completing his studies with the main focus on communications engineering, he joined Westdeutscher Rundfunk (WDR) in Cologne in 1990.

Working within the newly-founded technology group of WDR, his field of responsibility is to analyse and assess new technical developments concerning all aspects of broadcasting. The main objective is to achieve potential improvements at operational level and to provide the customers with technically optimized services. Since the transition to digital broadcasting began, he has been involved in all key aspects of transmitting the broadcast services via satellite, cable or terrestrial channels.

Stefan Wirts studied electrical engineering with a focus on communication engineering at the University of Applied Sciences in Cologne, Germany. In 2001 he joined Westdeutscher Rundfunk (WDR) in Cologne.

In the technology group of WDR, he analyses and assesses the new technologies and trends concerning digital broadcasting. His field of interest covers MHP and DVB. Before the launch of DVB-T in the region of Cologne/Bonn in May 2004, Mr Wirts and the technology group of WDR were involved in the planning phase.

that about 40% of all TV households in Germany rely on satellite transmissions: a sufficient time frame is needed, in a purely market-driven situation, to prepare these millions of satellite viewers for the analogue-to-digital transition.

In contrast to the satellite and terrestrial cases, it is not exactly clear from today's perspective to what extent and how fast the vertical structures in the digital cable market can be overcome and horizontal structures be implemented – thus unleashing free-TV and a free retail market for TV receivers, based on open technical standards, as a driver for a rapid digital take-up similar to DVB-S and DVB-T.