

On the eve of the revolution

Digital television broadcasting in April 1994

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In a relatively short time, the Digital Video Broadcasting Project has grown into one of Europe's fastest-moving and most ambitious projects in the media environment.

Starting with a handful of specialists, DVB now involves over 130 companies and organizations in a joint effort aimed at establishing a coordinated set of standards for the digital transmission of television programmes by satellite, by cable and in terrestrial channels.

A new page has been opened in the history of broadcasting, and the DVB Project is a key element in the process.

1. EBU participation in the DVB Project

The EBU Technical Committee decided in April 1993 to actively cooperate in the Digital Video Broadcasting Project, in the development of digital satellite and cable broadcasting standards. The decision was not an easy one. Digital broadcasting systems would inevitably bring more competition for viewers' attentions, and more competition for

EBU Members. However, the alternative would have brought even more problems.

With or without the EBU, digital satellite and cable systems would inevitably emerge in Europe in the near future. As a partner in the discussion, the EBU could use its weight to help to ensure that at least there was a unique standard in Europe, a standard which allowed HDTV when needed, and a standard which would be as common as possible to a digital terrestrial television standard.

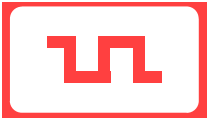
The discussions and the working arrangements have been sometimes difficult. EBU Members – and many others – have invested much time and money. They did not always get what they wanted. But the objectives have generally been achieved.

A digital satellite broadcasting system has been developed which can be used from any European satellite transponder, current or planned. The system has the capability for broadcasting conventional quality and high definition television. The baseband coding family, multiplexing, and first level forward-error correction will be the same for all transports: satellite, terrestrial, and cable.

There is even some prospect that the European system will also be used in other parts of the world.

If a measure of success is taken to be the development of an open system, then conditional access

Original language: English
Manuscript received 27/4/94.
This article is based on a presentation given by the author to the EBU Technical Committee, Amman, April 1994.



(CA), in which the EBU has not taken a major part, has not so far been successful. However, the arguments in favour and against an open CA system are complex.

The DVB Project is now turning its attention to the choice of channel coding and modulation for terrestrial television. There is also the prospect that the group will examine the interface with telecommunications network delivery.

A single technical coordination group, a common technical philosophy, and common standardization route, will apply for all digital television delivery media in Europe. This should be quite a benefit for the European public.

2. Structure of the DVB project

The DVB Project is not what it was in April 1993. As the year went on, the number of participants in the project increased dramatically. In early 1993, it looked like about 30 organizations would be involved. Today, there are about 130 members. The number of working groups has risen to over 20. Meetings sometimes have over 80 participants. One key meeting left a photocopying bill of 20,000 pages. The DVB Project is now a large and complex affair.

The structure of the DVB Project is given in *Fig. 1*. The largest group is the Technical Module. There are two Commercial Modules, which set commercially-based guidelines for the technical standards developed in the Technical Module.

The Technical Module itself has effectively become a decision and coordination group, because of its size. The detailed technical discussions take place in groups below this.

For the satellite standard, the EBU agreed to arrange for the work to be done in EBU Specialist Group V4/MOD. To speed up the work, the group was temporarily split into two parts, V4/MOD-A (multiplexing), and V4/MOD-B (modulation). It was necessary to open membership of the group to other DVB members. The Service Information system is being developed in EBU Specialist Group V2/SI, which is also open to other DVB members. The outputs from these groups follow two approvals paths in parallel, via the EBU structure and via the DVB structure.

The large-area cable network (CATV) system was developed in a newly created group, not part of the

EBU, DTVC (Digital Television by Cable), but the EBU provided the secretariat. The approvals path for this group is only via the DVB Project, but EBU Sub-group V4 is kept informed, and is able to comment on the system. An examination is being made of whether SMATV (Small Master Antenna Systems) can use the same system.

EBU Working Party R is represented on the DVB-TM by the Chairman of Working Party R. He has special responsibility for the coordination of terrestrial planning studies, and chairs an Ad-hoc group on terrestrial planning for digital television. The EBU assures the secretariat.

Dr. Ian Childs (BBC) coordinates digital audio.

The EBU Headquarters in Geneva provides a Project Office, handling the accounts, and much of the administration, for the DVB Project. Two contract staff have been appointed at the EBU Headquarters to assist the work. Members of the DVB Project pay a small subscription fee.

Separate funding from the European Commission, intended to help laboratories who contribute research and development in satellite and cable system, is available in the framework of the Euro-Image Project.

3. System philosophy

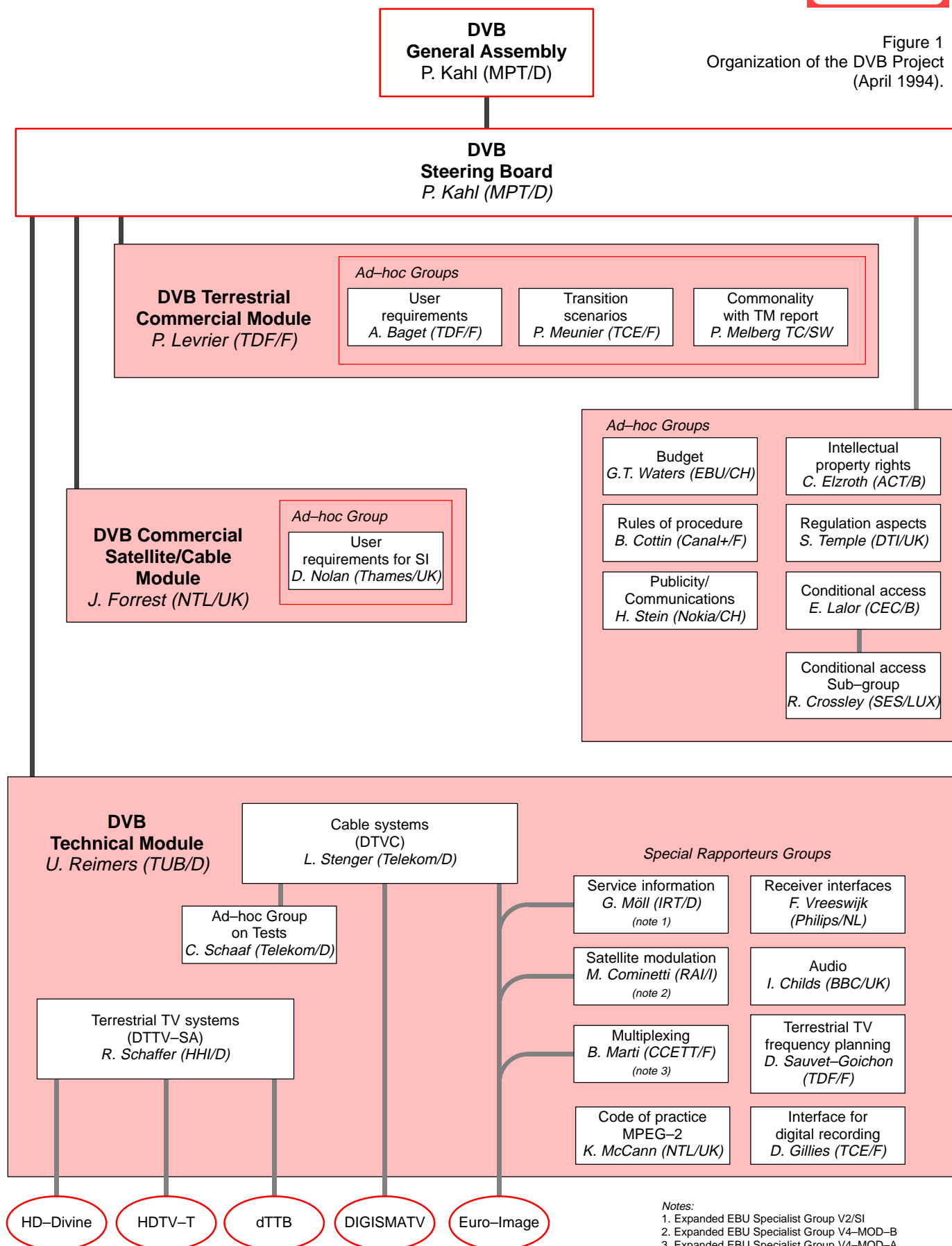
The requirements for the satellite/cable system, suggested by the Commercial Satellite and Cable Module, included modest-sized dishes, receiver costs of less than 1000 Swiss francs, a system to work on any satellite transponder, and so on. The requirements for the terrestrial system are still in preparation, but certain issues are the subject of consensus.

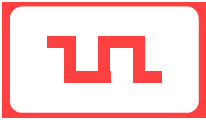
The general technical solution developed, valid for all media, has the following basic philosophy.

- Systems are designed as containers to carry MPEG-2 video and audio.
- Systems will use the common MPEG-2 transport stream-multiplex.
- Systems will use a common RS forward-error correction (FEC) system.
- Modulation and channel coding systems, and any necessary additional error correction systems, should be chosen to meet the media transport circumstances.



Figure 1
Organization of the DVB Project
(April 1994).





High 1920 pixels 1152 lines	X	80 Mbit/s	X	X	100 Mbit/s
High-1440 1440 pixels 1152 lines	X	60 Mbit/s	X	60 Mbit/s	80 Mbit/s
Main 720 pixels 576 lines	15 Mbit/s	15 Mbit/s	15 Mbit/s	X	20 Mbit/s
Low 352 pixels 288 lines	X	4 Mbit/s	4 Mbit/s	X	X
Levels Profiles	Simple No B-frames 4:2:0 Not scalable	Main B-frames 4:2:0 Not scalable	SNR Scalable B-frames 4:2:0 SNR scalable	Spatially scalable B-frames 4:2:0 SNR scalable Spatially scalable	High B-frames 4:2:0 or 4:2:2 SNR scalable Spatially scalable

Notes:

1. Profile/Level combinations marked X are not defined as compliance points.
2. A maximum of one SNR enhancement layer (in addition to the base layer) is allowed in SNR scalable, Spatially scalable and High Profiles.
3. A maximum of one Spatially scalable enhancement layer (in addition to base layer and SNR enhancement layer) is allowed in Spatially scalable and High Profiles.

Figure 2
MPEG-2 coding family.

Loosely comparing the different media transport circumstances, as a generalization, the broadcasting-satellite environment has bandwidth but no power, the cable environment has power but no bandwidth, and terrestrial television environment is similar. These all call for different trade-offs in the modulation systems and error correction systems used.

4. Vision and sound coding system

The sound coding specified is MPEG, which is also used for Digital Audio Broadcasting (DAB); it has been well described in many earlier publications.

The MPEG-2 vision coding system is less familiar, and is a family of standards which have arranged degrees of commonality. The family is summarized in Fig. 2.

A number of different coding and compression techniques are specified, and collectively they constitute a basket of tools, on which to draw. There are said to be five Profiles. That is to say, there are five subsets of tools taken from the complete range. (Some of the tools are actually not included in any Profiles, but this is because they might be included in Profiles in future, if there proves to be a need.)

There is method in the selections of tools drawn together for each Profile. The Profiles become progressively more sophisticated, and each additional Profile adds additional tools to the previous Profile. This means that each additional Profile will do more than the last, but is also likely to cost more to make, and thus cost more for the consumer.

The inputs to all the systems are YUV component video. However, the first four of the five Profiles code the colour-difference signal line-sequentially, like SECAM. That is to say, R-Y on one line, B-Y on the next, and so on.

The Profile which has the fewest tools is called the *Simple Profile*. It uses motion-compensated hybrid DCT coding.

The following Profile is called the *Main Profile*, and has all the tools in the Simple Profile plus one more compression tool (bi-directional prediction). It will give better picture quality for the same bit-rate than the Simple Profile, but will cost more silicon area. A Main Profile decoder will decode pictures that have been encoded with both the Main and the Simple Profile. This compatibility pattern applies to the succession of Profiles.

The Profile after the Main is called the *SNR Scalability Profile*, and this has all the tools of the Main Profile plus one more. This is the ability to separate the data into two parts, which might be thought of as a base-layer signal and a top-up signal. The base-layer signal is a version of the picture with a



reduced signal-to-noise ratio, but which only requires a fraction of the bit-rate of the total signal. The top-up signal, when added to the base-layer signal, improves the signal-to-noise ratio of the picture. When added together, the two parts give about the same quality for a given bit-rate as the Main Profile. This data partitioning feature costs additional silicon, but no extra bit-rate, and has its uses.

The base-layer signal can be made more robust than the top-up signal, so that when there is not enough signal strength to receive the total package, the base-layer signal can still be received. Furthermore, if there were times when there is not enough data capacity available to transmit the total bit-rate, a lower bit-rate version could be transmitted.

The following Profile is called the *Spatial Scalability Profile*, and has all the tools of the SNR Profile plus one more. This is a second method of partitioning the data. This time the data can be partitioned in terms of resolution. There is again a base-layer and a top-up signal, but this time the base-layer picture is the same picture, but at lower resolution. The sum of the base-layer and the top-up picture gives a complete picture of full resolution. This partitioning feature costs silicon, and also it costs quality, unlike the SNR partitioning. To provide the same quality as for the Main Profile needs 10–20% more bit-rate, so it has an overhead.

This system has its uses. The lower resolution layer can be made more robust, and can provide a broadcast signal for covering a wider area, or coping with more difficult reception conditions, at a lower resolution.

The following Profile is the *High Profile*, and it includes all the tools of the Spatial profile plus one more. This is the capacity to code line-simultaneous colour-difference signals. This costs silicon area, and may cost quality for a given bit-rate at lower bit-rates. However, at higher bit-rates, when the nuances of quality really matter, the line-simultaneous colour difference may benefit quality. In effect, the High Profile is the “super system” designed for the most discerning applications, where bit-rate is not a problem.

Coupled with the five Profiles are four *Levels*. These correspond to the image format which is used as the input. The lowest layer, is the *Low Level*. This is a quarter Recommendation 601 picture format. The following level is the *Main Level*, and this corresponds to the normal Recommendation 601 image format. The following level is the *High-14 Level*, corresponding to an HDTV pic-

ture with 1440 samples per line. The fourth level is the *High Level*, and this corresponds to an HDTV picture with 1920 samples per line.

Decoders for any given level also decode pictures at all levels below them. However, decoders at a given level will not decode a higher level, unless a spatial scalability bit-stream of lower resolution is available as part of the higher level.

Not all combinations of Levels and Profiles were thought useful or needed, and to date there have been requests for eleven of the 20 combinations to be considered as “approved”. These are termed the “MPEG-2 Conformance Points”.

Each Conformance Point can operate over a range of bit-rates. The range was chosen in each case to provide up to completely coding-artifact-free pictures. MPEG-2 is thus a variable bit-rate system.

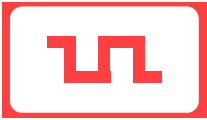
The MPEG-2 systems allows interlaced or progressive scan, and either 50Hz or 60Hz frame rate. There is a ceiling on the number of luminance samples at each conformance point, which means some combinations are not possible.

Given that all the digital media in principle allow any member of the MPEG-2 family to be broadcast, it still has to be decided which to use in a given set of circumstances. Manufacturers will only make receivers for services that are actually broadcast. The only requests received for first-generation DVB receivers for 11/12 GHz satellite and corresponding cable services are for Main Level/Main Profile services operating with 625-line interlace scanning. This will therefore be the basis for first-generation DVB receivers.

If a broadcaster wants manufacturers to make receivers corresponding to a given Profile and Level, he has to announce programme plans to provide such services, and take up an appropriate dialogue with receiver manufacturers.

Having decided on a given MPEG-2 conformance point, a decision has also to be taken on an operating bit-rate, or a ceiling on operating bit-rate, if the system is being operated in a variable bit-rate mode.

Not all the conformance points have been simulated or built, but a series of evaluations of the Main Level/Main Profile performance have been made with simulated systems. These were subjective evaluations of systems with a series of fixed bit-rates. There are several reasons why these results should be treated carefully, including the following:



- MPEG–2 encoder design can have a major influence on received picture quality.
- To really understand how the codec operates a relationship has to be established between picture quality and probability of occurrence, rather than simple point measurement of picture quality.
- The bottleneck on received quality can be the home receiver in practice.

However, the results tended to suggest the following:

- To match Recommendation 601 studio quality it is probably necessary to have a system which can operate up to about 9Mbit/s.
- To match PAL quality overall, a system is probably needed which can operate up to about 5Mbit/s.
- 50 Hz scanning consistently provides better quality for the same bit–rate than 60 Hz.
- Feature films are easier to code than video shot with an electronic camera, and will probably look good even at 4 Mbit/s.

5. Multiplex system

The multiplex structure is a fixed–length packet system which has 187 bytes of useful data; it is known as the MPEG–2 Transport Stream. The MPEG–2 TS has some Service Information elements, and adequate provision for a more developed system to be added.

The DVB Project is developing a full Service Information system which can be used with the MPEG–2 TS. This should be completed in May 1994.

The MPEG–2 TS is capable of signalling the presence of a conditional access (CA) system, but the actual scrambling system and the key management system is not defined in the MPEG–2 system.

The DVB Project has studied the prospects for a CA system standard, but to date the work has concentrated only on an optional common scrambling system.

6. Satellite modulation system

The satellite system had to be designed to cope with a range of transponder bandwidths (26 MHz to 72 MHz, –3dB), and a range of transponder

powers (49 dBW to 61 dBW). The potential satellites included Astra, the Eutelsat series, Hispasat, the Telecom series, Tele–X, Thor, TDF–1 and 2, and DFS.

The system devised is a single–carrier system, rather than a multiple–carrier system. Multiple–carrier systems require transponder back–off to reduce intermodulation, and lead to more expensive receivers. The major advantage of multiple–carrier systems is the ability to address individual sub–channels from different up–link sites, but this advantage is outweighed by the disadvantages. Thus the satellite system is essentially a digital time–division multiplex of services.

The satellite system, like all the systems, can be modelled as a kind of onion. In the centre, the onion’s core, is the payload, which is the useful bit–rate available. Surrounding this are a series of layers to make the signal less sensitive to errors, and convert the payload into a form suitable for broadcasting.

The video, audio, or other data is inserted into fixed length TS packets. The packetized data constitutes the payload.

The first step is to form the data into a regular structure, an 8–packet frame.

The next step in processing the payload is to randomize the data contents. The following step or onion layer is to add a Reed Solomon (RS) error–correction overhead to the signal. This is a very efficient and powerful error–correction system, and it adds less than 12% overhead to the signal. This is called the “outer code”. There is a common outer code for all media transports.

After this, a further error–correction layer is added, using a convolutional code, preceded by convolutional interleaving. This second error–protection layer, the inner code, can be adjusted, in the amount of overhead, to suit the transponder and the needs of the service provider. Thus the thickness of this next–to–outer onion skin can be varied.

Finally the signal is used to QPSK modulate the broadcast carrier.

There are thus two major variables: the total size of the onion, and the thickness of the second error–correction outer skin. In each case, the receiver will discover the right combination to use by a process of very rapid trial and error on the received signal.



A combination of payload size and inner code can be chosen to suit the service operators' environment. One combination will be for a 36 MHz (1dB) transponder to use the 3/4 convolutional code rate, in which case about 39 Mbit/s will be available as the payload. This seems likely to be a relatively widely-used format. Other examples are given in the DVB documents.

7. Cable modulation system

The cable network modulation system is based on quadrature amplitude modulation (QAM). The system is centered on 64QAM, but lower-level systems, such as 16QAM and 32QAM, can be used. In each case, the data capacity of the system is traded against the robustness of the data. A 15% roll-off is specified.

Higher-level systems using 128QAM and 256QAM are also possible, but their use will depend on the capacity of the cable network to cope with the reduced data eye height.

Echo-cancellation will probably be needed for the higher-order systems, and techniques of blind equalization (where no training signal is transmitted) are being studied.

In terms of capacity, an 8-MHz cable channel can accommodate a payload capacity of 38.5 Mbit/s in 64QAM without spillover.

8. Digital terrestrial television system

It was the development of a digital terrestrial television system that began the digital broadcasting story in Europe in about 1990. The original thinking on digital terrestrial television brought forward many revolutionary concepts about multi-layer systems, designed to make the system more attractive, many coming from EBU Members.

For European 8-MHz terrestrial channels, the practical limit on a broadcast payload is about 24 Mbit/s, but the payload may be less if a substantial error-correction overhead is needed. In North America, system payloads of about 18 Mbit/s are being used with 6-MHz channels.

The two key new concepts were "graceful degradation" and "scalability". The idea was that a system could be developed which suffered less from the familiar digital brick-wall failure characteristic ("either it's working perfectly, or it's not work-

ing at all"). This would help provide more customer-friendly coverage.

Furthermore, the benefit of a scalable system was that the broadcaster could address several markets at once, by arranging the system so that conventional-quality receivers and HDTV receivers could both receive the programmes. The conventional receivers could even be arranged to receive a specially robust signal that would work well with set-top aerials. Alternatively, the system could be used to start a service with conventional quality and move to an HDTV service later, without disturbing the conventional-quality audience.

These concepts were explained in detail in the Report of the DVB on digital terrestrial television in Autumn 1992.

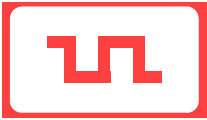
Since that time, three consortia, HD-DIVINE, HDTV-T, and dTTb have continued to study the options for digital terrestrial television.

The MPEG-2 process was strongly influenced by the European ideas on scalability and it was largely as a consequence of them that the MPEG-2 provides the means, at the baseband level, to implement the kind of system suggested.

The MPEG-2 system can provide a three-step graceful degradation characteristic for HDTV signals. It can provide a top HDTV layer, and beneath this an HDTV signal at lower signal-to-noise ratio, and beneath this a 625-line signal. The HDTV data is partitioned into three parts: a base 625 layer and two top-up layers which bring the signal progressively to noise-free HDTV. This might take typically, respectively, 6 Mbit/s, 6 Mbit/s, and 12 Mbit/s.

To make the baseband system function as required in the broadcast system the modulation system must be arranged to give the most robustness to the base layer, and progressively less robustness to the other two layers. For example, the base layer might have 8QAM modulation, and have, in constellations around the 8 QAM, the second and third steps signals effectively as 16QAM and 32QAM.

This is certainly an elegant idea, but it does come with a penalty. If the 24Mbit/s HDTV signal is broadcast as a stand-alone signal, it might be expected the signal should be receivable at a carrier-to-noise (C/N) ratio of, say, 19 dB. If, instead, a scalable system is used and the base conventional layer is designed to be receivable at a C/N ratio of, say 10 dB, the HDTV signal will now require a C/N ratio of something like 25 dB. What is more, it could be slightly less good quality than the stand-alone HDTV.



Different groups view this trade off differently. The HD-DIVINE project believes a stand alone system to be the most valuable. In the dTTb and HDTV-T projects, they believe the scalable approach to be the more attractive.

In the DVB Project this is not a matter of conflict however, because the digital terrestrial system is being designed, like the satellite and cable system, as a container for MPEG-2 systems. The system will be developed so that either the non-scalable or the scalable can be supported. Furthermore any combination of multi-programme systems which fit into the container can be used.

All three projects believe that the modulation system should be based on OFDM (orthogonal frequency division multiplexing). This is a system with a large number of carriers which share the information content of the signal. OFDM has been used successfully for the DAB system. Its strength is that it can operate in very strong multipath conditions.

The transmitted signal needs a somewhat wider slice of spectrum than would otherwise be needed, and the extent of the so called "guard interval" depends on the maximum time delay for the echoes that it needs to cope with.

Because of the multipath immunity of OFDM, it is potentially possible to operate a whole broadcast network on the same frequency in what is known as a single-frequency network (SFN). In areas of coverage overlap, for the receiver, the weaker of the two is like an echo signal. However, if the two transmitters are far apart, the time delay between the two signals will be large, and this means that the signal must have a long guard interval. The feature of being able to operate an SFN does not come free.



David Wood graduated from Southampton University in 1968. He currently works at the EBU headquarters in Geneva, and is Head of the Division which is concerned with the co-ordination of research and development among EBU Members.

David Wood has been particularly interested in image quality assessment for many years, and was until recently the Chairman of the CCIR Joint Interim Working Party 10-11/6 on this subject. He has recently been nominated to Chair a new Working Party on Conventional and Enhanced systems for CCIR Study Group 11A.

There are three different potential operating environments for digital terrestrial television: broadcasting in a currently unusable channel (such as an adjacent channel), broadcasting in a clear channel, and broadcasting in an SFN.

One of the design problems for the developers is that the three environments may lead to three different optimum solutions.

Furthermore, some organizations have recently suggested that instead of using OFDM, a single-carrier system could be used. This would have the major advantage that the terrestrial service could be launched immediately, because the current cable network specification could simply be used as it is.

Strongly linked to the technical systems development of the digital terrestrial television system is the coverage and frequency planning dimension. Europe presents a complicated patchwork of different environments for the planners. The Special Rapporteur for frequency planning has been cataloging the situations that exist, and the options open for introducing digital terrestrial systems, given different requirements for received signal strengths.

There appears no simple way forward which can universally be applied across Europe. The situation could be different if it were possible to switch off the current PAL/SECAM broadcasts and replace them with digital services. In this case, terrestrial bands would be an enormous resource for digital broadcasting channels. However, this is not the case, and at least for an interim period both analogue and digital services will have to live side-by-side. This means that there are major restrictions on what can be achieved, in terms of both broadcast bit-rates and coverage possible. Very difficult choices have to be made between alternative digital terrestrial introduction scenarios.

It is not yet clear how the final solution for digital terrestrial television will emerge. The concept which would appear to meet the requirements of the maximum number of different circumstances found in Europe is one with not just flexibility to include any MPEG-2 system, but also a flexible number of OFDM carriers, from two to eight thousand.

Test systems are being built with multilayer QAM and COFDM, and major demonstrations will be made in mid-1995. It remains to be seen when there will be consensus on systems or scenarios, but it may be by late 1994.



9. Receiver manufacturing environment

Fig. 3 shows the conceptual elements of DVB receivers.

In order to make DVB successful, both the programme material and the receivers will need to be available. It is only the combination of these that will bring success. The availability of consumer-attractive programmes is not known, but the indications are that it will be possible to assemble and sell DVB 11/12GHz satellite/cable receivers in the second half of next year.

The receiver architecture of digital television receivers can be expected to follow a set pattern over time. This is the so-called 'PACMAN' system. A pacman, for the benefit of the older readers, is a character from a video game who successively eats all the objects in play. In the receiver, successively, there will be fewer and fewer integrated circuits, until finally there are just one or two. This is the same pattern that many other major consumer electronic products have followed.

A number of component and receiver manufacturers are actively engaged in developing DVB MP/ML receiving systems. By way of example, but not to imply support or preference, the plans of LSI Logic can be considered, this being integrated circuit company which has made information on its plans available.

LSI Logic proposes a first phase of receiver implementation which uses five existing chips: MPEG-2 video decoder, MPEG audio decoder, demultiplexer, RS FEC decoder, and QPSK demodulator. Apart from this the receiver will need

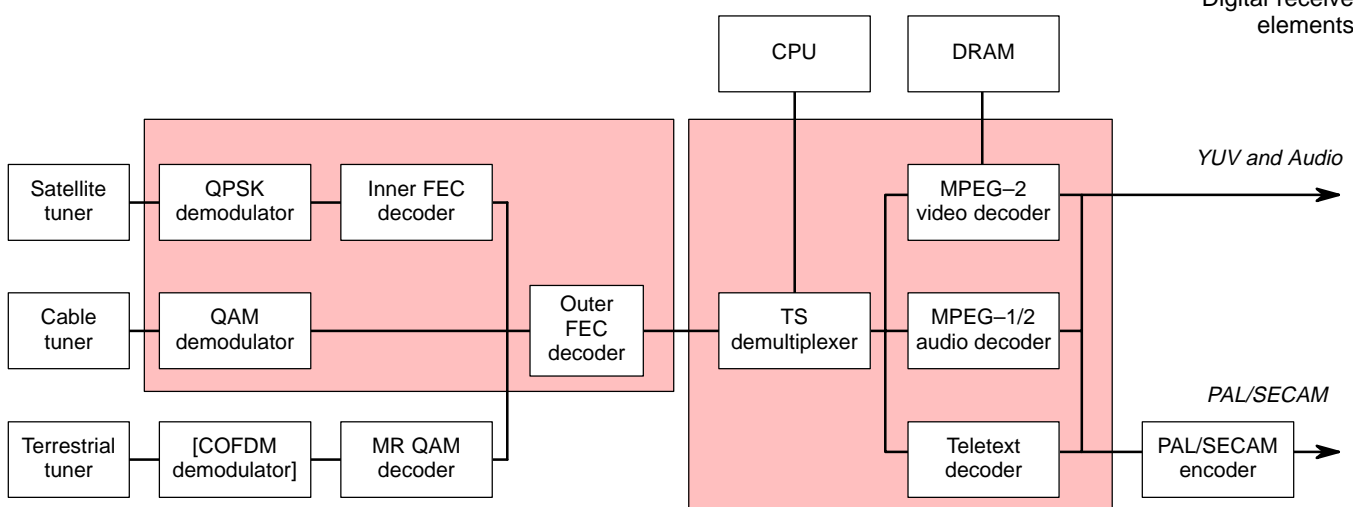
additional DRAM for the MPEG-2 decoder, a CPU to control all the elements, a tuner, and a PAL encoder. Samples of all these chips are already available, or will be available this year.

For a second-generation architecture, LSI suggest using a single combined MPEG video and audio decoder chip, a single CPU chip which both demultiplexes and controls the system, a single channel decoder chip which decodes both QPSK and QAM and performs the RS decoding, plus DRAM, tuner and PAL encoder. Examples of this generation of chips may be available in 1994.

For a third-generation architecture, LSI proposes a single chip which performs the channel decoding, demultiplexing, control, and source decoding. The only additional chips would be tuner, DRAM, and PAL encoder. Examples of the single-chip system may be available in 1996.

LSI logic estimate that the price of the ICs will allow receivers to be built, both initially and later on, in the price bands agreed in the Satellite and Cable commercial module. The retail cost of consumer electronics products is about 2.5 times the manufacturing cost, so the cost of the DVB chipset, including DRAMs, and the box, will be about 300 to 400 Swiss francs for the first receivers, and should fall in a few years to 150 to 200 Swiss francs.

In essence, a combined DVB satellite and cable receiver is likely to cost about the same as a domestic video recorder. However, cost estimations depend, more than anything, on production volume, so sound cost calculations have to be made case-by-case.



Note: The terrestrial system may be broadcast as a group of streams having different priorities.

Figure 3
Digital receiver
elements.

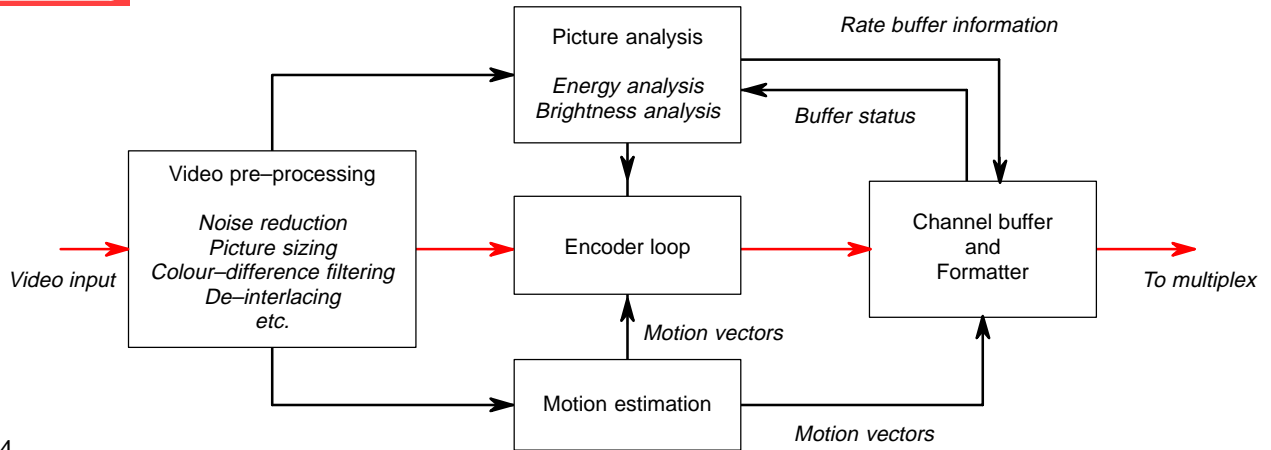
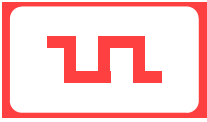


Figure 4
MPEG-2 encoder.

10. Broadcast equipment

10.1. MPEG-2 encoders

To provide signals, broadcasters will need professional quality MPEG-2 video and audio coders and multiplexers. The MPEG-2 system philosophy was to specify only the decoding protocol. The encoder is thus allowed to do, to some extent, what it likes, as long as the signal can be decoded in the standard way.

This means that encoding technology can evolve and improve over time, while the consumer is assured that his receiver will always work. This system combines the need for receiver investment stability with encouragement to the market to produce ever better picture quality.

Fig. 4 shows a conceptual block diagram of an encoder. The freedom for improvement lies largely in the two blocks marked “analysis” and “video pre-processing”. In the video pre-processing block, the kinds of tools that can be used to improve picture quality include noise reduction, picture sizing, colour-difference bandwidth, de-interlacing, etc. The analysis unit can make an energy analysis or brightness analysis of the picture, and use this information essentially to create the best possible match to the weaknesses of the human visual system, for the scene concerned.

Professional encoders will not be inexpensive, in the early years at least. If MPEG-2 encoders are ever to be used in consumer equipment, or the high-end amateur market, they will have to be appropriately priced in the longer term.

A number of manufacturers have announced the intention to make MPEG-2 MP/ML encoders, and at least one could be seen at the NAB Convention in March 1994.

10.2. Digital recording

The current plan for digital video cassette recording is that the home recorders will either record 625-line analogue components, via an internal (and rather simple) encoder working at about 25 Mbit/s, or incoming data itself (such as data in DVB format) will be recorded in a transparent way, with the VCR being used effectively just as a container.

A international consortium consisting largely of manufacturers has developed the digital video recorder system (the “DVC”). The DVB Project is working with the DVC project on interfaces, etc.

11. Conclusions

The DVB Project has to be seen as a remarkable achievement. The system developed combines the flexibility to cope with the evolution of broadcast media in the years ahead, with the capacity for an early start at consumer-affordable prices.

The dawn of the age of DVB in 1995 is seen by industry as “the opportunity of the decade”. How EBU Members will make use of the new opportunities remains to be seen. What is certain is that within the EBU the expertise is available to implement the systems, if the programme makers and strategists decide to take up the challenge.