Satellites, science and success
The DVB story

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The European DVB Project is seen as something of a model for the development of new systems in many parts of the world.

In this article, the author describes the lessons learned in the 1980s which led to the foundation of the DVB Project in 1993, and the successes it has since achieved.

1. Introduction

Success is a science. If the conditions are right, the results will come.

The DVB Project is probably *the* major success story in European broadcast technology of the last twenty years. It will provide our television future and more besides, possibly for the next fifty years. A confluence of the right events and the right people made it all happen, resulting in a unique set of specifications for the broadcast systems of tomorrow. DVB systems also look like being used beyond Europe – in fact the first broadcast services were in the Far East.

2. The past is a foreign country

In the early 1980s, various internal working groups of the EBU developed the MAC/packet television system. The hope was that this system would form the unique standard for satellite broadcasting in Europe. In the (then) new domain of satellite broadcasting, the MAC/packet system was to sweep away the old PAL and SECAM divisions which had cost the European consumer a lot of real money and inconvenience. The MAC/packet system was elegant and well-designed; it was a mix of the best analogue and digital technology available at the time.

The EBU invited the European consumer electronics industry to take part in the standardization of the MAC/packet system, but participation was modest. Maybe the invitation was not forceful enough. Or maybe industry realized too late what was happening. In any event, no matter how good the MAC/packet system was, a subtle but important element was missing – European industry, and indeed some broadcasters, did not feel they "owned" the system.

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The news, in the mid 1980s, that the European Commission was preparing a Directive which would bind the European states to use the MAC system for satellite television services was initially greeted with enthusiasm at EBU headquarters. But smiles faded when the final Directive appeared. It limited the use of the new "universal" system to only part of the band likely to be used for television satellite delivery. The future of satellite delivery was now going to be made more complex by the introduction of the MAC family, rather than more simple. The intention was being defeated, probably by that old enemy – the over-compromise needed to achieve complete consensus.

In the mid 1980s, the giants of the European consumer electronics industry were beginning to feel that many European broadcasters were not entirely on their side. They thought that EBU Members were not helping enough to prevent a US-promoted 1125-line HDTV broadcast system from gaining a foothold in Europe. They also thought there was a real risk of European industry falling badly behind other parts of the world, in the development of HDTV. European industry had only modest know-how in the technology of HDTV at the time.

A bold and imaginative plan was drawn up by European industry to develop an extension of the EBU's MAC system which would provide HDTV pictures, i.e. the HD-MAC system. But this time it was not the EBU groups who were offering the manufacturers the chance to join their studies. Now the manufacturers were in charge; on the HD-MAC Steering Committee, there were only manufacturers (at least at the outset).

A few years earlier, something had been developed which the manufacturers did not "own". Now something was being developed which the broadcasters would not "own".

Once again, the system (HD-MAC) represented the cutting edge of technology. It might have had a chance of succeeding, if the predictions made in the early 1980s – concerning the time-scale for HDTV displays to become available – had come true. In fact, even by the time HD-MAC was developed, you would still have needed a large bank loan to buy an HDTV receiver – and it would have been a dim screen at that. These were hardly the right conditions for a massive sales take-off! Nor were they the right conditions for European broadcasters, ever more pressed by competition, to invest in HDTV and to start new services. Hence, they did not do so.

The MAC/packet system was put together in something over a year. This meant that, at the end of the development stage, the technology used was still relatively state-of-the-art. HD-MAC, on the other hand, took a lot longer to develop – about five years. When the project began, the digital broadcasting of video – at the bit-rates possible for satellite transponders and terrestrial television channels – was just a dream. During the five years of the project, however, digital compression techniques improved many times over. In the time it took to develop HD-MAC from a highly-original technical concept, large technological strides had been made. The *development cycle* had been longer than the *new ideas cycle*.

By the early 90s, the European broadcast business had learned – the hard way – a whole series of lessons about the introduction of new technology. Next time it would have to be done right.

3. The light of experience

There is a very elegant model for data interchange – the ISO-layer model – which sees the process of data exchange as a stack of elements, one on top of the other. Each layer builds on the previous layer and the complete process is the sum of the layers.

Similarly, the broadcast industry has a set of layers which form a value chain. As shown in *Fig. 1*, it begins with a content provider, then a programme service provider, then a delivery system operator, then the consumer electronics manufacturers and finally, the viewers. The lesson from the eighties is that all elements of this stack must find concrete benefit in changing to, or adopting, a new system. Each layer must be sold on the idea. If they are not all "on board", a new technology will not happen. No one will succeed unless everyone succeeds.

Today, we increasingly see just one organization in control of several layers of the broadcast chain – a process known as *vertical integration*. In this case, the introduction of new technology becomes more "controllable". But, as far as the public is concerned, there are also traditional "downsides" to

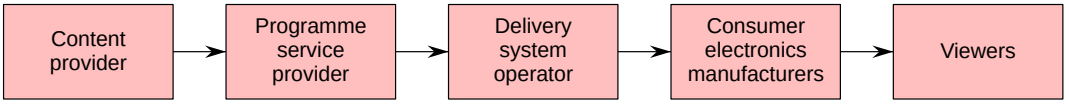
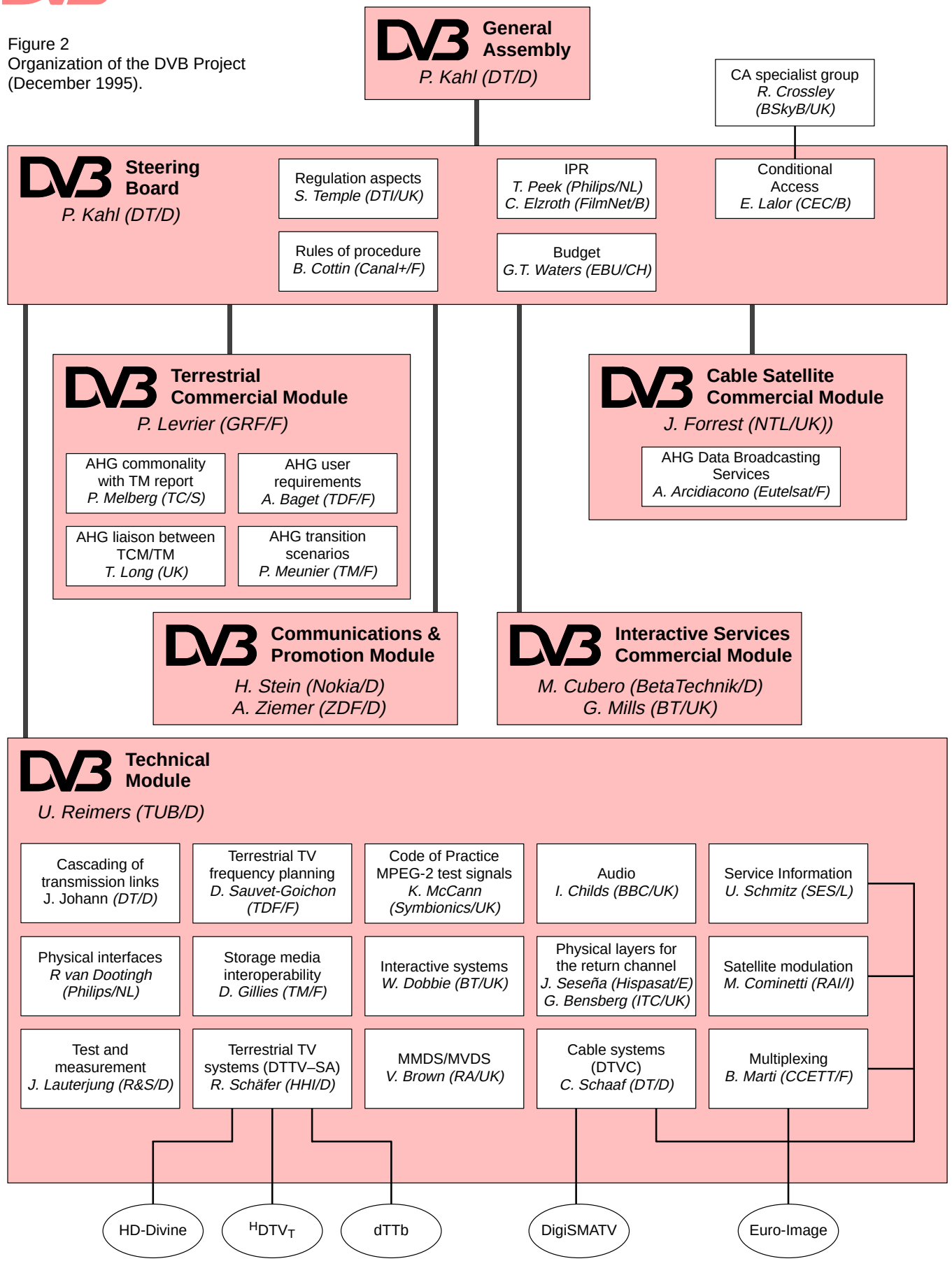


Figure 1
Principal layers which form a value chain in the broadcast industry.

Figure 2
Organization of the DVB Project
(December 1995).



vertical integration, including the adverse effects on the competition for services. Many EBU Members would like to see a separate, thriving, and independent consumer product industry maintained, acting on its own initiative and taking its own risks. While the DVB Project has not made it certain that this will be achieved, it has made it more possible.

Bringing all the key partners together for pre-competitive development was the dream of the "European Launching Group", the precursor of the DVB Group in the early 1990s. The intention was to bring together the four main constituents of the broadcast industry:

– broadcasters;

– consumer electronics manufacturers;

– signal carriers;

– national radio regulatory bodies.

They were to belong to a single group, and would all have a fair say in the discussion. This has now been achieved and is what the DVB group is today – a committed forum, representing the entire broadcast business, whose *raison d'être* is to foster agreements on new standards for digital television broadcasting.

4. DVB objectives

The three by-words of the DVB Project have been the same since the project began – *open*, *interoperable* and *market-driven.*

The systems for digital television broadcasting need to be *open* in the sense that they are available to all manufacturers to produce.

They must be *interoperable* in that they should use the same general architecture and baseband coding, transport, and error correction schemes. This means that much of the receiver circuitry will be common to the different delivery media (satellite, cable, terrestrial, etc.). The systems should use the maximum number of generic elements and, only where unavoidable, should use application-specific elements.

The systems should be *market-driven* in the sense that they should accord with what is likely to be saleable, rather than accord with what engineers think the public ought to be interested in.

The DVB Project is organized in a tree structure. As shown in *Fig. 2*, there are groups (Modules) which deal with commercial matters, and a Module dealing with technical issues. Sub-groups, which report to the Modules, tackle the more-detailed questions. The Modules report regularly to a Steering Board.

There are currently about 180 Member organizations in the DVB Project. Most are European, but a good number now come from the Far East, North America, and Australasia. The DVB Project Office is organized by the EBU, from its Headquarters in Geneva, and the DVB Steering Board is managed by staff at the Federal Department of Communications in Germany.

The DVB plan was to develop a set of specifications for digital television, covering a range of delivery media. These are shown in *Table 1*.

Universally applicable parts of each system are listed in *Table 2*.

Many of these elements are already complete and the remainder will be completed over the coming months. In future, the specification for an *Interaction Channel* for interactive television will also be targeted.

Each of the delivery systems is designed as a *data container* which can carry any type of data the service provider wishes. Nevertheless, the coding systems will normally be MPEG (audio and video).

DVB specification	Delivery medium
DVB-S	Satellite broadcasting system for the 11/12 GHz bands
DVB-C	Cable transmission system focused on 8-MHz cable channels
DVB-CS	Transmission via SMATV systems
DVB-T	Terrestrial broadcasting system for the UHF bands
DVB-MS	MVDS broadcasting system (> 10 GHz)

Table 1
The DVB set of specifications for digital television.

DVB sub-system	Universal application
DVB-SI	Service Information system
DVB-TXT	Fixed-format teletext delivery system

Table 2
Universally applicable parts of each DVB system.

In the late 1980s, Joint Technical Committee No. 1 of the ISO/IEC[1] formed a group called MPEG[2] to standardize audio and video digital compression systems. The agreements subsequently reached in that group were an amazing stroke of fortune for the DVB Project. It presented the Project with what it needed at exactly the right time – the most advanced digital compression system available, for both sound and pictures, and furthermore a system which had worldwide agreement. This meant that the two projects, MPEG and DVB, could feed off the success of each other, to stimulate even more the manufacture of the integrated circuits needed for DVB receivers. The same circuits would go into all sorts of audio-visual products, thus ensuring the lowest costs and the widest availability, coupled with the most advanced digital compression techniques available. All the DVB Project had to do was reach out and grab these ready-made baseband coding systems.

5. The market for new technology

The need for a market-driven approach was the result of burned fingers (or perhaps burnt-out cheque books) in the age of MAC and HD-MAC. We do not learn from our successes but from our mistakes. The engineers now realized that, before designing a new broadcast system, it was necessary to decide what the system should do for the public and how much it should cost to be successful on the European domestic market.

The price factor is critical. Some years ago, the EBU carried out some market research to evaluate the public reaction to high-definition television; HD-MAC pictures from an Olympic Games were displayed at various public sites in Europe. We found that, in spite of the large public appeal of HDTV for sports programming, there was still a relatively low ceiling on the price that viewers would be prepared to pay for equipment to receive this new technology. This ceiling price was, in fact, well below the likely retail costs of HDTV receivers at that time. It was clear that the hour of HDTV broadcasting had not yet come.

At the start of the DVB Project, there was considerable experience in France, Germany and the UK on the manufacturing and marketing of analogue set-top boxes for satellite reception. This experience gave some clues to the amount the public might be willing to pay for a much wider choice of channels. The known public appetite for an ever-increasing choice of channels, coupled with the prospect of a low-cost set-top box which would work in conjunction with an existing television receiver, gave much impetus to the Project.

One of the other lessons learned from the past was the need to shorten dramatically the time taken to market a new system. The development of a new system needs to be done in months instead of years, if the risk of being overtaken by new technology – before the product even reaches the shops – is to be removed.

6. Development priorities

When the European Launching Group was set up, it seemed that the pathfinder digital television system would be based on terrestrial transmissions. However, it soon became clear that this was not to be the case. For many reasons, digital satellite television was going to lead the way.

The world of terrestrial television broadcasting in Europe is a very complex one, as there is frequency congestion in many parts; frequency channels for terrestrial use are regarded as a precious national resource and their use is bound up in legislation and governmental decrees. Finding the channels to broadcast digital terrestrial television was going to be a major headache, across almost the whole continent.

Furthermore, the practical environment of terrestrial television broadcasting is a complex one. It is a world where the public expects, almost universally, to receive services via a rooftop antenna and, very often, via just a simple antenna sitting on top of the television set.

To develop a digital terrestrial television system was certainly a key target for the DVB project. But it was going to take time and effort. Effort was needed to find a modulation system that could live comfortably in proximity with analogue television channels. Effort was needed to sort out the complex legislative framework needed to start new services in each country. Effort was also required to consider a transition plan for the move from analogue to digital – on the assumption that eventually all terrestrial television broadcasting would be digital for the sake of efficiency.

1. The International Organisation for Standardisation (ISO) and the International Electrotechnical Commission (IEC).
2. Motion Picture Experts Group.

7. DVB-S – the first specification

Bearing these points in mind, it was clear that the digital *terrestrial* system was not the first job that should be tackled. The first target should be digital *satellite* broadcasting – DVB-S. The system required here was an easier one to develop from the technical viewpoint, and was the easiest to introduce from a legislative viewpoint. National or pan-European coverage is readily available from satellite channels, and governments regulate them with a light touch, at least in the direct-to-home (DTH) bands.

The satellite specification was begun and finished in about six months. There were problems and disagreements over the parameters. That is normal. But there was also great enthusiasm for the objective, and a spirit of cooperation. This was the honeymoon period – which, some say, often comes in the period just after a new standards group has been formed.

The DVB-S system combined MPEG coding and transport with a straightforward QPSK modulation system. The data capacity is selectable, according to the transmitter bandwidth, the transmitter power and the target antenna size. The target shop price for the set-top receiver box is 450 ECUs.

The DVB-S specification was fixed in 1993, and passed through the formal process of ETSI standardization. By 1994, the stage was set for programme service providers to make their plans for services. This was completed and a range of DVB-S services were scheduled to begin in Autumn 1995 and Spring 1996. In this system, a popular combination of error correction rate and transponder bandwidths leads to a digital delivery package, running at about 39 Mbit/s. This can carry between six and ten conventional-quality television channels – depending on how critical you are about quality.

8. DVB-C and DVB-SM – the partners of DVB-S

A cable partner for the DVB-S system was clearly important for many parts of Europe. It seemed most efficient to design the system to be capable of taking all the services provided by a single satellite transponder and transcribing them onto a single terrestrial cable channel. The DVB-C system, centred on the use of 64-QAM[3] modulation, was thus developed by the DVB Project and formally standardized by ETSI[4]. It has already been used on cable networks in Germany.

Southern Europe has a preponderance of localized cable systems. These are called SMATV[5] systems and are distinct from cable networks which cover large areas, known as CATV[6] systems . After extensive practical tests on SMATV networks, the DVB-CS system has been agreed. This effectively allows re-transmission on the SMATV network of either the DVB-S or DVB-C formats, depending on the operating environment of the SMATV network. The DVB-CS system has also been standardized by ETSI.

The technical characteristics of the DVB-S and DVB-C systems were delineated in extensive practical trials within the Euro-Image Project[7].

9. DVB-T – the terrestrial system

By now, it was the turn of digital terrestrial tele vision to take centre stage within the DVB Project. Research into the best technical parameters needed had been continuous over the previous two or three years, via a number of pan-European collaborative projects; in particular, the HD-Divine, $^{H}DTV_{T}$ and dTTb projects.

Digital terrestrial television did indeed prove to be a complex technical issue. At the time this article is being written, the DVB Technical Module has just recommended a system to its parent bodies. A range of technical parameters have to be chosen, and the final choice will have an impact on the receiver costs, its capabilities, and when it could be in the shops.

Some parts of Europe need a digital terrestrial system earlier than others and some countries have more acute frequency-congestion problems than others. This has led the DVB Technical Module to conclude that the best outcome for digital terrestrial services would be to allow for two options:

3. Quadrature amplitude modulation.
4. European Telecommunication Standards Institute.
5. Satellite master-antenna television.
6. Community antenna television.
7. The Euro-Image Project was set up to study the performance of DVB systems for satellite and cable delivery, and the Service Information aspects. Coordinated by the EBU, it was partially funded by the European Commission.

1) "2k" OFDM plus QAM

This option is aimed at those areas that need to start services early; it uses a less-sophisticated modulation scheme than the second option.

2) "8k" OFDM plus QAM

This more-sophisticated option is aimed at those who need large-area Single Frequency Networks (SFNs).

Receivers that are designed to receive the 8k/QAM system will also need to be able to receive and interpret the 2k/QAM broadcasts. This is a dual system with one-way compatibility and has now been agreed by the DVB Steering Board.

10. The Conditional Access debate

The DVB project is a democracy. Inevitably there will be groups with different interests and viewpoints in any such gathering. This turned out to be the case with the development of a pay-TV or Conditional Access (CA) system. In this case, the views of EBU Members were often different from those of the majority of other members. However, as is normal in this situation, the majority view was carried and adopted.

The EBU Technical Committee originally argued that the best interests of Europe would be served by the development of a unique basic CA system. This would be used by all service providers and would allow easy public access to all services, without the need to buy or obtain a number of different additional set-top boxes to de-scramble pay-TV services. The idea was that each programme service provider would control his own services via a device such as a separate smart card, which could be supplied by individual programme service providers or groups of them.

Other organizations argued that a unique CA system was not in the interest of Europeans. One reason put forward was that it would be too easily pirated and, once the code had been cracked, no channel would be safe.

There was majority support for the collective development of one part of the conditional access system – the *scrambling* system. However, what has been developed in fact is *a* common scrambling system and not *the* common scrambling system. Similarly there was majority support for the development of a common receiver interface, to which different conditional access systems could be connected. Once again, this is not a mandatory but an optional interface for DVB receivers. Finally, DVB members agreed to a code of conduct which would help to reassure those without their own CA systems that they would be given fair access to the proprietary systems of others.

These moves were welcomed by EBU Members as steps in the right direction, but there were (and still are) fears that these measures are not sufficient to ensure that the public has ready access to all services. It may still mean that the viewer has to buy or obtain several additional boxes for his/her television, and that programme service providers who enter the market at a later time will find it difficult to gain a foothold with audiences. Time will tell whether the anxieties of EBU Members are justified.

11. Moving ahead

Today's technical challenges in the DVB Project include the development of specifications for MVDS[8] television. Two specifications may well be needed for different MVDS frequency bands.

The format for an *Interaction Channel* for interactive television is also an important item for the future.

8. Multipoint video distribution system.

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Mr. Wood is Chairman of ITU Working Party 11A (Television Systems and Data Broadcasting) and Chairman of the EC RACE Image Communications Project Line.

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An important worldwide standards group called DAVIC[9] was formed some time after the DVB Project was launched. We could be forgiven for thinking that this may have been prompted partly by the success of the DVB Project. DAVIC is drawing together – and specifying where necessary – the systems for all types of audio-visual delivery media, including broadcasting. The DVB proposals have been submitted to DAVIC.

The DVB Project has now completed, or nearly completed, its job. It has paved the way for the digital broadcasting revolution in Europe. Have we done all the right things, at all the right times? Inevitably not. But the record will show that, overall, it was a success and an effective vehicle to launch the digital revolution.

There is a saying in South America: *"Thinkers prepare the revolution. Bandits carry it out"*. We must hope that those who provide the programme services for the new digital broadcasting universe will find ways to use this magnificent resource wisely.

Acknowledgements

Very many engineers and others have contributed to the success of the DVB Project and it would be impossible to name even those who most deserve recognition. Nevertheless, we can note that both Prof. Ulrich Reimers and Dr. Mario Cominetti have already received well-deserved awards for their efforts. Furthermore, the staff of the DVB Project Office – Lou Dutoit and Peter McAvock (see *Figure 3*) – have worked tirelessly on the project.

Photo: Chris Miles

Figure 3
Lou Dutoit and Peter McAvock at the entrance to the DVB Project Office in Geneva.

9. Digital Audio-Visual Council (see the article beginning on *page 51*).

Terrestrial DVB agreed

In December 1995, the Steering Board of the European DVB Project agreed on the specification for the terrestrial broadcasting of digital television signals.

The specification describes a *dual-mode* transmission scheme which allows for either a "2k" or an "8k" Orthogonal Frequency Division Multiplex (OFDM) system to be used. The 8k system – based on the use of 6817 carriers – is compatible with the 2k system which uses 1705 carriers. Both systems use Quaternary Amplitude Modulation (QAM) of each carrier. Either system may be used to transmit large amounts of digital data (video, audio, text, graphics or general data) to receivers which may use either a rooftop aerial or a simple indoor antenna.

The specification, referred to as DVB-T, is closely related to the existing specification for satellite transmission (DVB-S) and to the specification for cable distribution (DVB-C).

The introduction of DVB-T in Europe will most probably start in the United Kingdom as early as 1997, initially using the 2k variant which has been designed for early-start applications. The 8k variant – which offers larger-size single frequency networks (SFNs) than the 2k variant, and is therefore preferred in some terrestrial situations – is likely to be introduced shortly after, when suitable receivers are available.