HDTV

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Analogue HDTV in Europe

What are the key issues in analogue HDTV/EDTV systems? *

B. Pauchon (GRF - TDF)

Analogue enhanced or high-definition television systems tend, by nature, to be amenable to evolutionary development and implementation. HD-MAC, the newest member of the MAC/packet family of standards whose development has been fostered by the EBU for a number of years, is the fruit of just such an evolutionary approach. Having gained the support of the European Commission as the only non-digital high-definition satellite emission system for Europe, HD-MAC is set to establish an early foothold in the high-definition market. It therefore has an important rôle in promoting public demand for better pictures, better sound and, above all, for the 16:9 aspect ratio.

PALplus, a 16:9 compatible development of the PAL system which has been the backbone of European 4:3 colour services for a quarter of a century, is set to sustain the interest of millions of viewers in the services of broadcasters who must continue their terrestrial services in the period of transition to all-digital HDTV - a transition which is expected to last well into the next century.

1. Introduction

What are the analogue enhanced or high definition systems available or likely to be available in Europe?

- enhanced composite systems (PAL and perhaps SECAM);
- D2-MAC and HD-MAC (hybrid analogue/digital systems).

Would they be able to live together?

Would they even be able to live with digital television?

In other words, are enhanced composite systems, D2-MAC, HD-MAC and digital systems going to be friends or foes?

Before dealing with the heart of these interesting questions, a brief reminder of some of the history of the MAC packet system, where it is today, and the recent activities of the European Commission (EC) to help the introduction of D2-MAC 16:9 and HD-MAC, will be appropriate. This will concen-

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trate on the Directive issued by the Council of Ministers of the EC on D2-MAC and HD-MAC and the Memorandum of Understanding associated with it.

Then, in the second part of the paper, some general, and I hope useful, remarks will be offered on the crucial issue: enhanced composite systems, D2-MAC, HD-MAC, digital systems - friends or foes?

2. Activities of the European Commission to stimulate the introduction of D2-MAC 16:9 and HD-MAC

The MAC/packet system is the result of extensive work by the EBU at the beginning of the 1980's. After many discussions, a final compromise was reached at the EBU Technical Committee which met in Seville, Spain, in 1985.

The implementation of the system suffered from some delays which occurred for a variety of reasons: the chipsets did not come as early as expected, in particular because question marks were raised about the need for dual-standard receivers, D2 and D both members of the MAC family. Then came the question of conditional access systems which had to be defined prior to the launch of the programmes. As you can imagine, getting different competitors around a table in order to persuade them to use the same conditional access system to reduce the number of boxes in the house, (but at the same time allowing the viewer to switch [zap] from one programme to another) was not an easy thing. Then came the merger of two British operators resulting in BSkyB and finally the fact that the UK abandoned the D-MAC system.

At last, however, a number of programmes are being transmitted in D2-MAC via several satellites: TDF, TVSat, Olympus, Astra and others. But to be honest, as most of these programmes are also available on current PAL or SECAM sets via terrestrial TV or satellite or cable distribution, there are not yet many homes equipped with MAC/packet receivers.

In this context, it appears that the unique advantages of MAC are:

- its ability, available now, to transmit 16:9 pictures and to fill 16:9 displays;
- its ability to be upgraded, in a fully-compatible way, to high definition HD-MAC (and it should be remembered that compatibility works in both directions - downwards and upwards).

Other features, such as digital sound, also exist but which are not unique to the MAC systems.

Consequently, the manufacturers have worked intensively on 16:9 displays and the last I.F.A., in August 1991 in Berlin, was the first time these new television sets were exhibited to a large public.

But the chicken and egg problem remains - why manufacture large quantities of 16:9 television sets and offer them to the public at a reasonable price if there are only very few 16:9 programmes? And why produce and broadcast 16:9 programmes if there are not many viewers equipped with 16:9 sets?

In order to resolve this dilemma the Commission of the European Community, under the authority of the Vice-Chairman Filippo Mario Pandolfi, took two key initiatives last year:

- a Directive;
- a Memorandum of Understanding (MoU).

The Directive has now been issued. It is applicable until the end of 1998, but every two years opportunities are given to the Commission to propose to the Council of Ministers that the Directive be adapted if necessary.

The partner of the Directive is a Memorandum of Understanding (or MoU) between all parties involved; this has not yet been finalized.

The Directive applies to standards for satellite broadcasting of television signals. As far as transmission standards are concerned the main points of the Directive are, in summary, that:

- only HD-MAC may be used for non-digital HDTV transmissions;
- only D2-MAC may be used for non-digital 625-line transmissions in the 16:9 format;
- all 16:9 receivers must incorporate a D2-MAC decoder from 1 January 1994, with other receiving equipment incorporating a standardized socket.

Further provision is made for the use of D2-MAC by 4:3 services starting after 1 January 1995, subject to the adoption by Council of a Commission proposal on financial support for such services. Commission proposals are also required by 31 December 1993 as regards other services with a view to gearing efforts to the widespread introduction

on 1 January 1995 of D2-MAC, with an increasing share of 16:9.

At the same time as adopting this common position, Council requested the Commission to intensify its contact with the representatives of the various sectors concerned with a view to reaching agreement on the Memorandum of Understanding to be signed in parallel with the final adoption of the Directive. Council also invited the Commission to take immediate measures to facilitate the implementation of initiatives for the broadcasting of 16:9 D2-MAC services. This raises the question of Community financial support, for which the Commission must make proposals covering the period 1993-1997 by 30 April this year at the latest, independently of the support which may be made available in 1992. Preliminary consideration of a support package has led to the following orientations:

1. The strategic importance of the development of 16:9 services as an essential part of the evolution towards HDTV has thus been confirmed by Council. Since the natural market for satellite television is Community-wide as the same satellite signals can be received across national borders, it is essential to act at Community level.

2. As has been stated on several occasions, the financial support needed from the Community budget for the development of the above mentioned services has been estimated to be of the order of magnitude of 800 to 1000 million Ecus over a five-year period.

One general principle with an effect on the overall amount of resources needed, and which can guide the concrete application of these incentives, is that of a degressive approach. This implies that the highest level of incentives would be made available at the start of the period, in order both to give a clear signal to the market and to provide for the market to move subsequently to its own spontaneous evolution.

Another important principle is equitable access to financial support. To this end measures will be taken to ensure a broad balance, both in linguistic and geographic terms, of the distribution of the incentives.

3. As far as the incentives are concerned, three different categories could be considered:

a) Financial incentives provided for broadcasters in order to support the cost of *transmission* in 16:9 wide-screen format and D2-MAC standard.

   The priority objective is the rapid emergence of a sufficient number of D2-MAC services, both to make available to the European consumer an improved quality of television and to open the way for the introduction of HDTV.

   In line with the degressive approach, the level of financial support will be reduced progressively over time as follows: the earlier the service starts the higher the level of financing and whatever the starting date of the service, the financing will be highest in the first year and reduced progressively in subsequent years. The level of financial support will be higher for those services using D2-MAC in 16:9 format and also related to the percentage of programmes in this format within each service.

b) A second category of financial incentive relates to the *production* of *new programmes* in 16:9 format, and the *conversion* of suitable existing programme material into the 16:9 format.

   Support will be provided on the basis of the extra cost of making a programme of improved technical quality in the 16:9 format.

   A suitable proportion of the sum made available will be reserved for programmes produced by independent producers and producers established in countries with a lesser audiovisual capacity.

   Conversion costs for re-scanning existing programme material for the 16:9 format should also be taken into account.

c) Specific incentives will be required for cable operators, in order to cover the extra costs arising from their need to update their networks and make them able to receive and distribute D2-MAC signals. This will principally involve the adaptation of head-end equipment.

4. The support provided by the Community will be managed by an "entity" with an appropriate legal form, created under the forthcoming Memorandum of Understanding. The MoU will, on the basis of mutual commitments, allow broadcasters, equipment manufacturers, satellite operators and cable operators to mount a joint effort for the introduction of enhanced television services.

In this framework the "entity" will administer the financial support to develop in particular the following activities: producing and broadcasting programmes in 16:9 D2-MAC; ensure the availability of receivers in the market; ensuring sufficient satellite transponder capacity and cable network capacity.

Basic rules of the functioning of the "entity" will ensure the transparence of the distribution of financial support, as will the role of the Commission in monitoring its operations.

At the time of writing, no more can be said because the negotiations about the establishment of this MoU have only just started.

3. Enhanced composite, D2-MAC, HD-MAC, digital systems: friends or foes?

Assuming that the delivery to the public of 16:9 D2-MAC and, later, HD-MAC programmes, will be a success, a question immediately arises: *what should be the strategy of existing broadcasters for whom the quasi-totality of the audience is reached by terrestrial transmitters?* How will they remain economically healthy, that means how will they avoid losing a critical amount of audience which finds them less attractive because of their old-fashioned 4:3 aspect ratio? That is especially problematic for those serving regional or local audiences, for whom renting a satellite channel would be inadequate. But it is also a problem for those serving national audiences for whom the best strategy is to avoid forcing viewers to buy communication satellite dishes and tuners in order that they may receive their programmes in 16:9 aspect ratio, because at the same time these viewers would be well equipped to watch the many programmes offered on satellite channels by competitors. The answer is simple: the best solution is to offer existing programmes, in the 16:9 format, through existing transmitters and antennas, in a way which is as compatible as possible with existing 4:3 sets. This is why, from the terrestrial broadcasters' point of view, the PALplus project was born. This is also why, in France, attention has always been paid to the applicability to SECAM of the solution found for the PALplus system. Indeed, it was at the EBU Technical Committee meeting in Constance, Germany, that it was decided to set up the Ad-hoc Group V/EPS - EPS standing for Enhanced PAL and SECAM.

Examination of the activities of the PALplus project group shows that the same manufacturers (particularly Thomson, Philips, Grundig and Nokia), who actively support the MAC and HD-MAC systems, also play a major role in the PALplus project. This is not a coincidence: compatible enhanced composite systems, such as PALplus, will be another means to fill, and therefore to sell, the 16:9 displays for which they have already invested heavily in the context of 16:9 MAC and HD-MAC.

The immediate development of sales of 16:9 sets relies exclusively on the use of the MAC system, that means satellite and cable networks, for the next several years (at least until the finalization of the PALplus project). This is why the European Commission is making all the effort mentioned earlier.

But the development of any new audiovisual service, especially if it requires additional purchases by the customer, such as a dish and a satellite tuner, is relatively slow in the first two or three years. Therefore, it is certainly in the interest of manufacturers, in order to help the introduction of the 16:9 format, that the screens of these new 16:9 sets will be filled not only by programmes carried via satellite, but also, in a compatible way, by the most popular existing programmes which are transmitted by the terrestrial transmitters.

Of course, a third way of filling these 16:9 screens will be the implementation of digital systems, which everyone seems to agree will be based on the 16:9 format (with, however, some attention paid, at least in Europe, to the large proportion of viewers who will remain equipped with 4:3 sets).

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But there is no doubt, given the time required for their large-scale development, that these digital systems will not help the development of the 16:9 market in the immediate future.

So now we come to the crucial question: *are all these systems friends or foes?*

To help find some answers to this question, some other questions may be posed, some of which might be felt to be provocative:

- Will enhanced composite systems such as PALplus develop well in the absence of success of their "raison d'être", i.e.: 16:9 MAC?
- Moreover, would it be good strategy for broadcasters to actively support the move to PALplus if 16:9 MAC appears not to be very successful? Would it not then represent a move resulting in more expense for no additional audience (and for commercial broadcasters, no additional revenue)?
- In other words: what will make broadcasters avoid the temptation of being conservative and trying to resist a move from the present 4:3 composite systems as long as possible ?

There seems to be at least one good reason: whether we like it or not, the future is 16:9. 16:9 is the only parameter firmly agreed upon for HDTV, 16:9 sets are here and manufacturers have invested a lot of money in producing these displays. Therefore, it is likely that by any means available to them - 16:9 MAC, PALplus, digital - they will try to catalyze their sales for these receivers. There would certainly be no unanimity among broadcasters to stay on the defensive against this move, and even if they did, other means of distributing programmes (satellite, cable, cassettes, disks...) would try to bypass broadcasters by taking their chance to offer a more modern image by offering 16:9 programmes. In such a context, surely no dynamic broadcaster could let others (whoever they may be - other terrestrial or satellite broadcasters, cable operators, home video), have the advantage of a modern image, precisely by offering the modern 16:9 aspect ratio to viewers. In simpler terms, it is far better to be in on the move, in order to have a chance to control it and to adapt it to one's interests, rather than to stay outside it, on the defensive.

This remark leads to rejection of the temptation of being conservative (at least in a visible manner...). Having said that, let us turn back to the original question: 16:9 MAC or enhanced composite systems - friends or foes?

The following remark may lead to answer: the best and fastest way to see the 16:9 set market develop is to create competition between 16:9 services. Considering that 16:9 MAC is a reality today (at least as far as the availability of the satellite channels and the receivers offered to the public are concerned), the best immediate way to reach this goal is to stimulate competition between 16:9 MAC and enhanced composite systems. That is, in all probabiluthe reason why European manufacturers have sought the support of the European Commission for 16:9 MAC and HD-MAC, while being very active in the PALplus project at the same time.

Before concluding, some other possibly provocative questions may help to encourage further reflection on these matters:

- Will digital high definition develop quickly in a prosperous way if HD-MAC is not successful*. It is the same question as that discussed earlier for PALplus and HD-MAC: would digital high definition be a sufficient attraction in itself to succeed rapidly in the absence of competition from HD-MAC or MUSE?

- How fast will the large scale implementation of digital television be? From this follow several subsidiary questions:

- Can HDTV, digital or not, really develop until large flat displays are available?
- Although digital transmission is the only way for High Definition Terrestrial television, high definition is only one option for digital television, in particular terrestrial. Other options include personal television (with built-in antennas) or a 4:2:2 quality (16:9) service for fixed receivers at lower costs than the current ones for the transmission network. How much time will be necessary to clarify what to do with digital?
- How stable are digital techniques at the moment? In other words, considering the extremely fast progress in digital compression, how soon will we be in a comfortable enough situation where we will be able to select algorithms which will have less risks of being superseded by new ones in a short timescale?
- Inversely, although the future will be digital, if it takes time for digital high definition television to take off and develop on a large scale, would this not give a large enough window of

* That is in the European context - the same question might be raised in Japan with the MUSE system. For the United States the question would be - will digital high definition develop fast in a prosperous way in the absence of the strong push we see from the FCC?

opportunity for HD-MAC and MUSE to develop in a viable or even successful way? (One has to keep in mind, that HD-MAC would be helped in the meantime if 16:9 MAC were to be successful, because of the compatibility between these two systems.)

The answers to these questions are not independent of what will have happened in the meantime for enhanced composite systems and 16:9 MAC. Therefore it is not possible to deal with high definition in isolation of enhanced 16:9 systems. It is a global question. Also, high definition is not the only option for digital television which may well have a role to play in the competition for enhanced television systems.

The author does not have the advantage of a crystal ball and he will refrain from predicting the future of all these different systems born in the brains of brilliant research engineers.

It is hoped that this overview of European analogue HDTV/EDTV will foster a better understanding of the situation and stimulate thought about some of the different evolving parameters which have to be taken into account when weighing up the chances of the different candidates which aim to participate successfully in the future of television.

PALplus today*

U. Reimers (NDR)

1. PALplus - responding to the television environment

The world today seems to be the world of MAC standards or the world of digital television but there is a good reason why one has to think about the future of PAL or, more specifically, about its compatible enhancement PALplus. That reason is the huge number of television receivers out there in the world which will have to cope, one way or another, with the changing environment of television production, and most notably the advent of the 16:9 aspect ratio.

Before considering the development of PALplus in detail, an outline of the present-day situation in Europe, as regards the existing or planned television standards, will be appropriate.

One key message is that PAL, as the standard for the majority of Europe, is more successful than ever. This is due to the political changes in Eastern Europe which, for example, have led to a change in East Germany from SECAM to PAL. It is due also, of course to the success of direct-to-home satellite transmissions. In fact the changes in Eastern Europe have also made a difference to the SECAM world, in as much as SECAM has lost a major territory in Eastern Germany. Nevertheless, these two standards, together, are still the most actively and the most successfully used standards in Europe.

D2-MAC, especially in its 16:9 form, is massively supported by the European MAC Directive. The first transmissions of 16:9 D2-MAC have started via satellite both in France and Germany and the Netherlands are about to commence with such a service.

The big challenge is that in the autumn of 1991 receivers in the 16:9 aspect ratio were introduced by different manufacturers in several countries. Consequently, 16:9 can be made available in viewers' homes. The figure in Germany some nine months later is that about 10,000 pieces of equipment are out there. A lot of them of course are with dealers but there are increasing numbers of 16:9 sets in the home although until recently prices were ranging between US $4000 and US$ 6000.

All these sets are multi-standard sets. Most of them can show D2-MAC pictures, but *all* of them can show both PAL and SECAM pictures. This of course causes a problem because they are 16:9 sets and the signals that are transmitted in PAL and SECAM today are normally 4:3 pictures. This is a vexation, both artistically and commercially, because if you deliver a picture originally in 4:3 as-

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pect ratio via a 16:9 display using a vertical expansion - the typical default condition of 16:9 receivers - then you risk losing valuable information; for example the station logo at the top of the picture could be lost, and that may be a commercial disadvantage for all concerned.

A new wave of 16:9 receivers has recently been introduced into the market-place in Germany with screen diagonals of about 28 inches. The prices are now approximately in the range of high-end 4:3 receivers today. This implies that 16:9 reception is no longer an expensive exercise, especially as HD-MAC is being used increasingly for coverage of the Olympic Games and for a number of other events. Moreover, the new aspect ratio is gaining a lot of publicity these days.

The common message derived from this review of today's television environment is that we have to appreciate that both 16:9 and PAL (and SECAM) are going to be with us in the future and that we have to take some action to make sure that PAL and 16:9 can be used together. In the context of the future of PALplus, account must be taken of the fact that 16:9 pictures may be with us in one or more of the following scenarios:

- the possible success of 16:9 D2-MAC;
- the possible success of HD-MAC on satellite;
- the existence of receivers in the market-place.

This might mean that the broadcasters may be forced to simulcast 16:9 programmes via satellite and terrestrial channels. Satellite transmissions would use the D2-MAC and HD-MAC standards and for the terrestrial channels broadcasters would have to remain with PAL and SECAM. Broadcasters produce a lot of programmes and they produce them *once* in *one* aspect ratio. It is inconceivable that broadcasters would envisage having double programming with 16:9 in parallel with 4:3. This means that, especially for large events like sports,

Table 1
Partners in the PALplus project

Broadcasting organizations	ARD	Germany
	BBC	United Kingdom
	IRT	Germany
	ORF	Austria
	SRG	Switzerland
	UKIB	United Kingdom
	ZDF	Germany
Industry	Grundig	
	Philips	
	Nokia	
	Thomson	

if the decision is taken to go to 16:9 a solution must be found for the 4:3 networks which as noted earlier, are mainly PAL and SECAM.

This leads to the establishment of the *basic rules of development* of PALplus:

- that it is to function as as a 16:9 version of PAL;
- that it is aiming at the best possible picture quality;
- and that it has to incorporate technical compatibility with existing PAL contribution networks, PAL transmitters, PAL receivers and, of course, PAL VCRs at home.

In other words, PALplus is not meant as a system that is to replace HD-MAC or to oppose the development of HDTV, but instead it can be seen as a reaction to the advent of 16:9 pictures.

With these aims in mnd, the PALplus project was set up as a common activity for a number of European broadcasting organizations and the industry (*Table 1*). The participation of industry, and in particular major companies which are also investing heavily in D2-MAC and HD-MAC, is based on their understanding of the fact that the future 16:9 receiver undoubtedly will be a multi-standard receiver having a 16:9 tube and incorporating decoders for D2-MAC, probably for HD-MAC, and of course for PALplus and something probably for SECAM.

So there is no scenario where we have multiple systems fighting each other but in the end they will all find their introduction into the receiver with a 16:9 aspect ratio.

2. The PALplus display

What is the PALplus signal going to look like on such a 16:9 receiver? It is going to be a full-screen 16:9 picture with 576 active picture lines. *Fig. 1* shows the relative sizes of images on the 36-inch 16:9 receiver on the left and on a 33-inch 4:3 receiver on the right and both are given in the dimensions relative for the same viewing distance for both receivers. Which means that on a 4:3 receiver (which is today's "standard" receiver in Germany) the display would be of the letterbox type, with black bands at the top and at the bottom.

An important question has been whether or not this is acceptable; whether or not the industry can really go to 16:9 transmission knowing that many millions of receivers will have black bands top and bottom. The letterbox is in common use in a number of European countries, especially when films

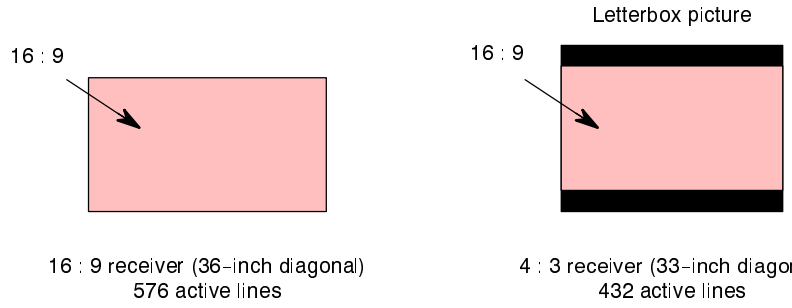


Figure 1
Display of PALplus signals on 16:9 and 4:3 receivers (same viewing distance in both cases)

are shown, so it is nothing really new to our viewers; it might nonetheless be more annoying when we have a full range of 16:9 programming including news and sport which in the past have been in 4:3 format.

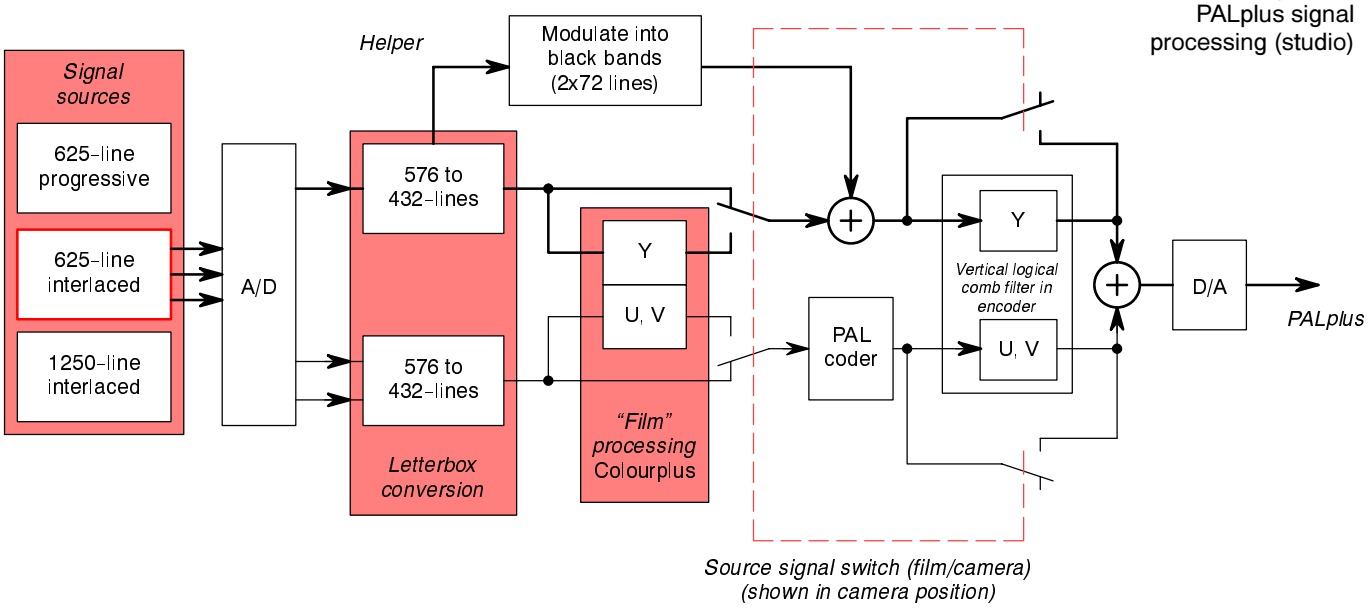
The black bands are *black* but not *blank*, since they carry the difference information that is needed to make a 576-line active picture out of the 432 displayed lines on a 4:3 receiver. In field number 1, line 60 is the first line of the picture that carries active signals; all the lines between the blanking interval and line 59 (inclusive) carry helper information that is necessary to restore the resolution from 432 active lines to 576 active lines in the 16:9 PALplus receiver.

3. The PALplus technique

Fig. 2 shows the basic processing in the PALplus system. It is necessary to allow for the use of different programming sources such as 625-line progressive or 1250-line interlaced formats, which would be the HDTV studio standard for HD-MAC transmissions of tomorrow. But, in the start-up phase at least, we will almost certainly work with today's studio standards: 625-line interlaced.

After A/D conversion, the luminance signal is compressed in such a way that out of 576 active lines, 432 active lines are generated. This is a filtering process of the sort in widespread use in digital video effect systems in studios today. The procesing produces difference information which we call the "helper signal". This information is transmitted in the black bands, so it needs to be compressed into the 2 x 72 lines at the top and on the bottom of the picture. Extensive signal processing is necessary at this stage to make sure that this signal can be transmitted in the black bands and remain invisible to viewers using 4:3 receivers - but without incurring an excessive noise penalty afterwards. The compressed 432 lines and the helper signal are added together and the chrominance part is compressed from 576 lines to 432 lines. No attempt is made to enhance the resolution in the chrominance since the PAL system already offers

Figure 2
Block diagram of PALplus signal processing (studio)



excess resolution in the vertical direction. The next step is PAL encoding of the chrominance signal and, by means of a vertical logical comb-filter system in the encoder, the addition of luminance and chrominance information. Finally, the complete PALplus signal is transmitted.

If the source material is film, successive television fields include the same motion phase (because they are scanned from the same film frame). In this special case, a data channel signals to both the encoder and the decoder the fact that the source was non-interlaced. The entire system is switched into "film processing" or "colour plus" mode. This is simply a means to allow processing of the interlaced signals of two fields, which came from the same film frame, to obtain enhanced luminance and chrominance resolution in both the horizontal and vertical directions. The chroma processing which is normally included in this vertical comb filter is changed as well in the film mode and the receiver of course knows about it.

4. PALplus development programme

This presentation of PALplus will close with a review of progress so far and plans for implementation.

Table 2
Status and schedule of the PALplus project

First public demonstrations (preliminary system)	autumn 1991
Final choice from among many proposals	October 1991
PALplus demonstration at IBC'92	July 1992
Integrated circuit design	to end 1993
Experimental transmissions begin	1994
Regular PALplus services begin	autumn 1995

Dr. Ulrich Reimers *was assistant professor at the University of Braunschweig from 1978 to 1982, where he conducted research in the field of CCD cameras. In 1982 he joined the BTS company where he held senior positions relating to product design for advanced HDTV studio systems. Since 1989 he has been Director of Engineering at Norddeutscher Rundfunk (NDR) in Hamburg.*

Dr. Reimers is a member of the German national HDTV platform, and of the Steering Committee of the PALplus project. He is President of the Fernseh- und Kinotechnische Gesellschaft (FKTG).

Since PAL is not necessarily tied to HDTV studios, solutions have to be found for PALplus processing in the many situations that can occur in today's studios. Methods are needed which will permit PAL, 625-line 2:1 component analogue and digital studios to serve as as potential sources for PALplus. The problems range from small matters such as the data signaling for the receiver, through larger problems like subtitling which in many countries normally takes place in those areas taken up by the black bands in the PALplus system which are used for helper transmissions. There are also, of course, some major problems, like the adaptation of existing PAL studios with composite signal processing to a situation in which the final signal to be transmitted is not PAL but PALplus.

A matter of concern for all PALplus project members is transmission, so extensive transmission tests have been carried out. One of the tests to establish the viability of the PALplus concept was done early in 1992 using the network of ZDF in Germany. This is a very complicated network incorporating many transmitters and gap-filling stations and it has a wide range of transmitter types.

Also, hardware for tests and demonstrations has been built, proposals have been made for VCR systems for PALplus and work has started on the standardization of the PALplus approach.

The time schedule for PALplus development is shown in *Table 2*. The first public demonstration of PALplus was in autumn 1991 at the *Internationale Funkausstellung* in Berlin. The preliminary PALplus system was used on that occasion, but since then work has progressed on making a selection between twelve PALplus signal processing algorithms proposed by the broadcasters' research institutes and by the industry. Out of these twelve algorithms a combination of two has been selected as the basis of the final PALplus standard. This standard has recently been implemented in hardware both in the encoder and decoder, and in July 1992 during the IBC in Amsterdam there was a large and extremely successful demonstration of the PALplus project, showing the PALplus picture quality achievable with the defined signal processing algorithms.

The design of integrated circuits has been started and should be complete by the end of 1993. Experimental transmissions in 16:9 aspect ratio are planned for 1994 and regular PALplus services may start in the autumn of 1995. The *Internationale Funkausstellung* in 1995 is again the critical date. The use of the expression " ... *may* start ..." is deliberate. In effect, as noted earlier, PALplus is not an isolated standard; it is a response of the PAL

broadcasting world to the arrival of 16:9 programmes coming via various other media. Therefore, there remains a possibility that the introduction of PALplus might be delayed if there is no real 16:9 infrastructure which would necessitate the transmission of 16:9 pictures in PAL, for, without such an infrastructure the PAL broadcasters would hesitate to give all 4:3 sets a letterbox picture unnecessarily.

EBU evaluations of HD-MAC*

J.L. Tejerina (Retevisión)

1. Introduction

The HD-MAC system is an HDTV satellite emission system developed as a high-level member of the MAC/packet family, in a way which is compatible with the conventional (625/50) MAC system. The HD-MAC system can be used either in 12 GHz DBS channels or in cable networks with channels 12 MHz wide.

HD-MAC is being developed by the European project Eureka 95, which is aiming to develop all the necessary elements of the HDTV broadcasting chain, from the studio equipment to the usual consumer-type devices. The MAC/packet family was developed in the early 80s by the EBU Members to make optimum use of the DBS channels available in Europe, and to provide a higher quality television system.

The development of the HD-MAC system is at present approaching its completion. Large demonstrations of full coverage of important events with HDTV production and HD-MAC satellite emission have taken place on the occasion of the Winter and Summer Olympic Games, the Sevilla International Exhibition Expo 92 and other events.

The European Community recently issued a Directive, whereby HD-MAC is the unique non-fully-digital HDTV system to be used in Europe after January 1995. Therefore, as potential users of the system, the EBU Members have a major interest in knowing the performance of the system.

In order to obtain the necessary performance data, the EBU Technical Committee established in 1989 a small group of specialists to carry out a full evaluation of the HD-MAC system.

This EBU Evaluation Group performed preliminary tests of the HD-MAC system in April 1990 and April 1991, and started a series of subjective and objective assessments in October 91 at the DBP Telekom premises in Berlin. The first phase of the evaluation proces was concluded in March 92, and further tests may be made later in 1992.

2. EBU objectives for the HD-MAC evaluation

The following objectives were set up at the time of planning the tests for the HD-MAC evaluation:

- to establish where HD-MAC lies in the quality spectrum, with reference to HDTV studio quality and MAC quality;
- to establish the information needed to predict HD-MAC satellite broadcast coverage;
- to establish the information needed to check that HD-MAC complies with the WARC-77 Plan;
- to establish the information needed to predict HD-MAC performance on cable networks;
- to establish the degree of backwards-compatibility with 625/50 MAC, associated with HD-MAC.

3. Organization of the tests

The tests were organized as a cooperative joint effort of the Eureka 95 Project and the EBU.

The recording of the processed signals and most of the expert assessments took place in Berlin in October 91 at the DBP Telekom premises.

* Edited text of a paper delivered by the author at NAB HDTV World, Las Vegas, April 1992, up-dated to include a summary of the test results.

A very large number of equipment items was needed to carry out this evaluation. They covered source equipment, encoders, satellite and cable simulators, decoders and receivers. The equipment was provided by a number of EBU Members and by industry.

The editing of the HD-MAC evaluation tapes was a very complex task, carried out by a BBC specialist in Berlin. It was completed by the RAI Research Centre in Turin.

The formal subjective assessments were carried out by four laboratories: the BBC Kingswood Warren, the DBP in Berlin, the RAI in Turin and Retevision in Madrid.

The expert assessments were finally completed in Turin.

4. Test methodology

The evaluation were arranged in three groups, as follows:

Satellite broadcasting evaluation

- Basic HD-MAC picture quality
- Basic quality of the embedded compatible MAC picture
- HD-MAC noise performance
- Noise performance of the compatible D2-MAC signal
- Impairment versus C/I ratio

Cable system evaluation

- Impairment versus SNR
- Impairment versus C/I ratio
- Impairment versus echo interference

Basic quality after satellite and cable transmission in tandem

- Basic quality and noise performance tests were carried out by formal subjective assessments, with expert assessments of some characteristics. Interference tests were only threshold assessments.

4.1. HD-MAC basic quality

The purpose of the basic quality test was to assess the picture quality of the HD-MAC system after satellite broadcasting and under normal receiving conditions. The assessment of the potential quality difference between up-converted 16:9 MAC and HD-MAC was also included.

The reference source used was the studio HDTV picture, recorded digitally using a four-machine D1 VTR system operating with 1440 samples/line. The subjective assessment method used was the doublestimulus continuous quality scale method (DSCQS) and the viewing distance was 3H as recommended by the CCIR. Nine test sequences were used (seven moving sequences and two still scenes).

The source test material for up-converted 16:9 MAC was obtained by down-conversion from HDTV (using 720 samples/line).

The main quality attributes examined during the tests were (among others):

- film-like programme type;
- short duration aperture effects;
- mode selection noise;
- mode transitions;
- motion compensation;
- noise in saturated colour areas;
- static resolution.

4.2. Compatible MAC picture quality

This test consisted of the assessment of the quality of the embedded MAC picture after satellite broadcasting under normal receiving conditions. A comparison with conventional MAC and PAL was also included.

The method used was the DSCQS method at viewing distances of 4H and 6H. The reference was conventional MAC encoded from a 4:2:2 source and down-converted from HDTV with side-panel cut (720 samples/line).

4.3. HD-MAC noise performance

The aims of this test were the assessment of the FM noise failure characteristic of HD-MAC, the determination of the threshold of the first noise spikes, the determination of the carrier-to-noise ratio (C/N) at the limit of usability, and a comparison with the noise performance of up-converted 16:9 MAC.

Six values of C/N ratio were chosen by expert ranging experiments to cover the impairment scale range. The method used was the double stimulus

impairment scale (EBU method) at a viewing distance of 3H. The reference was HD-MAC after satellite transmission with a C/N ratio of 30 dB.

Three sequences (two moving and one still) were used.

4.4. Compatible MAC noise susceptibility

The purpose of this test was to assess the FM noise failure characteristic of the compatible (embedded) MAC, to determine the threshold of first noise spikes, to determine the C/N ratio at the limit of usability and make a comparison with the noise performance of both conventional MAC and PAL.

The same six C/N ratio values as chosen for the HD-MAC test were again used, as well as the same test method (EBU). The reference was conventional MAC after satellite transmission with a C/N ratio of 30 dB.

4.5. Impairment versus C/I ratio

This was an expert assessment of the threshold of perception of interference and the point of unusability at a viewing distance of 3H, It was intended to check the WARC-77 compliance (co-channel interference less than 30 dB and adjacent-channel interference less than 15 dB). The worst-case condition was HD-MAC interfering with HD-MAC.

The wanted signal was a still picture (EBU "boats" test slide) and the unwanted signal either a grid pattern or a computer-generated picture.

4.6. Impairment versus signal-to-noise ratio in cable networks

The purpose of this test was to assess the AM-VSB noise failure characteristic and determine the threshold of perceptibility of noise and the level of unusability.

The method used was the double stimulus impairment scale at a viewing distance of 3H. The reference was HDTV at the cable system output with a very high signal-to-noise ratio (S/N) of 55dB. Six values of S/N ratio were used, ranging from 50 to 25 dB.

4.7. Impairment versus carrier-to-interference ratio

This was an expert assessment of the threshold of perception of interference and point of unusability in cable systems.

4.8. Impairment versus echo interference

This was an expert assessment of the perceptibility of a single echo for a range of different amplitudes and delays.

4.9. Basic quality after satellite and cable transmission in tandem

This was an expert assessment of the HD-MAC and embedded MAC picture quality after satellite and cable transmission, and comparison of both with the respective satellite output quality.

The satellite path was real single-hop (Kopernikus satellite) and double-hop (Kopernikus and TV-SAT) satellite links. The reference was the source HDTV picture.

5. Choice of the test sequences

The following criteria were used for choosing the test sequences for the picture quality tests:

- A minimum of two still pictures plus a number of moving sequences with a limitation in the total number in order to keep the duration of assessment sessions within practical limits.
- The test sequences had to be representative of common tekevision programming: sports, theatrical performance, documentary, etc.
- They had also to be representative of usual practices in HDTV production: zooming, panning, complex motion, etc.
- They had to come from different sources and be representative of those sources: studio, outside broadcast, computer-generated pictures.
- They had to cover all the attributes to be explored: resolution, block-switching artifacts, motion-portrayal, film mode, etc.
- They had to cover a wide spectrum of criticality from critical to non-critical pictures, whilst avoiding highly critical pictures with low probability of occurrence, which could be considered unduly critical, such as it is recommended by the CCIR.

- They had to be digitally recorded from the origination. The only digital recording system used at present with the 1250/50 system is the "quadriga" format, an arrangement of four D1-format VTRs in parallel. Only a few laboratories have this hardware, and the software available in that format is still scarce. For this reason, sequences that had been recorded first in the analogue domain were also accepted and, in one case, a fully-analogue sequence was selected because of its interesting content.
- The picture quality had to be high. This proved difficult to achieve, because much of the material available was relatively noisy, probably due to poor lighting conditions in the case of the theatre performances or insensitive lightweight cameras in the case of documentary programmes.

The following criteria applied to the choice of sequences for the noise performance tests:

- The test sequences should test only for noise performance in order to clearly differentiate this test from a picture quality test.
- There had to be only one still picture and two moving sequences, to ensure that the tests were feasible in practical terms.

In total nine sequences were used for the HD-MAC picture quality test, seven for the compatible MAC picture quality test, three for the noise performance tests and one for interference tests.

6. Test equipment

The provision of the test equipment was a difficult task because of the complexity of the hardware involved. The main equipment items were the following:

The *HDTV sources* consisted of:

- 1 digital quadriga VTR
- 1 analogue VTR (BCH 1000)
- 1 camera (KCH 1000)
- 4 D1 VTRs for recording at different points of the chain.

The *television sources* include two D1 VTRs for source, and backup.

The *HD-MAC encoder* and *multiplexer* were provided by PKI, located in a container and linked by optical fibre links to the test centre.

The *satellite simulator* reproduced a WARC-77 channel of 27 MHz width and a frequency excursion of 13.5 MHz/V. The FM modulator and demodulator were equipped with the E7 non-linear pre-emphasis and de-emphasis characteristics.

The *satellite link* was implemented with a two-hop link (Kopernikus and TV-SAT) using in both cases the normal parameters for DBS emissions (the Kopernikus transponder bandwidth was 36 MHz). Also a single-hop link through Kopernikus was tested.

The *cable simulator* reproduced an AM/VSB modulation cable channel, with 10% roll-off.

Other equipment included *HD-MAC, MAC and PAL decoders* and a *MAC up-converter* from 625 to 1250 lines.

The main *display* consisted of two 38-inch Sony professional monitors. Other professional and consumer displays were also used.

7. Outline test results (first phase)

The first phase of the evaluation demonstrated that the HD-MAC system is compliant with the WARC-77 requirements.

The quality of HD-MAC for the nine test sequences used was such that only one sequence exceeded (i.e. failed) the conventional measure of transparency on the double-stimulus continuous quality scale, and in this case only by a few percent. The quality potential of the system therefore seems high. However, in the specialist examination of picture quality, circumstances were identified in which artefacts could arise. Further evaluations will therefore be made later in the year, after refinements, designed to reduce these artefacts, have been implemented in the HD-MAC equipment.

José Luis Tejerina *is Director of Technology at Retevisión. He is involved in many aspects of the development of high-definition television, including within the EBU where he is Chairman of Specialist Group V1/HDTV (Parameters, quality and signal format of high-definition image signals). He is also Chairman of the Ad-hoc Group on HD-MAC evaluation. Mr. Tejerina is an active participant in the studies of the CCIR, where he chairs Working Party 11E concerned with picture quality evaluation.*

The FM failure characteristic showed that impairment at grade 4 on the CCIR quality scale (perceptible, but not annoying) was reached at a carrier-to-noise ratio of about 18 dB. Further evaluations will be made on a modified RF characteristic which should lower this figure.

The compatible MAC picture proved to have artefacts which could make the MAC service unattractive. The impairment sometimes exceeded 12% on the DSCQ scale. Further evaluations will be made on a promising process intended to improve the compatibility of HD-MAC displayed on a D2-MAC receiver.

8. Conclusions

The HD-MAC evaluation was an impressive task. It was the result of good cooperation between Eureka 95 and the EBU. Several organizations made major contributions to the success of the evaluation, with the provision of equipment, logistic support or manpower resources. It was made possible thanks to the strenuous work of the relatively few members of the Evaluation Group.

This task was of course not trouble free, but in spite of the limitations it can be regarded as a significant EBU achievement.

Getting ready for the show . . .

Plans are well advanced for the 18th Montreux Television Symposium and Technical Exhibition, taking place in the well-known Swiss lakeside resort in June 1993. The Symposium programme will cover a full range of topical subjects, with high-definition and enhanced television systems high on the agenda. A full day will be set aside for "Advanced Technology Day", giving an insight into the concepts which have yet to develop beyond the laboratory: flat screen displays, opto-electronics, optical and static signal storage and three-dimensional television. Cable distribution will be the subject of a series of sessions running concurrently with those on television production and transmission; here too, new technologies will be much in evidence, including the integration of television in broadband networks, optical fibre distribution to the home, and new cable services.

18th MONTREUX

A special "Highlight" session will honour the EBU which in 1993 - a year of considerable significance for European unity - celebrates the 40th anniversary of the start of regular Eurovision programme exchanges.

Workshop sessions have become a regular feature of the Montreux Symposium and the next event is no exception. A special feature which aims to attract the many visitors who are able to attend the Symposium only over the weekend - the "Weekend Forum" will cover topics of inter-disciplinary interest, such as marketing, programming and management.

The Technical Exhibition will be accommodated in recently modernised and expanded facilities and the 6th International Electronic Cinema Festival will be held at a new cinema venue just a few minutes walk from the Symposium and Exhibition.

Further information about the 18th Montreux Television Symposium (10-15 June), the Technical Exhibition (11-15 June) and the International Electronic Cinema Festival can be obtained from the organizers: PO Box 97, Rue du Théâtre 5, CH-1820 Montreux, Switzerland
(tel: +41 21/963 32 20, fax: +41 21/963 88 51).