HDTV

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HDTV programme production

The development of 1250/50 HDTV

B. Scott (Vision 1250)

Once the euphoria of the new enhanced and high-definition emission technologies has worn off, the viewing public will be no more aware of the technical innovations of HDTV than they are of colour subcarriers in today's conventional systems. No doubt many viewers will remember the 1990s more for the change of aspect ratio than for the improvements in intrinsic picture and sound quality.

Apart from a firm belief in the economic viability and practical feasibility of enhanced television services, a necessary pre-requisite for the launch of new services will be the ability to show top-quality 16:9 programmes on a full-time basis.

The 1250/50 HDTV production standard is the common denominator permitting the launch of 16:9 programme-making throughout Europe, safe in the knowledge that, whatever the choice(s) of emission standard, the programmes will be broadcastable. Trust in this production standard has opened the way to major initiatives assisting broadcasters to master the 16:9 format and the technical quality, and is leading to new ways of handling signals in the production environment.

1. The origins and operation of Vision 1250

The CCIR meeting held in Dubrovnik in 1986 rejected the Japanese proposal for a single world HDTV production standard based on 1125 lines, 59.94 fields/sec. Following this decision the European Council of Ministers decided to encourage the formation of a special task force to develop a system suitable for Europe and the 75% of the world which currently uses a 50-Hz television standard. As a result of this initiative the Eureka 95 project group was formed which includes manufacturers, broadcasters and universities among its members. The result of their work was the creation the 1250-line/50 Hz standard which was demonstrated on a number of occasions early in the development programme. The success was such that by 1989 it was clear that a special organization was needed to promote 1250 HDTV and take it from the research and development stage to a broadcast service.

Original language: English.
Manuscript received 18/8/92.

Vision 1250 was the Grouping created in July 1990 as a result of this need with the brief to promote the 1250/50 standard worldwide primarily by facilitating programme production. It was perceived that this method would have a number of advantages:

1. Programme makers, broadcasters and other parts of the HDTV industry would get training and experience in HDTV production.

2. A programme library would be built up forming a basis for the start of a regular service.

3. Demonstrations would be mounted using real programmes.

4. Industry would receive feedback on the equipment which it was manufacturing.

The Grouping now contains 34 participants from the various branches of the television industry including EBU Members, manufacturers, independent film and television companies and transmission authorities. They work together with the European Commission to achieve the aims set out.

The principle of operation is that equipment is provided to the grouping by those members who are manufacturers (notably BTS and Thomson), with support from their national government where appropriate. The units are then made available by Vision 1250, along with technical assistance and training, to participants wishing to make programmes in HDTV. The European Commission supports this initiative and funds all the technical assistance, maintenance and training as well as giving financial help for demonstrations and promotions.

The operation is financed in the following way:

- The central overheads are covered by the annual subscription fee, which all members pay, of 40,000 ECUs.

- Equipment is provided free by the manufacturers.

- Programme producers pay the costs of their production, including the operational staff.

- The EC support maintains the equipment, trains participants' staff and pays for demonstrations and promotional activities.

2. The fleet, the equipment and its use

When consideration was given to the technical requirements for the new organization, the events of 1992 were taken into consideration. Both the Winter and Summer Olympic games were to be held in Europe as well as the Expo'92 in Seville. It was decided therefore that the available fleet of outside broadcast units and supporting equipment had to be large enough to cover these major events.

So although the initial amount of equipment made available to Vision 1250 in 1990 was limited, the delivery of the main fleet of outside broadcast units, made at the beginning of 1992, created the largest HDTV OB fleet in the world. It comprises some 25 vehicles of all types from 6-camera units equipped for major sport or drama productions down to single camera "flight case" units. Support to the main units is given by editing units, slo-motion units, a master control unit, HD-MAC encoders and decoders and by some specialised graphics and film transfer equipment. In this way a complete service is provided from the camera to the receiver. The production equipment is supplied primarily by Thomson and BTS with receivers by Thomson, Philips, Nokia and Seleco. The manufacturers also house and maintain the equipment as well as providing training on it for all participants, thus ensuring widespread expertise across Europe.

Facilities are also provided by the participants to transmit and broadcast programmes when that is required. The services of the transmission authorities such as France Telecom, Retevision and the Deutsche Bundespost Telekom are essential in this respect, as are those of the members who are broadcasters. Assistance from Eureka 95 is also gratefully received when major technical demonstrations are to be mounted.

To service the needs of major outside broadcasts or studio productions, there are four large units each containing six cameras (four full-size and two portable) with two VTRs ready to record or replay the programme. Two of these units have slow-motion equipment, an essential feature for sporting occasions. For the Olympics and similar sporting events, where there is an even greater need for slow motion, three separate small vehicles are equipped with magnetic disc units giving a recording time of 124 seconds in two sections. They are all supported by tender vehicles able to carry all the necessary ancillary equipment.

The Olympics and other programmes intended for immediate broadcast, require the support of a mas-

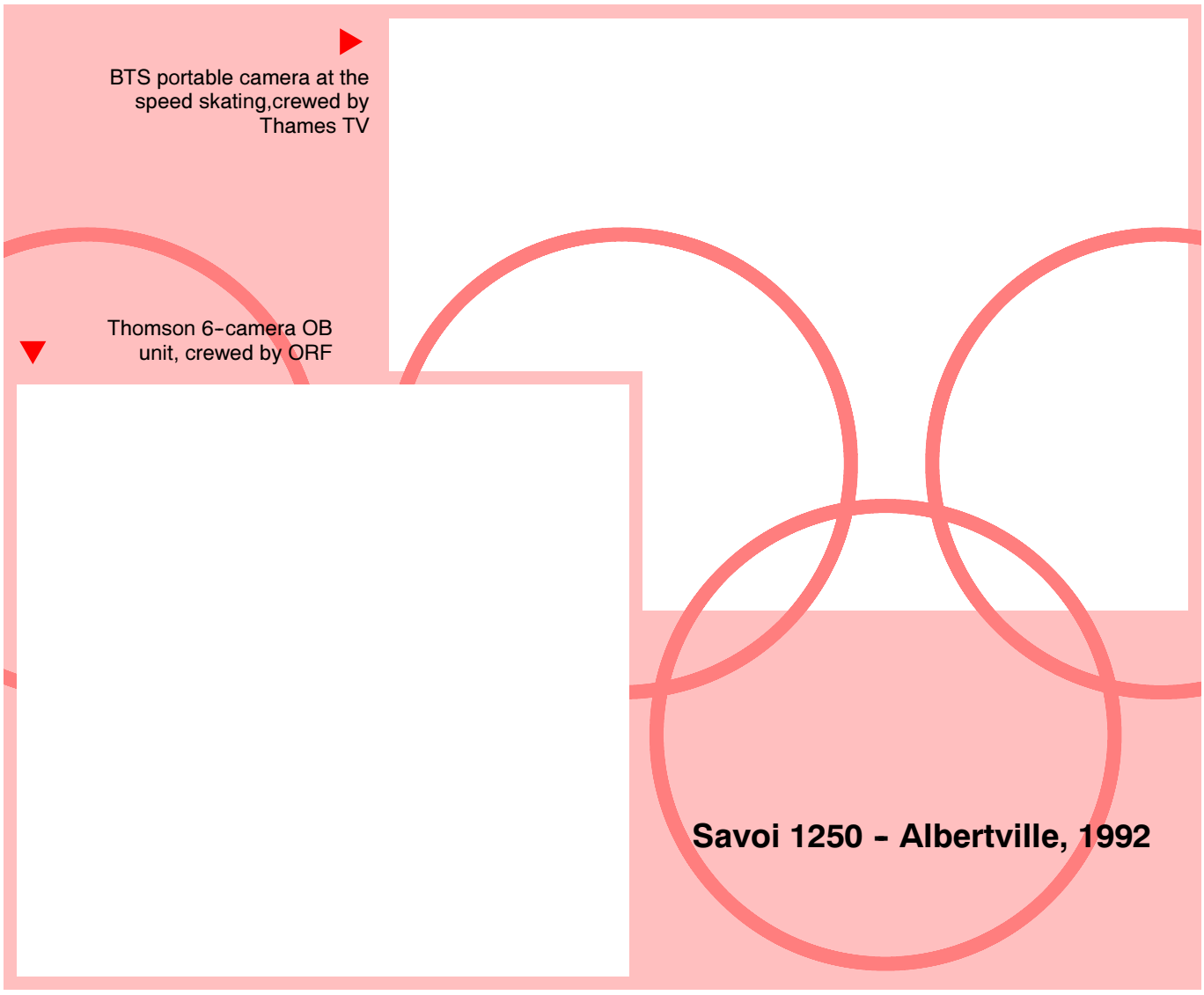
ter control unit. This purpose-built container unit is able to supervise two transmissions simultaneously when the need arises. Two HD-MAC encoders, one from Thomson and one from Philips, have also been built for the Vision 1250 fleet.

A range of units is provided for smaller or less technically-complex productions, or to support a larger vehicle by providing pictures from a remote position. They include two three-camera units with two VTRs, two two-camera units fitted with two VTRs and two two-camera units with one VTR, all supported by their own tender vehicles.

For those occasions when the producer prefers to use a single camera to make the programme, a single-camera VTR unit with one VTR is being provided as well as a single camera and VTR fitted in flight cases. At the Winter Olympic Games in Albertville new CCD cameras were introduced for the first time in 1250 high definition.

Of course every programme requires some post production and for this purpose Vision 1250 is equipped with three editing units with three VTRs each.

In many productions there is the need for other ancillary equipment and this is kept in a pool so that it can be made available wherever it is required, irrespective of the choice of basic camera unit. Included in this category are special effects equipment and a graphics work station using an HDTV Paintbox. Among the supporting equipment are fibre optic cable systems able to carry the full HDTV RGBS or YCrCb signals at 1.3 GBits/s over distances of more than 60 km, as well as some others able to carry HD-MAC or bit-reduced video at 140 Mbit/s.



The ability to transfer from HDTV tape to film is an important requirement which has been fulfilled by developments in Europe by ExMachina (part of the Thomson group) and BTS. In the reverse direction, film to tape transfers can be made using the Rank Cintel telecine or by a new development, which is the result of a collaborative venture by BTS and Kodak. The 1250/50 standard, with its 25 Hz frame rate, is ideally suited for these processes.

Vision 1250 has, as part of its brief, to mount demonstrations promoting the 1250/50 system throughout the world. Six demonstration units which include VTR for playback, large screen Seleco projection units and monitors are available for this purpose.

This outline of Vision 1250's facilities gives an indication of the commitment being made by all parts of the television industry to ensure that

Barcelona 1250
1992

BTS camera covering the athletics, crewed by the RAI-Radiotelevisione Italiana

Thomson camera at the volleyball, crewed by Barcelona 1250

1250/50 becomes accepted as a world standard for HDTV and is introduced into regular service in Europe at an early date. This is with the active encouragement and financial help of the European Commission.

3. The Olympic Games

For the Winter Olympic Games, held in the Savoie region of France centred on Albertville, the French Government set up the organization "Savoie 1250". Using the Vision 1250 fleet it mounted the first ever large-scale demonstration of the 1250 HDTV system.

A complete programme channel, called "Euro HD", was created which included, in addition to the Olympic coverage, news and interviews from a two-camera continuity studio and other programmes previously recorded by Vision 1250 members or film tranferred to video. 13 hours per day were broadcast, with commentary in four languages, for the entire 15 days of the games.

The output was seen by viewers in HDTV at 60 "Eurosites", specially set up across Europe. In addition some 80,000 viewers of D2-MAC receivers were also able to watch the channel, some with 16:9 widescreen receivers, although without the other enhancements of HDTV. It is estimated that some 350,000 people across Europe were able to view this demonstration of European HDTV.

Barcelona 1250 was created for the Summer Games by the Spanish organizations RTO'92, RTVE, Retevision and Pesa. 18 events were covered from 16 venues and a mixture of live and recorded Olympic sport was broadcast for 15 hours per day for the duration of the Games. This, too, was a major outside broadcast utilising the entire Vision 1250 fleet with 41 cameras and 28 VTRs. Operational crews previously trained in the techniques of HDTV, many of whom had worked at the Winter Games, were drawn from EBU Members from all over Europe.

Commentary was provided in five languages and the transmissions in HDMAC were distributed by Eutelsat II F3 and by Telecom 2A satellites and broadcast on DBS satellites by Eins Plus on TVSAT, Antenne 2 on TDF1/2, and by RAI-SAT on Olympus. The transmissions were received at nearly 700 special HDTV viewing sites in all countries of Europe, allowing more people than ever before to see the excellent picture quality provided by the European system. Again viewers with D2-MAC receivers were also able to see these broadcasts.

The Olympics were major events in the calendar of 1992 where all the available equipment is in action. But they only employed the units for a total of about two months (including the preparation time) and so there has been plenty of equipment at other times to meet the programme-making demands of the participants.

4. Expo'92 in Seville

Retevision, the Spanish transmission authority, is responsible for a television technology exhibition in its pavilion at Expo'92 in Seville where 1250/50 HDTV is prominantly featured. In this pavilion a studio of 400 m^2 has been constructed and Vision 1250 has equipped it with three cameras and all the associated equipment needed in a full production studio. At various times mobile units have also been made available for production on the Expo site. Programme makers have thus been given an exciting opportunity to make their productions utilising these facilities either inside the studio or in the surrounding area of the Expo. Many hours have been produced by "Sevilla 1250", a company set up in conjunction with Retevision, making a unique record of the events of the Expo.

*After formal education, **Brian Scott** spent several years in the development of television receivers and professional studio equipment. In 1961, he joined ABC Television (UK), initially in an operational rôle and later in the project Group of the Engineering Department.*

On the creation of Thames Television in 1968, he was appointed Deputy Head of Projects and in 1973 Chief Engineer, a post he held until retirement in 1989. During this period he represented Thames Television in all engineering matters and was Chairman of the Technical Committee of the Independent Television Companies Association from 1985 to 1988, a time when there was fierce debate concerning HDTV standards.

In 1990, Mr. Scott was invited to join Vision 1250, the newly-formed organization for the promotion of 1250/50 HDTV, as Deputy Director General with responsibility primarily for publicity matters.

Fibre optic cable is installed to distribute HDTV services to the pavilions of the European Commission and the 12 Member States. Vision 1250 designed and installed the system which feeds the special displays provided by the Eureka 95 partners in these pavilions. Programmes are supplied either from live transmissions or from videotape recorders specially installed and operated by Vision 1250. More than 12 hours per day of HDTV are being shown in the European pavilions for the whole of the six-month period of Expo'92.

5. Programme making

The more usual work of the Vision 1250 participants is in making their own programmes and more than 200 hours had been produced by the beginning of 1992. This year, with the vastly increased resources described, total production is expected to approach 1000 hours. A substantial part of this will be at the Olympics but at other times the participants will be producing their programmes in all genres utilising the equipment at their disposal.

The work of the members of Vision 1250 encompasses all types of programme - music and arts, commercials, drama, light entertainment, documentaries and features and, of course, sport. They choose for themselves the programmes they make and for a variety of reasons. Initially it is often for experimental purposes, in order to provide training and an understanding of the different requirements of HDTV. Later there are productions or co-productions exploring the new opportunities offered.

The real world of television has arrived for 1250 HDTV and, while they make their programmes, the participants are increasingly taking into account the commercial factors - which frequently include historical value.

In building up a library of programmes there will be a tendency to choose those programmes which have a lasting quality and a commercial future. The music and arts category is a favourite and documentaries about the culture of Europe are also popular. The big state occasions are now frequently recorded on HDTV, as are the big sporting events for these are both spectacular and have great archival value.

6. The future of 1250 HDTV

The future of HDTV is assured: across the whole of the world there is exceptional interest and activity in it. It is seen as the next major step forward in television giving a new experience to the viewer who will be able to take advantage of the new large screen sets as they become available. In Europe the ever wider use of the D2-MAC system for satellite broadcasting is easing the transition to the compatible HD-MAC standard. The demonstrations of the Albertville and Barcelona Olympics make the point in this regard.

It will not be long before HDTV is providing a regular service across Europe and the public at large can benefit from the way in which the European Commission and the participants in Vision 1250 have assisted its early introduction.

The Dublin conclusions - Reflections on the use of a wider picture*

J.J. Peters (EBU)

In common with Vision 1250, the EBU is concerned to initiate action so that HDTV penetrates into the world of television production, where operators will have to familiarize themselves with the new technique and programme creators will have to adapt their art to the environment of the wider picture and the higher definition.

With these objective in mind, the EBU has organized two events aimed at production staff:

- one (Geneva, 1990) was on the precise subject of compatibility between production of pictures at the 16:9 format and the display of those pictures on 4:3 screens;
- the other (Dublin, 1991) was intended to give a survey of problems of production in HDTV.

The aspect of HDTV production which has been covered in the greatest depth in both these events has been picture composition. This review of the impressions gathered during these events will be

* Paper delivered by the author at NAB HDTV World, Las Vegas, April 1992.

concerned essentially with this aspect, and with editing, which can be considered as the other major dimension in the making of a programme.

1. Picture composition

The general impression, gained above all in the Geneva symposium, is that the "compatibility" ingredient leaves a somewhat bitter taste in the recipe for wide-screen production.

The main picture characteristics mentioned with regard to the wide picture aspect ratio were as follows:

1. The 16:9 aspect ratio clearly confers a different "spaciousness" to the action, a new scenic expanse in which to arrange the elements of the picture. The horizontal dimension is amplified, which tends to favour broadside shots in relation to the camera axis, rather like in a stage production.

2. The scene can accommodate a larger number of subjects. The balance of masses or lines enriches the scope for bringing in a larger number of components. Generally speaking, the picture content and structure will be more complex.

3. The common view is that the angle of vision offered by the 16:9 frame is closer to the angle of natural vision; this means adopting a directing and framing approach which is better-suited to this enhanced freedom. The characters can evolve across the whole of the screen so that there is continuity in their movements and postures. In other words, the scene is no longer split into a sequence of local shots: there is cohesion in time and space.

4. The wider angle also obliges the director to build the picture in such a way that it confers a natural and uncontrived feel to the scene. A more subtle approach to scene arrangement is therefore called for. The effect must be legible, but not forced.

5. The wider angle is not only a new opportunity to treat the scene in the two dimensions of the picture plane. To switch from "life size" to "picture size", the wide aspect ratio offers additional possibilities for access to depth, by playing on the various planes along the camera axis.

   More particularly, it conveys more effectively the relationships between these successive planes, insofar as a large number of picture elements can be displayed simultaneously in the wider frame.

6. Different choices are needed for framing, camera movements and shots. This characteristic derives from those mentioned above. The wider area is automatically accompanied by a larger number of longer shots.

So what of these characteristics when it comes to displaying the 16:9 picture in the 4:3 frame?

Most of them can only be retained if the "letter-box" technique is used. With the other techniques, be it for isolating the central part of the picture - as with the "window" technique - or "sliding" window follow-up - as with "pan and scan" - the benefit of the wide screen is of course more or less lost depending on how much use was made of them.

In general, the main effects are that continuity is interrupted. All the picture elements can no longer be mobilised. Access to depth is restricted; the effects can perhaps be recaptured via a series of shots perceived as being juxtaposed, but the simultaneity is lost.

In terms of pure composition, only the letter-box technique respects the artistic intention materialised in the picture.

Such a detailed analysis was perhaps not needed to arrive at this conclusion, since it accords with the preferences of (most) European broadcasters, as shown for years in the presentation of films on television. Most EBU Members show "wide screen" films (i.e. films in aspect ratios of 1.85:1 and 1.66:1) using the letter-box. This choice is justified not only by the fact that it respects the integrity of the complete picture, but also by the cost and complexity of scene-by-scene re-framing in the case of the "pan and scan" technique.

Films in Cinemascope (in the aspect ratio of 2.35:1) are shown using the same letter-box technique but, in the great majority of cases, parts of the left and right of the picture are first removed to leave a surface of only 1.85:1. These therefore seem to be the proportions that represent the maximum acceptable limits for picture reduction on existing receiver screens. They correspond to a *maximum size* of details and the greatest permissible degree of annoyance caused by the black bands above and below the picture.

This general review of compatibility techniques would not be complete without mentioning a third technique, one that is widely used when the film is intended, from the outset, as a medium for both 4:3 television *and* wide screen cinema. It is the "shoot and protect" technique, in which the 4:3 picture in-

cludes the wide picture as well as details above and below which, hopefully, are interesting but not essential.

This third technique avoids the television screen being burdened with horizontal black bands, but it does not resolve the problem of the size of persons or details encountered with the letter-box technique. On the 4:3 screen, the main action takes place in a narrow zone in the centre of the picture, roughly equivalent to the lettter-box area.

However it does offer an interesting advantage as the composition examples shown at the Dublin workshop have demonstrated. In effect, a composition that is well made in the central - horizontal - part of the picture easily produces an acceptable composition for the complete picture.

The difference in the size of subjects on the 16:9 screen and the 4:3 was not specifically discussed at the symposium, but some reference was made to this aspect at various times. This problem is especially crucial for HDTV. It is well known that the full potential of high definition will only be realised on screens over and above a certain size: say a diagonal of 80 cm and over. While the low-definition small screen is not optimum for fine details, a high-definition wide screen is not optimum for imposing picture elements. It is a recognised fact (except for effects) that a person's face, for example, can only be satisfactorily reproduced in a scale of around 1:1 compare to the real face. This has been known for centuries - in the great painters have been producing large full-length portraits but the proportions of the face remains life size. This is an accepted reality in television today, since interview and discussion programmes usually present guests in a scale of around 1:1. But when HDTV screens become noticeably larger that those of 4:3 television, what will happen to close-ups, to the "talking head"?

It seems that, from the theoretical point of view of picture composition and in terms of practical television applications, the objective of a *single* picture composition for the 16:9 and 4:3 aspect ratios comes up against contradictions. Is there any point, then, in striving towards compatibility if the only achievable outcome is a lame compromise ?

A German director, Mr. Herbst, among others, stressed the closer links that are established, for the wide aspect ratio, between image space and programme content. A new approach will be needed for the presentation of chat shows or interviews if the viewer is to be spared having to look at insipid details surrounding the two subjects. But if the presentation is changed, what a loss this will be for the smaller screen where tight close-ups of each subject, or of both, work so well.

2. Editing

Let us now examine the problem of editing. Considering that the choice of shots for the wide picture differs from that for the narrow one, and that the action cannot be allowed to unfold in the wide picture in accordance with the same rules, one might reasonably also expect that different principles will govern the continuity of scenes.

The speakers who dealt with this topic expressed remarkably convergent views.

Reading a picture that is more complex both in construction and in respect of the information it contains naturally leads to a slower pace of editing. The eye must be allowed to "digest" the greater amount of information presented, and the shot must be of greater length in order to give the viewer sufficient extra time. Mr. Yasuma, a producer at NHK, quoted the results of eye movement tests on viewers watching the wide screen. The eye does actually roam across the picture. In the case of a general shot, the eye moves erratically or in orderly fashion depending on the viewer's relationship to the picture, but there is movement just as there is movement when watching events in the natural field of vision. Hence there will be more fixed shots than in conventional television. Moving shots, too, will have a more natural pace since they will preferably be tracking shots rather than zooms.

This constitutes another characteristic which must affect the use of a wider aspect ratio. As it provides a larger area in which the action can unfold more spontaneously, camera movements should be such as to reflect a realistic impression of space. In other words, they should be inspired by the natural shift-

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ing of the spectator's gaze. The human eye does not zoom. It shifts the axis of vision, it looks for depth by tracking. A similar form of movement is therefore the most appropriate as a means of smoothly complementing the free evolution of action in the fixed shots.

The videotape editor will endeavour to link the shots at a pace that respects this continuity of evolution or, if it has to be disturbed, will ensure that the transition between shots maintains the logic of "television presence".

In HDTV, it is not so much the pace of editing that guides or narrates, as the picture itself which allows the expression of the internal dynamics of the action.

Peter Sykes, a British producer/director (The Avengers) pointed out that the pace of the narrative is not expressed solely through the pace of the editing. "It is what takes place in the picture and on the soundtrack - entrances, exits, action, changes in lighting, set, or background, camera movements on cranes or dollies, the orchestration of the soundtrack - that sets the pace, as much as the editing".

This does not mean that the close-up will vanish from the screens with the advent of HDTV. But it will be used mainly to underscore an effect, to dwell on a point, to give particular weight to a subject or action; in other words, for reasons of dramatic impact.

On the occasion of the Geneva symposium on compatibility between the 16:9 picture and the 4:3 picture, Mr. Herbst had already stressed that, because of this difference in the realisation of dramatic presence, it was not reasonable to envisage that one and the same product could be presented on both types of screen, unless one was prepared to accept considerably reduced artistic quality.

3. Consequences

Other subjects necessitating adaptation to the HDTV picture-making process (and, by inference, the 16:9 environment too, in many cases) were dealt with at Dublin: Examples were lighting and set design. In virtually every area of production, the peculiarities of the wide aspect ratio and of the higher definition suggest that special work is needed to produce the special result - a different picture - at the display.

What consequences can we draw from the conclusions as far as programming is concerned?

All the investigations show that the wide screen is perceived as being of particular interest for the following types of programmes:

- films;
- dramas;
- sports programmes;
- plays.

If broadcasters and programme-makers in general want to "sell" the wide screen, then clearly these types of programmes, produced by making full use of the capacities of the wide frame, will have to be shown on 16:9 television receivers. The television viewer will then gradually, as and when he is able to, look to this new televisual experience, fundamentally because of the attractive choice of programmes, and hence the choice of the type of entertainment or information, and not simply because of better technical quality. The basis for the conversion will then be a sound one, with long-term prospects for success. But this approach will call for concerted efforts between industry and broadcasters on the one hand, and cooperation with the production world on the other hand. However this will not necessarily be easy - or immediately profitable, because as long as the flat screen "picture frame" receiver is not an industrial product, the market for large high-definition receivers will make only slow headway.

It is to be hoped that, if compatibility has to be implemented, it will not be applied to *all* programmes. It could be limited to programmes for which the impact of the size reduction and inadequacy of shots is minimal. As was suggested at the Geneva symposium, compatibility could be on an "à la carte" basis.

If conventional-definition wide-screen systems (D2-MAC, PALplus) come into general use, the compatibility will be obtained at the expense of definition only, which will often be acceptable (assuming that the compatibility predicted by laboratory tests turns out to be a meaningful reality). Otherwise, the problem will remain unchanged.

How can we change our production chain?*

E. Lionetti
(RAI–Radiotelevisione Italiana)

1. Introduction

For some time now it has been difficult to keep up with the hectic pace of technological development and the associated release of new products. Today, as we move towards new transmission standards implying radical changes in the production chain, along a road to international agreement strewn with obstacles, the future seems even more uncertain. It is worth stressing that it is practically impossible to come to any agreement laying down the basic production and, in particular, transmission standards. This is the main difficulty to be faced, and there is a great deal of confusion in this area. Manufacturers are not to be blamed – they do their job and they do it properly. They continually propose new solutions and, in fact, the fast development of basic technologies favours this trend. It is also clear that every new solution is better that the last one: MAC is better than PAL, MUSE than MAC, HD-MAC than MUSE – and digital is going to be far better than HD-MAC. But we cannot afford eight different transmission standards in less than five years. This is a very important point to be borne in mind.

It is therefore up to the users to provide a clear definition of what they are aiming at.

The same situation is found in the field of production. One instance is recording standards. RAI recently held a meeting to decide which format to use to transfer 45,000 hours of programmes from 50.8-mm tape. After a long discussion, one executive – clever but not informed – said "Why don't you dub on to film? – that is the only standard we know today.".

This is a very real problem we are facing: we cannot go on changing standards every five years, especially as the archives are very extensive. It is not difficult to foresee what the outcome might be when the money runs out in, maybe, a few years' time. So it is therefore very important that we should agree on a common strategy from a user's point of view and from the different organizations' point of view.

2. The material situation

Fig. 1 shows the current situation as regards annual sales of domestic equipment in Italy, which may be considered representative of almost all the industrialized countries. The curve has been virtually flat for many years. The only increase has been in VCRs (which for us means a reduction in audience), and we now have a small increase in the small-format colour sets. Black-and-white is finished.

Let us look at a second situation: broadcasting installations – transmitters and receivers (*Fig. 2*). There has been a very substantial increase in the number of these: in the RAI we are now approaching 5,000 and have achieved 99.2% coverage.

Transmission hours are also at a maximum (24 hours a day, close on 26,000 hours a year). This implies a huge quantity of programme material. And programme costs are also increasing. To cope with

Figure 1
Domestic equipment sales in Italy

Figure 2
Growth of Italian transmission facilities

* Edited transcript of a paper delivered by the author at NAB HDTV World, Las Vegas, April 1992.

this situation, last year we broadcast 5,000 movies – 15,000 over three years, in fact – yet we must consider that annual production worldwide does not exceed 1,500. To resolve this paradox, we have, quite simply, been raiding our archives. We have been broadcasting movies from as far back as 1911.

3. Constraints and expectations

Clearly, we are now at a crossroads. Saturation point has been reached everywhere: the market, the spectrum, costs. We need to make a firm decision to get out of this deadlock. From the manufacturers we have a straight proposal that the best, perhaps the only, solution is the introduction of new, advanced television transmission standards so as to induce consumers to change their television sets. To obtain the maximum advantage, the change-over should affect not only receivers for DBS, but also those for cable distribution and terrestrial broadcasting.

In addition, the changes should be easily perceived by the public. For example, changing the aspect ratio from 4:3 to 16:9 entails a radical innovation in one of the few parameters that have remained unchanged since the beginning of television. Furthermore, if the adopted standard is digital it will also meet the expectations of the telecommunication industry and cable operators already engaged in this field. A single system that could be used for all applications would be very attractive for all concerned. Those are the proposals that are in front of us.

The broadcasters' expectations are less clear. If we consider now the technical options we have for the new production chain, we need to change from analogue to digital video, from composite to components, from 4:3 to 16:9, from conventional to HDTV and, in the case of sound, from analogue to digital, from stereo to surround. These represent six revolutionary changes. Even assuming that the ideas on standards to be adopted are clear, the equipment available, and funds unlimited, just *one* of these would be enough to seriously affect technical designers' plans. This is another point to be borne in mind.

As far as the RAI is concerned, implementing at the same time all six revolutions, and in particular introducing HDTV transmission in DBS and an appropriate component standard in studios, means in practical terms the complete replacement of the reproduction, distribution, and transmission chains, entailing an estimated capital expenditure of around US$1,000m, 10 to 15 years of intensive work, and the associated loss in value of today's library of programmes.

This last point is extremely important. The RAI programme library contains around one million items. They were all made in 4:3, so that the moment we change over to 16:9 we are going to encounter problems when we want to use them. This, directly or indirectly, is going to be an additional cost that we shall have to allow for. We cannot just think about how we ought to modify the production chain – we should also think about how we can make programmes reusable. The archives are very important now and will be even more so in the future.

4. The options

It seems clear that, for the RAI at least, the revolutionary approach is already extremely difficult if a new production centre is to be designed from scratch; it is totally unrealistic if applied to existing facilities. This does not mean that the RAI will not keep up with change. We have done so already in the case of colour, but before entering this field we need to have checked everything carefully in advance. Not just the technical feasibility but also the real benefit obtained.

The quite different question now arises:- *why* should broadcasters change their production chain?

Possible answers are: to reduce production costs; to support DBS transmission; to remain competitive in terrestrial transmission. It should be nopted that the first two are *actions* while the third is a *reaction* – a reaction to the danger that a new DBS standard could make terrestrial transmission obsolete. But we ought not to react too soon, without having anything to react to: there is no use starting on an approach that would cost us 95% of the cost

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Mr. Lionetti has been involved in HDTV experimentation since 1981.

He is Chairman of EBU Sub-group G4 (Video origination equipment), a member of the Board of Vision 1250, and Chairman of the Italian section of the SMPTE.

already mentioned without *any* advantage because, whether we broadcast in 16:9 or 4:3, the audience is going to be the same. This may seem aggressive, but from the author's viewpoint as a broadcaster there is not *any* advantage in changing the aspect ratio and the standard in terrestrial transmission.

Attention must therefore be concentrated on two points. First, reducing production costs. In order to obtain practical as opposed to theoretical experience, the RAI has been working on this matter and making actual productions for the past ten years. It would appear that not one of the proposed standards has any chance of bringing production costs down. The reason is very simple: we need tried and tested, mature technologies, and technology takes three or four years to reach that stage.

A good example here is that of recording. All the new recording formats use metal particle tapes. The latter are more expensive than conventional ones and require more careful maintenance and, especially, very careful cleaning of the tape transport mechanism. Failing to exercise sufficient care in cleaning the tape transport may result not only in a loss in quality, but in complete erasure of the picture (this has been known to happen). In addition, cleaning a cassette recorder demands extra skills, such as partly dismantling the machine to clean it properly. As this cannot be done by an operator, maintenance people are also required. The running costs associated with using the U-matic format are doubled for Betacam SP, for example. The problems will no doubt be solved. But we cannot just go into new formats before they are really established because there will be a tremendous waste of money - and of quality, too, because no-one knows what is going to happen in the next five years? If this sounds very conservative it should be borne in mind that it is the opinion of one who has been working on new technology for very many years now, but from a production viewpoint. We still need very clear reference points. One of these concerns our archives and our recording standards.

We need clear references also for digital interfaces. The reason why digitization did not begin in 1981 when CCIR Recommendation 601 was issued was because, first of all, components can be handled only in the digital domain, and serial digital hardware is essential for distribution. So in this case a very clear and definite standard is needed. There are various way of making the necessary improvements, but if the accepted standard is changed we shall have to start again from scratch. That will take another four to six years.

5. The RAI's strategy for change

So the first point, concerning "H*ow* we will change our production chain", is that we will start conversion to digital video provided the digital video standard is defined and definitive. We like to work in both the composite and component worlds, according to the circumstances. However, this revolution alone will take us a lot of time, not only because of the capital expenditure involved, but also because of the mental adjustments to be made. Experience in the RAI is that we are not able to exploit more than 20% of the potential of the digital equipment. To be competitive and obtain maximum benefit we need to exploit the full potential.

Therefore, at least in Europe, the introduction of advanced transmission standards for DBS seems to be, in the short term, a more sensible and achievable goal. What is the outlook for DBS in Europe? What standard and what programmes? It must be realized that, while there may be shortages in many areas, there is no lack of channels. There are plenty of channels and plenty of programmes. So when a new programme service is launched, it is not advisable to rely on the programme content alone or on old ideas. And, of course, especially at the beginning when the audience is very limited, it is not possible to invest in very expensive programming. In addition, especially in the start-up phase of DBS, the technical options are very important as far as the viewer is concerned.

That is why the RAI first started producing and experimenting in HDTV. We first produced in 1125 lines, and as soon as a 1250-line system was ready we started experimenting with that. In our view, without a real step forward in quality, DBS will not take off. This in turn would mean that the audience would have to be programme-driven. This is a comparatively expensive approach because the cost of improved technical quality is only 10% of the cost of programming. It is worth investing in technology to persuade people that they need to buy a new dish and a new receiver.

Important experience was gained with the 1990 World Cup, where we produced complete coverage in high-definition. We also realized that there is also another possible market: what we call the "high-definition window on the world". So, apart from drama, apart from documentaries, what the audience likes is to be "on the spot". This is something we find very promising; it cries out for special events, for instance. But the way of shooting such events has also proved to be different. We are now in the second generation of HDTV production. For example, *Capitan Cosmo* was a drama

Figure 3
HDTV equipment required for the making of "real" programmes

based on special effects, a television movie, a way of trying to mix up two technologies: film and video.

The wide screen is also a way of just putting people in front of the stage in a theatre, so that what is important is not only the content but also the perception that the viewer is actually watching what is going on in the theatre. This is another part of the experience of "a window on the world". We plan to extend this with opera and sports events and with other programme material that has proved to have good audience appeal.

After Vision 1250 was created, the availability of technical facilities was no longer a problem. But, of course, this covers only 10% of the cost of a programme service; the remaining 90% should be allocated to real programmes, and in the RAI we have decided that the trial period is over. We have been experimenting for ten years, and now we are going to produce real programmes, and real projects, for a real market.

Figure 4
Effect of viewing distance on viewer satisfaction

Fig. 3 shows a list of facilities required for working in HDTV. For some time there was no equipment for tape-to-film transfer - so there was no market for drama. Without standards converters there was no market for sports events. Those facilities are at last available, and this means that we now have a complete production chain and can start addressing a real market.

On the second point concerning HDTV, "*How* can we change our production chain?" - my suggestion would be to introduce high-definition wherever it is economically convenient, but only in outside broadcasts because we expect that, for studio installations, the analogue solution is not going to be sufficient. We know from conventional television, that to handle analogue components is already difficult in 625; it is going to be *very* difficult in high-definition. So before organizing large installations an adequate digital solution must be available.

There are several possible applications for HDTV production and in the RAI we have experimented with most of them. Our conclusion, at least in Europe, is that HDTV will follow the broadcasting world because, while it is possible to have electronic cinema production for film or electronic cinema showings, only broadcasting can develop the power and investments that are needed to make the system *viable*, *reliable* and *convenient*. Broadcasting is essential to the development of high-definition because there is no reason why a film producer should use any one particular line definition - 1125 or 1250 lines instead of, say, 2000. The only reason would be that the broadcasting system is *more reliable*, *cheaper*, and *available*. Otherwise, we shall finish up with a number of different specialized standards: for computers, for the cinema, for other applications.

Only broadcasting can mobilize enough resources to make the system convenient. And to start broadcasting in HDTV a transmission standard is needed, along with a definite date for regular services, receivers, and good software. We are not selling technology - we are selling programmes. There is no way of convincing people that a programme service is better just because it is broadcast in high-definition. That approach works just once, because people are naturally curious, but, after that first time, programme content is crucial, as is some form of support for broadcasting, of course, because of the considerable capital outlay needed and the length of time required to recover it.

6. Further considerations

A few words on receivers. Receivers are the weak point. *Fig. 4* shows a calculation of the impact of not watching a receiver at a distance of three times picture height from the screen. There is considerable variation, of course, and extensive research

has been conducted, not only by the RAI, but also by other broadcasters in Europe. It has been found that people usually do not like to view from a distance of three times picture height. To persuade them to be watch from 3H you must enlarge the screen. Hence the viewing distance is dependent on screen size. In the case of the smaller screen sizes- up to 22 inches diagonal - people usually prefer a distance of 2.5m independently of the format. This means that to give a real perception of high-definition at three times picture height we may have to provide very large screens. This, in turn, implies a further technological improvement, as today's CRTs are not wholly suitable for the purpose.

And now another exercise. How many pixels per line are needed with today's technology? The graph reproduced in *Fig. 5* shows that high-definition requires 1920 pixels, HD-MAC 1440, and D2-MAC 960, then we come down to PAL and SECAM. Now, as regards the pitch of the CRT needed to display this quality fully - present values are around 0.7mm - this means that today's conventional CRTs are not fully able to display in high-definition. They are fully adequate for MAC and for the ??? format, and even for other formats, but not for high-definition.

Figure 5
Pixels per line required for various television standards

7. Conclusions

Opportunities for reducing production costs are very limited. At the same time, the production of new formats in terrestrial broadcasting is something that should be experimented - and *fully* experimented - before introducing a large quantity of new media. DBS production, at least in Europe, will be the first market that might could allow us to try out all aspects of the technology and then to extend our experience to other systems. DBS is therefore essential because it is a new market, involving new installations and new technology. We have a certain degree of freedom in working with it, while the cost is less than 10% of the costs mentioned at the beginning of this article.

A final point to be considered is evolution. *Fig. 6* shows worldwide penetration for black-and-white and colour plotted against average wages. There is clearly a cost relationship, but at all events it can be seen that the process takes more than ten years from the beginning to the end. For this reason *one* standard is not sufficient, because of the rapid pace of technological development. We need standards that can evolve with the technology of the receiver. One significant example is the European approach of having a family of standards that can be upgraded as the technology, receivers, and market evolve.

Figure 6
Worldwide B/W and colour television receiver penetration as a function of average wages

My conclusion is very simple. We need to agree on the future because we are the only ones that can. And in doing this, we must be careful not to direct all our efforts towards getting the egg tomorrow by killing the chicken today.

HDTV

New tools for the enhanced and HDTV studio centre*

A.H. Jones (BBC)

1. Introduction

Anyone who has sat close to a large screen displaying well-produced wide aspect ratio HDTV images will be impressed by an enormous increase in quality and viewing enjoyment compared with what is generally available today. Most people say that they would welcome such pictures in the home, provided that the equipment to produce them were not too expensive or take up too much space in the living room. A BBC survey has shown that if this scenario were realised, a hang-on-the-wall screen of about 1 metre diagonal would be preferred.

In practice, however, it will be some time before all of these conditions, namely, large screens, wide aspect ratio, full HDTV quality, low cost, and low bulk, are going to be met in the domestic environment. So the question arises as to whether, for the time being, a scenario in which only some of the desired features are achieved will be worth having. For example, would a modest move towards HDTV quality be attractive on today's screens? Is a wide aspect ratio desirable at today's picture quality? And when we say "for the time being", how long is that? Should we still look for the fulfilment of all our hopes one day and, if so, how long will that take? It is questions of this sort that underlie the debates in Europe, not to mention the rest of the world, that surround the development of enhanced and high definition television.

It is very interesting to compare the approach to these issues in the majority of Europe with the approach in the USA. The USA is firmly resolved to introduce advanced digital broadcasting for terrestrial services in advance of clear information about the detailed performance of any of the proponent systems. Europe, on the other hand, is still exploring a number of different approaches, including the digital one, with a tendency to leave in abeyance, for the time being, the important decisions about what we will actually broadcast.

The other noticeable difference between America and Europe is that by choosing the digital solution, America has clearly opted for a revolutionary rather than an evolutionary change, both to the signal and to the receiver. This gives an increased freedom of action, within existing spectrum constraints, but with compatibility at the programme level ensured by simulcasting. It is worth pointing out that the use of simulcasting means that the new system will have to establish itself in the market place on the basis of technical quality; whereas if a new programme service were also available, then that would undoubtedly provide a further impetus to the consumer.

Most of the European options, meanwhile, are also subject to the constraints of the existing broadcast spectrum, but some of them are designed for compatibility with existing receivers, and some demand new receivers.

Regardless of whether the new system is going to provide new programmes or simulcast existing ones, appropriate provision has also to be made at the studio centre, and such provision normally has to take account of a requirement to produce signals on both the new and the old standards from the same programme origination equipment. Extra cost will doubtless be involved, but a strategy is needed which will allow an attractive new service to be offered from day one, while spreading the expenditure over time and making efficient use of both the old and the new equipment.

In these days of rapid technological advance, it is sobering to recall that studios are, in the BBC at least, refurbished at intervals of 10 to15 years, and the central apparatus areas at intervals of 20 years. So, if a costly interruption to the normal pattern of refurbishment is to be avoided, the strategy has to be in place well in advance of the new system launch date. With the uncertainties that exist in Europe at the moment, therefore, how should we plan for the future?

The answer lies in flexibility, - the installation of what is necessary to allow existing or future equipment to carry a range, or even a mixture, of different signals, pending a decision on what will eventually be required. Two suggestions are now offered for further consideration:

2. "Clean" PAL and NTSC

Despite the existence for several years now of a component digital studio standard and, indeed, of component digital equipment, many of today's studio areas, and in particular the switching and routing infrastructure of the studio centre, still op-

* Paper delivered by the author at NAB HDTV World, Las Vegas, April 1992.

erate with composite signals - in the case of the BBC, PAL is used. Some of the flexibility we are seeking would be provided if these PAL-based systems were able to carry component signals without loss.

Once a signal based on CCIR Recommendation 601 has been through a conventional PAL chain, its quality is marred by cross effects and/or bandwidth limitations, and with the cascading of PAL codecs the situation can only get worse. However, studies by the BBC, addressed in the first instance directly to this problem and, more recently, to questions of enhanced PAL broadcasting, have opened up the possibility that an improved PAL coding and decoding technique will largely overcome these problems and so enable existing PAL equipment to convey a much better YUV quality. Although much has been done to establish an optimum set of enhanced PAL techniques, studies of their application throughout the existing PAL environment are still at a relatively early stage. Nevertheless the prospects are encouraging and, what is more, similar possibilities exist for enhanced NTSC.

The conditions we would like to fulfil in the use of enhanced or "clean" PAL are as follows:

- The new PAL signal should have all of the features necessary for it to be handled in existing equipment, as though it were a standard PAL signal.
- YUV signals should emerge from the PAL decoder free of the well known PAL-related or other artifacts.
- The luminance and colour difference bandwidths achievable through the enhanced system should be as large as possible and, insofar as limitations exist, it should be possible to tailor the spectral content of the input signals independently so as to convey the spatio/temporal information that will be of greatest value to the viewer.
- Subject to any such limitations, it should be possible to cascade YUV-PAL-YUV interconnections without loss.

A full description of the enhanced PAL techniques developed by the BBC falls beyond the scope of this presentation, however they are based on the following general principles:

1 Sampling and filtering can be cascaded without progressive signal deterioration, if the filtering characteristic is low-pass and anti-symmetrical about half the sampling frequency.

2 Modulation, filtering and demodulation can be cascaded without progressive signal deterioration if the filtering characteristic is anti-symmetrical about the carrier frequency.

3 A signal that is double sideband modulated symmetrically onto a carrier will give zero output when sampled, provided that the sampler phase is appropriately adjusted.

4 Sampling at $2f_{sc}$ is equivalent, over the band $0-2f_{sc}$, to spectral inversion followed by modulation onto a carrier at f_{sc}.

5 The demodulation of a double sideband modulated signal will yield a zero output if the demodulating phase is appropriately adjusted.

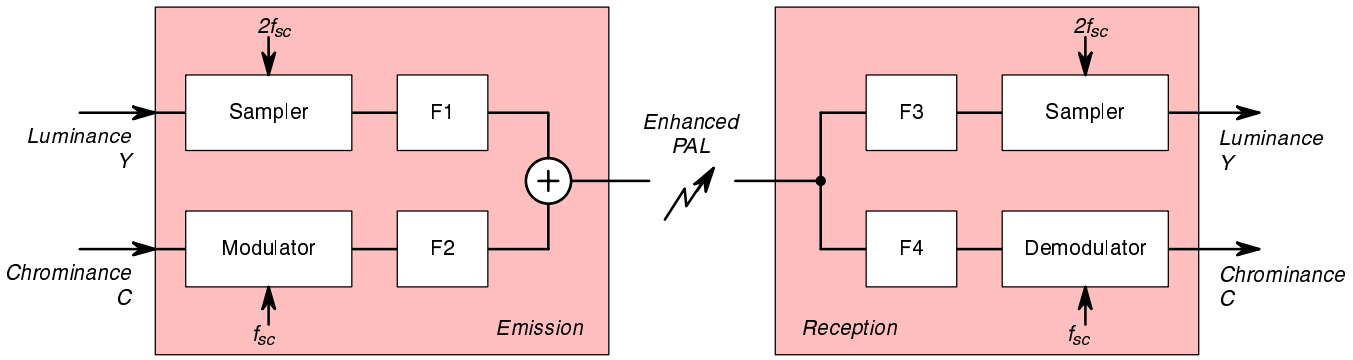
A simplified diagram of the enhanced method of luminance and chrominance signal processing is given in *Fig. 1*.

The filter response product F1×F3 satisfies the first of the above principles, i.e. is anti-symmetrical about f_{sc}, ensuring the cascadability of the Y signal.

The filter response product F2×F4 similarly satisfies the second principle, ensuring the cascadability of the C signal.

The filter response product F1×F4 satisfies the third principle, ensuring the absence of cross-colour.

Figure 1
Principles of enhanced PAL processing



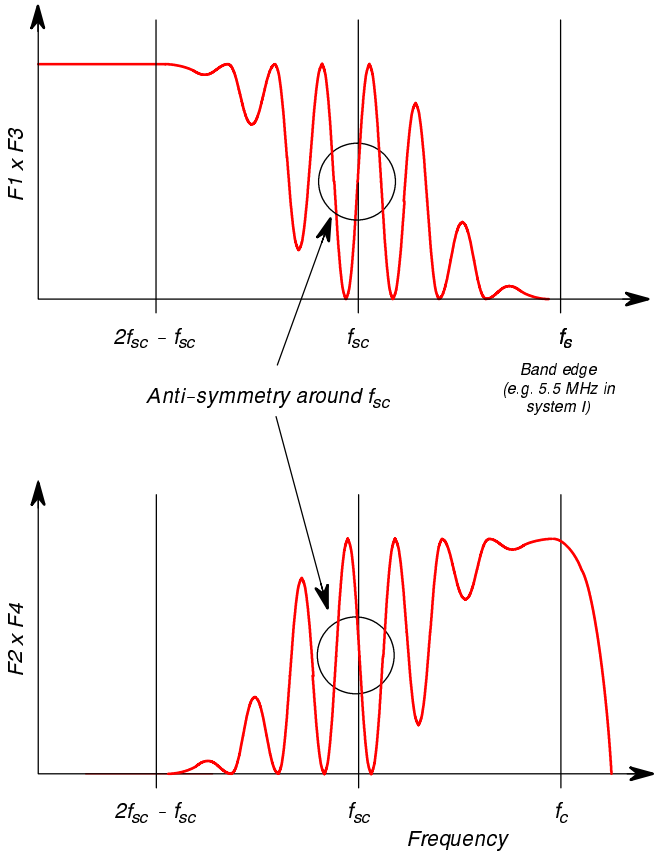


Figure 2
Line-combing action achieved by ensuring that C = U ± V

The filter response product F2×F3 satisfies the fourth and fifth principles, ensuring the absence of cross-luminance.

A further requirement is that the output of the adder should look like a conventional PAL signal, i.e. U and V must be in phase quadrature and the V axis must be switched. This is ensured by making C = U ± V on alternate lines and ensuring that F2, and hence the other filters, have a line-combing action in the region of f_{sc}, as indicated diagrammatically in *Fig. 2*.

In this way, the system provides for the transparent, cascadable, and totally independent transmission of two signals - luminance within an average (horizontal) bandwidth of f_{sc} and colour difference signals (line alternated) within an average (horizontal) bandwidth of (f_c - f_{sc}).

The input and output signals are nevertheless pre- and post- processed respectively so as not only to constrain their bandwidths, and in the case of colour-difference signals to convert to and from U ± V, but also to introduce any required spatial or spatio-temporal trade-offs, for example to give increased horizontal resolution in stationary areas at the expense of high-frequency diagonal resolution in moving areas of the picture. To preserve cascadability, principles *1* and *2* should also apply to the pre- and post- filters.

Of course, it is not possible fully to preserve all of the information that can be conveyed by a Recommendation 601 signal - the system bandwidth is not sufficient for that - but with judicious filter design, a comparable picture quality should be possible. Further work is required to optimise such a system taking into account the particular requirements of PAL-based studio equipment.

These same principles may be applied to the production of enhanced NTSC signals if the following modifications are made:

1 A phase discontinuity of 180° is introduced every line into the $2f_{sc}$ sampling process.

2 A phase discontinuity of 90° is introduced every line into the f_{sc} carrier.

3 The C input has a 4-line rather than a 2-line cycle, e.g. it could be U + V, U - V, - U - V, - U + V on successive lines.

Such a "clean NTSC" system could satisfy in the NTSC domain all of the requirements expressed above in relation to PAL.

2. Optical wavelength and time-division multiplexing

The second suggestion relates to the arrangements necessary for studio centre routing and switching. The requirements of HDTV make optical routing a very attractive possibility for the future, particularly where digitally encoded signals are anticipated.

Optical fibres have an enormous capacity. It is nowadays possible in the laboratory to modulate the lasers that drive them with bit-rates of some 5 to 10 Gbit/s, and components working to 2.5 Gbit/s will soon be generally available. This bit-rate will carry up to ten television signals coded according to Recommendation 601, but it is convenient in practice to use various standard multiplexing arrangements which, after the inclusion of sound and ancillary data, mean that eight signals are carried in the bit-stream.

In addition, it is possible to convey several of these bit-streams through a single fibre by causing them to modulate lasers of slightly different wavelength, and then combining their outputs to form a single beam of light. How many different wavelengths

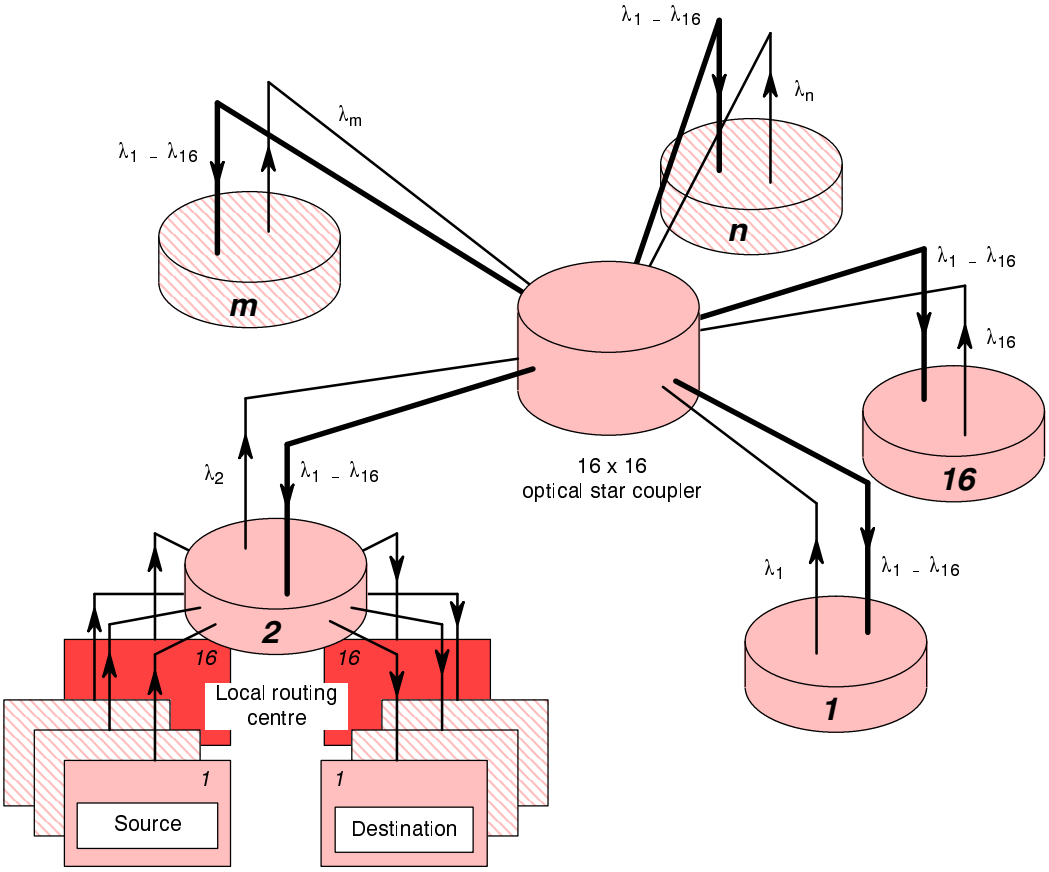


Figure 3
Configuration of a multi-purpose optical routing and switching network

depends on how much power is available from each laser, bearing in mind that each local area in which a laser is situated is also going to require a feed of the combined signal - in other words the light from each laser is going to have to be divided amongst all the areas without, for the time being, the benefit of optical amplification. Using light at wavelengths of about 1.5 microns, the practical answer at present is of the order of sixteen different lasers.

This suggests a system of the type shown in *Fig. 3*, based on sixteen local routing centres (LRC), each accepting and delivering a mix of digitised video, audio, and ancillary data signals. The diagram is of an example in which the 16 inputs and outputs at LRC2 are of digitised PAL form.

At each routing centre these signals are combined into a 2.5 Gbit/s stream which modulates a laser emitting light at a wavelength of about 1500nm. The laser wavelengths used in different routing centres are separated by intervals of about 4nm, and their outputs are combined in a central optical star coupler. The multicoloured light is then sent back to all of the local routing centres, at which the required signals are obtained by a process of wavelength and time-division demultiplexing. The wavelength division demultiplexing could be done using a diffraction grating with sixteen output fibres positioned so that each one catches light at one of the original wavelengths.

The development of this system is being carried out within a European collaborative endeavour called RACE Project 1036. The various building blocks are being assembled; a complete optical path has already carried television signals, and the first demonstration of a 16-laser prototype system is scheduled for later this year.

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This demonstration will confirm the feasibility of wavelength and time-division multiplexing (WTDM) as a means of routing signals around a television studio centre, or indeed within any other type of customer premises network, on optical fibres. The success achieved so far has prompted a follow-on project in which the switching and routing facilities within an operational studio centre will be re-equipped using these WTDM techniques. One of the manufacturers involved in the project is intending to produce the necessary equipment in quantity and, all being well, we shall soon see the system in use in a real studio environment. Meanwhile a further RACE project is developing a means to upgrade such a system, increasing its capacity by a factor of at least 20:1 using coherent optical techniques. And another is developing a means of interfacing with the ISDN digital point-to-point transmission network.

It is clear that this approach will completely revolutionise routing and switching within television, not to mention radio, studio centres. Two of its properties are of special interest.

The first is that all signals are available everywhere as required. No centralised routing switcher is needed, with appropriate booking arrangements to make sure that signals are sent from particular sources to particular destinations at particular times. Instead, there are selector switches operated at each local centre without reference to anywhere else.

Secondly, the concept of time-division multiplexing has an inherent flexibility. The idea is to use the 155 Mbit/s data containers being produced for the telecommunications industry. But what goes into the various containers can be entirely at the discretion of the user. So the signal presented to a given laser could contain two digitised HDTV signals, or eight 625- or 525-line YUV signals, or sixteen PAL or NTSC signals or a large number of stereo sound signals or, and this is of particular importance, any appropriate mixture of these. Moreover, the system can be built up in stages and extra building blocks added as the need arises. So a single routing system can live happily through the time when the studio centre operation is evolving from conventional television to HDTV.

Acknowledgements

The author wishes to thank his colleagues in BBC Research Department for their assistance in the preparation of this paper and the BBC's Director of Engineering for permission to publish it.

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EBU

Plus ça change . . .

At an Extraordinary Session preceding the 43rd General Assembly of the EBU, early in July 1992, approval was given to a proposal put forward by the Administrative Council to the effect that the name of the EBU, in French, should be changed to **Union Européenne de Radio-Télévision**. This name is thought better to reflect the wide-ranging interests of the Union, the former use of the word *Radiodiffusion* tending to give an impression of exclusive concern for sound broadcasting. The name in English remains unchanged, together with the abbreviation "EBU-UER".

The change is part of a package of measures aimed at modernizing and simplifying the EBU Statutes. Other important changes, made in preparation for the unification of the EBU and OIRT which becomes effective on 1 January 1993, are an enlargement of the Administrative Council from 15 to 19 members and an increase in the number of Vice-Presidents from two to three.

Attentive readers of the French edition of the ***EBU Technical Review*** will have noted that the new name of the Union has already been incorporated on the front cover.