

UHF AND COLOUR TELEVISION

by

F.C. McLean, Director of Engineering,
British Broadcasting Corporation

A speech delivered at a Luncheon at the National
Association of Broadcasters Convention, Chicago
6th April 1964

Mr. Chairman and Gentlemen,

It is a great honour to be invited to speak to you today, especially as by so doing I am following in the footsteps of my predecessor, Sir Harold Bishop, who spoke to you at this meeting two years ago. At that time he gave you a very comprehensive review of the engineering side of the BBC. Today I do not propose to cover anything like such a wide field, but to deal with only two subjects but in greater detail. These subjects are UHF television and colour. I would like to deal with them in the general European context but particularly with regard to our operations in the United Kingdom. In the U.K. they are inextricably mixed as it has been decided that colour shall be carried only on the 625-line standard which means that for very many years it will in our case be only on UHF, as our 405-line transmissions completely fill the VHF bands.

UHF television is not in general use in Europe but has been in service use in Germany on an extensive scale for more than two years. Initially, it was used to supplement the coverage of existing programmes carried on VHF but has fairly recently come into service for an additional programme. In Italy, UHF has been used for direct coverage of their service and also as a distribution means for feeding relay stations which re-radiate on VHF. In other countries in continental Europe, the transmissions so far on UHF have been only of an experimental nature. In the United Kingdom we have made experimental transmissions for some years and are about to start in a few days' time the BBC second programme which will be only on UHF. Initially it will carry black and white only but we hope colour will not be long delayed. This new service on 625 lines has already been on the air on an experimental basis carrying both black-and-white and colour transmissions for some months past. The existing services, both BBC and commercial, are on VHF and are carried on the 405-line standard. It is intended that at some time in the future and by some method still to be determined, existing services will be transferred to 625-line operation.

We have followed with great interest over many years the fortunes of UHF in the United States and have followed the arguments for and against inter-mixture. Our position is however different,

and we cannot avoid intermixture and are going into it in quite a big way. Moreover we have no option but to make it work, and somehow or other we have got to persuade the public to like UHF as well as they like VHF, and to like it well enough to pay the extra cost. How far we shall do this in the early years, I do not know. It is clear however that it will be difficult, and we are doing everything possible in the planning stages to ensure that we shall achieve our aim. The first stage in the programme of work was to carry out propagation service trials. Initially, these were done on black-and-white on a single channel in 1957/58. Then, because of the vagaries of UHF transmission as established in these trials, we repeated them in 1962/63, this time using two $12\frac{1}{2}$ kW transmitters radiating in the London area from a common antenna system on two channels spaced 80 Mc/s apart from a 650 ft tower on high ground giving a height above the mean terrain of the order of 900 ft. Gap-filling was used in the antennae. By this means we were able to compare the variations in signal strength from one frequency to another and to convince ourselves that it would be possible to radiate up to four channels from a given site and achieve more or less equal performance from all of the channels. Our plans cover that we shall eventually be radiating four transmissions from each site. From the work done, we think that in an area such as London the signal strength variations between the two

channels will, for about 92% of the locations in the area, be not greater than about 6 db, or not greater than about 10 db for 99% of the locations. These figures we think are within the range of a normal receiver. We have experienced of course some very heavy shadow effects on UHF, but in general it has turned out better than we feared inspite of the fact that the London skyline includes a fair number of buildings which, although not on the New York size, still in many areas give conditions approaching those in that city. We think that some 99% of the population within the +73 db contour should receive a good service. These transmissions were carried out on black and white and on colour using all three of the proposed colour systems. In all this we followed with keen interest the findings of the F.C.C. on their transmissions in New York as they became available, and in general we find ourselves in agreement. A full report on all our tests is due to be published shortly, although some of the information obtained has already been submitted to the C.C.I.R. The results of work done in Europe, inparticular in the Moselle Valley in Germany, in mountainous areas in Switzerland and in Italy, have not differed to any great extent from the results we have obtained in our tests in an area having only slight hills. The Moselle Valley results show a difference of 10 db for 95% of the locations. The effects are however accentuated in other respects and particularly in reception of colour signals, as I will mention later.

A secondary purpose of the tests was to examine the design problems involved in the transmitter, in the combining circuits, filters and antennae, but the main emphasis was on the propagational aspects.

The UHF plan for the whole of the United Kingdom, which is already in hand, envisages that when completed we shall have 64 main stations - that is, stations between 100 kW and 1000 kW e.r.p., using towers of various heights up to 1250 feet - 250 relay stations having e.r.p.s from 2 to 10 kW and towers heights of the order of 250 feet, and 1,000 fill-in stations having e.r.p.s of the order of 10 to 100 watts with towers of the order of 50 feet. At each of these stations, transmitters will be operating on four channels. The relay stations are to serve the large area gaps within the contours of the main stations and the fill-in stations are to cover local blind spots.

It is interesting to consider the capital cost of providing a single-programme service as the coverage figures increase. The first eighteen of the 64 main stations will give 62% coverage of the 52 million people in the U.K. at a cost per head of £1.15. The relay stations corresponding to the eighteen main stations will increase the coverage to 64% and the cost per head to £1.40. The low-power fill-in stations will increase the total coverage by a very small amount indeed and the cost per head will undoubtedly be very high, but we are not yet sufficiently far ahead to be able to say what this will be. This heavy increase in cost to provide a complete service is clear and the final small increase in coverage is uneconomical. Under our system however we have to do this.

We have a uniform licence fee over the whole country and people in all parts are entitled to demand, and do demand, a service. The anticipated total cost of the transmitting stations for a single-programme coverage of the U.K., but with provision for extension to four programmes, is of the order of £85 M as compared with the known cost of the VHF network giving 99.5 % coverage of £17 M. UHF is therefore for approximately equal coverage of the order of five times more expensive than VHF. If a less than complete coverage could be accepted, the UHF costs would fall considerably. The running costs of UHF are higher but not proportionately so. The cost of adding the second, third and fourth programmes to the above will be much less, but I need hardly say that we would never have gone to UHF had there been adequate space in VHF. The cost of operating such a large number of transmitters and the virtual impossibility of finding adequate manpower for attended operation is compelling us to design these stations for unattended operation.

Part of the need to go to UHF is however imposed by our major problem of somehow changing over from 405-line television to 625-line television. One way of doing this would be to duplicate the service in the UHF bands. To do this however, does mean that we must be able to give a service in UHF which is as complete and as satisfactory to all the viewers as the service that we give in VHF. In fact of course, we have to make the UHF service so attractive that the public will voluntarily choose UHF. The attractions we have to offer are a less evident line structure, increased definition, and low interference

levels. We hope that we shall be able to persuade the public to make this choice. Our test transmissions in the London area are fairly promising, and the continuous fall in the noise factor of receivers and improvements in the stability of receivers give us further hope. We feel however that we cannot be sure of this until we have had some little time of direct operational experience, so that this question of standards changeover is in abeyance for the time being.

The transmitter side of the problem is of course only half of the story. Appreciable improvements in UHF receivers have been made and current designs have noise factors of the order of 11 - 16 db, while the tuner units have high stability, very good second channel

rejection and low oscillator radiation. In a very high proportion of the locations, and I would not at the moment like to say how many, the UHF picture definitely looks better than the VHF picture. Part of this is due to the change of line standard but a larger part of the improvement is due to the low noise levels.

UHF receivers are also selling well. ^{current} All designs of sets in the U.K. are suitable for the inclusion of a UHF tuner, and some 25% of the deliveries of receiver are so fitted at an extra cost of the order of 10%.

I would now like to turn to colour. We have taken an interest in colour since the early 1950s, and our first experimental transmissions on colour on the NTSC system, adapted for 405-line operation, were made in 1955. Since then we have intensified our work, and over the last two years have made a considerable effort both in terms of men and money expended in this field. There has also been a very appreciable amount of work done on colour both in Western Europe and, although I cannot say the extent of it, in Eastern Europe. Pressure to start a colour service exists in quite a few countries in Europe, but I think it would be fair to say that, probably because we in the United Kingdom have the highest saturation of black-and-white television receivers - we have TV sets in 13 M of the 15 M households in the U.K. - the pressure is greatest with us. About a year-and-a-half ago, a coordinated programme of work on investigations into the various colour proposals was put in

hand in Western Europe by the European Broadcasting Union, and arrangements were made to keep Eastern European countries informed of what we were doing and to receive from them any information which they had available. This cooperation of the Western European countries has been very profitable, and a most intensive survey of the various problems has been made. The work organised by a technical committee which was divided into sub-committees ~~dealt~~ ^{dealt} with general principles, receivers, propagation, transmitters, distribution and origination. The report on this work has been published by the E.B.U. and also incorporated in the Proceedings of a C.C.I.R. meeting held in London in February. Very considerable work both in the form of laboratory and field trials was carried out in France, Germany, Italy, Switzerland, Holland and the United Kingdom but as far as I know very little elsewhere. I think it would be quite impossible here to give anything like a comprehensive statement of the situation but I will try to give some of the highlights as I see them.

The natural starting point was the NTSC system, and it was clear that any other proposals must be judged by reference to that system, and let me say what a wonderful achievement the formulation of the NTSC system was. In spite of the fact that it was originated so many years ago, that it was produced in a comparatively short time and that it was of such a novel character at that time, it has stood up remarkably well to the searching examinations which have been carried out in Europe. While other proposals have advantages in some respects, it is very much open to question as to whether their advantages in specific directions are sufficient when counted against their disadvantages.

In the opinion of a number of countries, amongst which is the United Kingdom, NTSC is the most suitable system for adoption as a European standard. The other two systems - SECAM and PAL - follow of course the basic concept of the NTSC system. Both send a full definition luminance signal and use the basic principle of the NTSC system, that it is unnecessary to send high definition in the chroma signal. The PAL system is closest to NTSC in that its parameters are the same, but the I signal is inverted in phase every alternate line in the same field. The system uses a delay line and synchronised switching in the receiver. The receiver then takes an average between the phase of the signal in the present line and the phase of the signal in the preceding line. In this way phase errors of considerable extent are corrected, and the loss of definition is minimal but the complexity of the receiver and its cost are increased considerably. The SECAM system also is basically similar to NTSC but instead of sending the I and Q signals simultaneously quadrature modulated on the same sub-carrier, it sends them in sequence and uses a delay line to ensure that at the decoder both the I and Q signals are simultaneously obtainable to enable the three colours to be resolved from the luminance and chroma information. The SECAM system uses frequency modulation of the colour sub-carrier, and by so doing avoids the use of either the hue control or a saturation control on the receiver. Whether this is an advantage or not is open to judgement. By avoiding the use of synchronous detection, the system is however independent of errors due to phase distortion.

It is, I think, an undoubted fact that, as far as the broadcasting and programme distribution authorities are concerned, both SECAM and PAL would represent a considerable easement as compared with NTSC. They simplify appreciably the programme distribution problem and particularly the problem of magnetic recording. When looked at from the point of view of the receiver, however, we find that the NTSC receiver is definitely the cheapest, has the fewest components and will give the best black-and-white compatible picture. The NTSC system also has the advantage that it is most readily applicable to the single-gun tube whenever this arrives. In locations where strong multi-path signals are evident, both SECAM and PAL show advantages compared with NTSC, PAL being the better of the two. On resistance to interference, NTSC is the better. The general assessment could be that, except in very mountainous areas, NTSC is somewhat the better signal, and the service area of an NTSC colour signal is about the same as the black-and-white service area. On the other systems, and particularly SECAM, the service area is reduced. I should here, however, make it clear that the remarks I have made refer to the SECAM system as its development stands today. Whether the situation will change in the future I cannot say.

We believe that the broadcaster must accept the greater care and cost involved on his side, and that the interests of the viewer must predominate.

The balance we draw therefore is that, while all systems have advantages in one way or another, the overall advantage, particularly to the viewers, lies with the NTSC ~~system~~ form of signal. The principal reasons leading to this view are:

- (a) the NTSC signal gives colour pictures that are marginally better ^{under} than conditions of no distortion or moderate distortion than the other systems, and pictures which are acceptable under conditions of appreciable distortion;
- (b) the black-and-white compatible picture from the NTSC system is better than that from either of the other two systems and is not appreciably worse than that obtained from monochrome transmissions. This we regard as particularly important because, for a considerable period of time, it is probable that the great majority of our thirteen million viewing households in the United Kingdom will be equipped for monochrome reception only;
- (c) the major problems associated with the NTSC system are in video tape recording and long distance point-to-point transmission, but the burden of these difficulties falls upon the broadcasting and transmission authorities, and not the viewing public. Furthermore if necessary until such time as the techniques are perfected, the signals can be recorded and transmitted from point-to-point on a different signal, the final broadcast signal being of NTSC form;
- (d) the receiver required for the NTSC system is the least expensive and the most rugged;

- (e) the NTSC system seems to have the greatest potential for further development in the receiver and, in particular, could be applied most easily to a single-guntube when such a tube becomes available;
- (f) the fact that the NTSC system is established in certain parts of the world means that a considerable amount of experience of this system is already available to countries wishing to start a colour service;
- (g) the choice of the NTSC system would bring us nearest to the achievement of a uniform standard of colour television throughout the world.

At the London meeting of the C.C.I.R., the Netherlands, Austria, Denmark and the United Kingdom came out definitely in favour of the adoption of the NTSC system in Europe. Sweden said it would accept NTSC or PAL, while Norway said it would prefer the PAL system. The remaining thirteen countries said they were unable to reach a conclusion on the basis of evidence available and that they would need to do more work. Some countries said that they would be able to reach a decision by the date of the next C.C.I.R. meeting due to be held in Vienna in April/May 1965, but other countries said only that they would be prepared to discuss the matter further at that meeting. In the U.K. we are however very anxious that the Vienna meeting shall reach a decision and will do everything possible to urge this decision and in due course to start a colour service - we hope in NTSC. However if we do not reach agreement on NTSC, we should hope to reach agreement with Europe

on another system. We would like to have the best agreement possible on a worldwide basis but the majority of our programme exchange is of course with the 50-field areas, and only within these areas can be exchange without a system of standards conversion. Agreement with these areas is of the greatest importance to us.

In the meantime we are carrying out the detailed equipment planning involved in starting a colour service in all respects which are not determined by the system used. We are actively considering the camera problem. Should we go ahead on RGB cameras or should we go to the constant luminance or separate luminance type of equipment. We are of course aware of the investigations and proposals made here, and we aware with more than usual interest an indication of the action you will take.

The EBU will continue to consider all these problems, and further investigations will continue to be coordinated. We understand that at their meeting in the summer the I.B.T.O. - the Eastern European Broadcasting Union - are also considering these problems, and perhaps after this we shall get some indication of their view point. With all this work in hand, we hope we are justified in feeling hopeful that the Vienna meeting in the spring of 1965 will reach a decision.

I referred to the international exchange of programmes. This must surely come in colour as it has in black and white. The satellite transmissions first by Telstar and later by Relay have been the outstanding events of the last two years. The picture quality has

been quite extraordinary and the feeling of downright participation given by instantaneous transmissions across the Atlantic has been most moving. This was of course particularly so in the transmissions following on the death of President Kennedy. To watch the funeral at the time it was taking place was indeed a most moving experience.

Perhaps the time will come when we shall have direct exchange of programmes and perhaps even the time when 50 and 60 field transmissions will be radiated in both continents.

Thank you very much for inviting me to speak to you today and for inviting me to take part in your discussion at this most interesting Convention.

FCMcL/MKPR
2.4.64