Planning for terrestrial digital television

K.J. Hunt (EBU)

R.I. Black (BBC)

This article is intended as a companion to that prepared by Mr. Petke and which also appears in this issue of EBU Technical Review. It describes some of the work being undertaken within the general area of EBU Sub–group R2 and, in particular, its Specialist Group R2/DTV. The latter was set up specifically to study the possibilities open to digital television transmission in the bands allocated for terrestrial use by television services. It has rapidly been established that there are short–term as well as long–term possibilities. In the short–term, the limitations imposed by the need for coexistence between analogue and digital services give rise to difficulties which must not be underestimated. In the long term, almost everything seems to be possible!

1. Introduction

The introduction of digital techniques to television transmissions in the terrestrial bands offers exciting new possibilities. Among these are:

- improved picture and sound quality;
- an increase in the number of programmes receivable at any location;
- a real chance of obtaining good quality picture and sound on a portable receiver[1] (at least within a reduced size coverage area).

The first and third of these possibilities arise if a digital television system is not affected adversely by the delayed signals which give rise to "ghosts" with conventional analogue television. This is a characteristic of OFDM signals. Indeed, these can make use of the energy within any delayed signals provided that the time difference between the main and delayed signals is not too large. This, so–called, guard interval is an important parameter of an OFDM system, and is discussed in more detail in *Section 4.3.*

However, it must not be assumed that all the problems of coverage and planning have been solved by the possible change from analogue to digital technology. It is rather the case that the challenges have shifted in nature.

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1. The term "portable" in this context is intended to mean a television receiver with an antenna which is built–in or which is attached to the receiver. It could also cover the case of a receiver connected to an antenna which is situated near the receiver, for example in the same room. The case of a portable receiver connected to a roof–level antenna is excluded.

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Power method

	Frequency (MHz)											
	65			200			500			800		
System variant	V1	V2	V3	V1	V2	V3	V1	V2	V3	V1	V2	V3
RF signal–to–noise ratio, C/N (dB)	14	20	26	14	20	26	14	20	26	14	20	26
Equivalent noise bandwidth (MHz)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Receiver noise figure (dB)	5	5	5	5	5	5	5	5	5	5	5	5
Receiver noise power (dBW)	–130.2	–130.2	–130.2	–130.2	–130.2	–130.2	–130.2	–130.2	–130.2	–130.2	–130.2	–130.2
Allowance for man–made noise (dB)	6	6	6	1	1	1	0	0	0	0	0	0
Minimum receiver input power (dB)	–110.2	–104.2	–98.2	–115.2	–109.2	–103.2	–116.2	–110.2	–104.2	–116.2	–110.2	–104.2
Feeder loss (dB)	1	1	1	2	2	2	3	3	3	5	5	5
Antenna gain, G (dB)	3	3	3	7	7	7	10	10	10	12	12	12
Effective antenna aperture (dB)	6.4	6.4	6.4	–0.3	–0.3	–0.3	–6.3	–6.3	–6.3	–10.4	–10.4	–10.4
Power flux density, PFD (dBW)	–116.7	–110.7	–104.7	–114.9	–108.9	–102.9	–109.9	–103.9	–97.9	–105.9	–99.9	–93.9
Conversion PFD/field–strength (dB)	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8
Equivalent minimum field–strength at 10 m a.g.l. (dBμV)	29.1	35.1	41.1	30.9	36.9	42.9	35.8	41.8	47.8	39.9	45.9	51.9

Voltage method

	Frequency (MHz)											
	65			200			500			800		
System variant	V1	V2	V3	V1	V2	V3	V1	V2	V3	V1	V2	V3
RF signal–to–noise ratio, C/N (dB)	14	20	26	14	20	26	14	20	26	14	20	26
Equivalent noise bandwidth (MHz)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Receiver noise figure (dB)	5	5	5	5	5	5	5	5	5	5	5	5
Receiver noise voltage (dBμV) (73 Ω)	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
Allowance for man–made noise (dB)	6	6	6	1	1	1	0	0	0	0	0	0
Equivalent minimum receiver input voltage (dBμV)	28.4	34.4	40.4	23.4	29.4	35.4	22.4	28.4	34.4	22.4	28.4	34.4
Antenna conversion factor (dB)	2.7	2.7	2.7	12.5	12.5	12.5	20.4	20.4	20.4	24.5	24.5	24.5
Feeder loss (dB)	1	1	1	2	2	2	3	3	3	5	5	5
Antenna gain, G (dB)	3	3	3	7	7	7	10	10	10	12	12	12
Equivalent minimum field–strength at 10 m a.g.l. (dBμV)	29.1	35.1	41.1	30.9	36.9	42.9	35.8	41.8	47.8	39.9	45.9	51.9

Note: At any frequency within the UHF band, the equivalent minimum field–strength value at 10 m, a.g.l. may be expressed as:
(*value at 500 MHz*) + 20 log (*freq*/500)
where *freq* is the frequency of interest, in MHz.

Table 1
Derivation of representative minimum field–strengths for digital television.

2. Signal characteristics

A very useful feature of analogue systems is that they "fail gracefully". While a signal level of X dB at the input to a receiver may be required to achieve a grade 4.5 picture quality (impairments are on the threshold of visibility), a signal level of $X–10$ dB results in picture quality which most viewers would still find acceptable. In contrast, a digital system may give near perfect pictures at a signal level of Y dB (in general, Y will be lower than X) but may give no picture at all at a signal level of Y–1 or Y–2 dB. This rapid transition to failure may either be seen as a weakness of a digital system or as a challenge to be overcome by system designer and coverage planner alike.

The system designer may be able to build in a measure of "graceful degradation" by means, for example, of a multi–level system. Such a system could consist of two parts. One of these would be more rugged and would carry a basic signal quality. The other part would be less rugged but would permit reception of a higher quality picture. The more rugged part would be available throughout the whole of the intended coverage area, the less rugged part might not be receivable at locations where the signal strength was subject to local degradation.

The coverage planner must ensure that a very high proportion of would–be viewers are able to receive at least the minimum signal level.

2.1. Minimum signal level

An early stage of the process must thus be to establish the minimum signal level at which a receiver will operate and convert it into an equivalent[2] field strength value which must exist at roof–level.

Such a process requires a number of assumptions (in particular, C/N ratio and receiver noise figures; feeder loss and antenna gain values are based on current experience) and it is probable that some of these may need to be reviewed as further information becomes available. *Table 1* shows the results obtained by Specialist Group R2/DTV when studying equivalent minimum field strength values. It will be noted that a set of system variants has been included. These are explained in more detail later.

It will be noted that two different methods have been used to derive these minimum values. This is because some users are more familiar with power levels and some with voltage levels. The two approaches lead to the same results.

2.2. Minimum median signal levels

As noted earlier, digital systems have a rapid transition to failure and the results given in *Table 1* represent *minimum* values. A signal level which is 1 or 2 dB lower than these values means that the particular system variant has failed completely.

In practice, it is found that field strength values vary considerably from their median value within a given relatively small area (or volume) around a nominal reference point. It is to be expected that digital signals will also exhibit this type of variation, although it is also to be expected that the standard deviation of the variation will be less than that for relatively narrow band analogue signals.

It is thus possible to estimate the difference between the median signal level and a value appropriate for any given percentage of locations. Conversely, it is possible to estimate the median value required in order to ensure that at a high percentage of locations the necessary minimum signal level can be achieved.

The real difficulty is that the necessary statistical information will not be available until digital television systems using OFDM have been built and tested. In the meantime, however, planning exercises must be carried out. To deal with this paradoxical situation, Specialist Group R2/DTV has proposed to adopt a value of 12 dB as the required difference without knowing *exactly* to what percentage of locations the minimum signal level can be delivered. The choice was not arbitrary, however. If the digital television system were to behave like an analogue system (which is highly improbable), at least 90% of locations would reach the minimum signal level if the median value is 12 dB above this minimum. On the other hand, if the digital television signal were to behave more like an (OFDM) DAB signal, then 99% of locations would achieve the minimum signal level. This range of 90 to 99% of locations is considered to form a reasonable basis for planning exercises.

2. The term "equivalent field strength" is used in place of the more conventional "field strength". This is because the latter really only applies to a narrow band signal, for example the carrier of an analogue television signal. With the type of digital system being considered, at least in Europe, the total power within a given bandwidth is a more appropriate signal level measure. However, in order to be able to compare the requirements for analogue and digital television systems, it is more convenient to retain units which can be directly related to those currently employed.

	Frequency (MHz)			
	65	**200**	**500**	**800**
System variant *(Note 1)*	V2	V2	V2	V2
Minimum field–strength value (dB)	35	37	42	46
Minimum median field–strength value (dB) *(Note 2)*	47	49	54	58

Note 1: The system variant represented here is chosen for the purposes of illustration only.

Note 2: No account has been taken of possible interference contributions. In practice, to achieve coverage at a high percentage of locations for minimum median equivalent field strength values as low as those given, it may be necessary to add a small margin (say, 1 or 2 dB) to allow for the combined effect of receiver noise (resulting from a low signal level) and interference contributions.

Table 2
Representative minimum median equivalent field–strength values.

Table 2 shows a set of representative minimum *median* equivalent field strength values. Only one system variant is shown for clarity.

2.3. System variants

It will have been noted that a set of system variants was introduced into *Table 1*. This also represents a pragmatic solution to the problem that no definitive European systems exist from which to obtain measured results. It was thus decided to establish a range of system parameters which was approximately representative of likely systems and for which planning estimates can be undertaken in order to assist systems designers to refine a system.

At the time that these variants were devised it was assumed that Variant 1 might represent SDTV (similar to today's PAL or SECAM), Variant 2 might represent EDTV and Variant 3 might represent HDTV. In all cases, it was assumed that each Variant would be part of a hierarchical or multi–level structure – which imposes penalties on the required C/N values. Recently it has been reported that EDTV can be achieved at a C/N value of about 13 dB although this was *not* as part of a hierarchical structure.

Alternative strategies are now being explored. For example, four SDTV signals may be accommodated in a single RF channel (of nominal bandwidth 8 MHz). However, such a composite signal requires a significantly higher C/N ratio than does a single SDTV signal in the same channel. In fact, the evidence available suggests that the C/N ratio required for the case of four SDTV signals in a single channel will be similar to that required for one HDTV signal in the same channel. Thus, there seems to be no inherent reason to change the values assumed for these variants. They still reflect a range of possible configurations.

2.4. Protection ratio values

As with C/N values, the protection ratio values can be expected to vary with the system complexity. For convenience, it was decided to adopt the same value for the co–channel protection ratio (digital to digital) as the C/N value for a given system variant, that is 14, 20 and 26 dB. This is expected to be approximately correct, but can be reviewed later as measured results become available.

When an analogue signal interferes with a digital one, there are techniques available which can help to reduce the protection ratio. In one way or another, these all involve discarding certain carriers of the OFDM signal, either at the transmitter or at the receiver. The latter seems to be more flexible in that it can permit a receiver to partially reject interference from different analogue systems. Such techniques are expected to permit analogue to digital co–channel protection ratios of 3, 9 and 15 dB for the three variants.

Because of the rapid transition to failure characteristic of digital signals, it is only necessary to derive one set of protection ratios for digital signals and these are appropriate for any time percentage.

In the very important case of digital signals interfering with analogue signals, there is likely to be little (if any) difference between the system variants. The digital signals appear to an analogue signal to be noise–like and the required protection ratios are well known in such cases. Two co–channel protection ratio values are needed, one appropriate for more or less continuous interference (usually referred to as the 50% time case) and the other where the interfering signal is only present for a few percent of the time. The values adopted are 45 and 37 dB respectively.

2.5. Guard interval

To a first approximation with an OFDM implementation, delayed signals which arrive with only a small time delay contribute positively to the wanted signal and those which arrive with longer delays may be regarded as negative contributors, that is as interference. In practice, this is too simple a view. Certainly, signals arriving with delays which are inside a small time interval, the "guard interval", all contribute positively. However, those which arrive with delays a little longer than the guard interval make contributions to *both* the wanted signal and to the interference. As the delay becomes progressively greater than the guard interval, the contribution to the wanted signal becomes less and the contribution to the interference becomes greater.

There are two main implications of the positive contributions of delayed signals. One of the main elements causing degradation of analogue signals is the presence of ghost images caused by signals reflected from objects near the receiving site. These delayed signals normally have fairly small delay times and it will be reasonably easy to design OFDM systems with a sufficiently long guard interval to ensure that such signals contribute positively. This is the main reason why it is expected that the variation of signal level with locations will be less for OFDM television signals than for analogue signals.

The other important implication is that it becomes possible to consider Single Frequency Networks (SFN). In such networks, all transmitters operate in the same channel and radiate exactly the same signal. To a receiver, the signals from a distant transmitter appear merely as a delayed version of the wanted signal and if the delay is less than [or near to] the guard interval then, again, the results will be a positive contribution. Special consideration needs to be given to the advantages and disadvantages of SFNs and these points are mentioned later.

3. Factors relating to implementation strategies

3.1. Transition period

The reason why the potential impact of digital signals on analogue one is so important is that the terrestrial television bands are very heavily used in the European Broadcasting Area by the analogue television services. Considering only the area west of Russia and taking account of only the television stations already in operation, there are approximately 1000 transmitters in use on each channel in the VHF and UHF bands. This number includes all of the relay stations, of course. However, the general principle adopted in Europe is to accord protection from interference for 99% of the time to all stations. (In some countries other time percentages may be used). It must be noted that in some countries there are also stations or even networks which have been co–ordinated but which are not yet in operation. These stations have not been included in the figure given above.

These analogue services provide television to hundreds of million of viewers and such services can be expected to be in operation for many years to come. As no new spectrum below 1000 MHz is likely to be given to television, any new digital services will have to share spectrum with the analogue services and they will need to coexist for a transition period which could last 10 to 20 years. At the end of this transition period it is expected that the analogue services will be stopped and only the digital services will remain. The end of the transition period may actually be gradual, rather than abrupt as suggested above.

During the transition period, protection of the analogue services is a major preoccupation and will be the major constraint on the size of the coverage areas that can be achieved for digital services. Clearly the size of the coverage areas which *can* be achieved is an important element when considering the viability of digital television services. This point is discussed in more detail later.

3.2. Post–transition period

While it is clear that the analogue services will no longer form a constraint either to the size or the number of digital services which can be achieved, it is not easy to foresee what the future will hold. (The same difficulty applies in general to attempts to foresee the future!).

Mr. R. Black *joined the BBC in 1961 and was Head of Service Planning at BBC Research Department before taking early retirement in 1991. He has continued as consultant to the BBC and is Chairman of EBU Specialist Group R2/DTV.* ▶

Mr. K. Hunt *is with the EBU Technical Department*

The well–known advantages of single frequency networks, in terms of spectrum economy, might be used to achieve multiple national coverages. However, it can be argued that satellite based services might be more appropriate in the provision of national (or multi–national) coverages in the future. Alternatively, the lower protection ratios of digital systems (compared with analogue ones) could mean a large increase in the number of regional or local television services, especially if such services are not required to provide a service to all populated areas.

At a later stage, these (and other) options will be fully explored so that informed choices may be made by the relevant authorities.

3.3 Protection of analogue services

At first sight, it should be relatively easy to investigate the impact of a new digital service on an existing analogue one. However, this neglects the important fact that television services in the European Broadcasting Area have been in a continuous state of expansion since the Stockholm Plan was established in 1961. While this Plan provides the framework, there have been many changes to its contents and to some of its concepts.

The starting point for consideration of possible digital services thus had to be an examination of the current state of the analogue ones. This process has demanded a considerable amount of time and effort and is, in some respects, still not complete. Enough results have been obtained to permit digital planning studies to commence.

As noted earlier, there are many relay stations operating and these may have coverage areas of only a few square km. Initial studies indicated that if all of these relay stations were to be protected by new digital services, then there would be very little digital coverage in many cases. Compromise situations are thus being examined. In these it is assumed that the radiated powers of the digitalstations will be chosen to ensure protection of all analogue stations whose powers are above some predetermined value. Experimental planning exercises will be carried out to determine the appropriate power level at which protection is to be accorded. Clearly, analogue stations with lower powers are likely to be affected and the extent of this will also need to be established, as will any possibilities for changes to their characteristics to ensure continuity of service.

3.4. Channels to be used by digital services

No constraints have been placed on the channels which may be usable by digital services, with the exception that co–channel operation with an analogue service at a given site is not possible. In practice, there may be other factors which limit the channel selection process. It is probable that viewers will have receiving antennas which will enable them to receive channels near the existing analogue ones, provided that the same polarisation is used. The broadcasters may also wish to consider channels near the existing ones if this would permit them to re–use existing transmitting antennas and feeders. This may be desirable (if it is technically feasible) in cases where the existing masts or towers do not have enough loading capacity to accommodate additional antennas or feeders. These are practical considerations which may later be used to make a selection from the choices offered by the planning (in those cases where there are choices, at least). These considerations will need to include an assessment of the rate of growth of the size of the audience for a digital service and its dependence on channel choice.

4. Results

4.1. General prospects

Only a limited sub–set of results is presented in *Tables 3* to *5*. These tables show the possible sizes of digital coverage areas for selected existing stations. Certain constraints must be emphasised:

– analogue stations below 1 kW effective radiated power have not been protected;

– no account is taken of interference to analogue stations which are not yet operating;

– no account is taken of interference to the digital services.

These constraints undoubtedly mean that the results shown are optimistic and this is a very important consideration.

The results show the size of the digital service area which might be achieved on each channel in the UHF band for channels 21 to 60. Channels above 60 have been excluded from the published results as they are unavailable for television usage in many countries. Two sets of results are shown in each case, one for variant 1 and the other for variant 3.

It can clearly be seen that while there is some hope of achieving not–unreasonable coverage in the variant 1 case, the prospects for variant 3 are very

Results for roof–level antenna and a C/N ratio of 14 dB.

Using polarization H, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20		6839		5090	9103		5957	7724		5696
30		7233	7229		4980	3716	1909	2233		
40	170	207	343	165	1208		161	314		
50	3806	6787	489		5281	2793		1632		183
60	1732									

Using polarization V, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20		6839		5090	9103		5957	7724		5696
30		7233	7229		5956	6836	2650	5038		
40	170	207	509	165	1208		161	314		
50	3806	7359	615		5281	4102		1632		183
60	1732									

Results for roof–level antenna and a C/N ratio of 26 dB.

Using polarization H, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20		2783		2019	3893		2384	3216		2274
30		2956	2954		1973	1458	672	801		
40			116		397			101		
50	1496	2759	166		2099	1030		564		
60	603									

Using polarization V, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20		2783		2019	3893		2384	3216		2274
30		2956	2954		2383	2782	971	1998		
40			173		397			101		
50	1496	3011	205		2099	1616		564		
60	603									

Set of results (3–SEP–93) for a digital station complementing analogue station X which has a coverage area (average of all used channels) of 6500 sq km.

No account is taken of interference to the digital service.

Calculations include all stations above 1000 W e.r.p.

No result is shown: for channels which are not available or which are in use by an analogue service in those cases where the coverage is too small to be calculated reliably.

Table 3
Sample results showing possible size of digital coverage area for selected existing stations.

Results for roof–level antenna and a C/N ratio of 14 dB.

Using polarization H, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20		600		4035	577	2892	4162	1136	1443	1250
30	4203	7463	647	4544	2121	366		641		1025
40	5047	3884	452		4538	970		3811	6042	1719
50	1966	4338	5979	1841	4331	4123	1722	198	2241	1880
60	5451									

Using polarization V, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20		600		2065	577	3909	2351	1136	1443	1250
30	2791	7463	691	2508	2977	794		892		1025
40	5047	3884	452		4538	970		3811	6042	3444
50	2415	4338	6055	3032	6628	4123	1885	198	2241	4392
60	8187									

Results for roof–level antenna and a C/N ratio of 26 dB.

Using polarization H, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20		187		1540	175	1069	1595	372	494	413
30	1613	3193	211	1765	757			209		333
40	1993	1476			1763	313		1446	2473	596
50	695	1673	2445	645	1670	1578	597		807	661
60	2170									

Using polarization V, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20		187		734	175	1486	854	372	494	413
30	1028	3193	225	916	1103	259		286		333
40	1993	1476			1763	313		1446	2473	1296
50	879	1673	2479	1126	2743	1578	663		807	1697
60	3555									

Set of results (3–SEP–93) for a digital station complementing analogue station Y which has a coverage area (average of all used channels) of 7500 sq km.

No account is taken of interference to the digital service.

Calculations include all stations above 1000 W e.r.p.

No result is shown: for channels which are not available or which are in use by an analogue service in those cases where the coverage is too small to be calculated reliably.

Table 4
Sample results showing possible size of digital coverage area for selected existing stations.

Results for roof–level antenna and a C/N ratio of 14 dB.

Using polarization H, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20		375	7593		463	6413			6254	2887
30			2992		3704	1125		1908		615
40	128	328	212	1176	290	621	838	366	3258	205
50	253	353	174		795		1790		169	3033
60										

Using polarization V, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20		375	4288		463	4158			4039	5914
30			2052		9820	3850		3738		615
40	128	328	212	707	290	621	537	366	5578	205
50	3253	353	174		310		1845		169	6262
60										

Results for roof–level antenna and a C/N ratio of 26 dB.

Using polarization H, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20			3236		118	2648			2574	1069
30			1113		1411	370		664		20
40				388		202	271		1223	
50					257		622			1130
60										

Using polarization V, area in sq km on each channel is:

Channel	0	1	2	3	4	5	6	7	8	9
20			1670		118	1611			1558	2414
30			724		4363	1475		1426		200
40				231		202	163		2262	
50							640			2578
60										

Set of results (3–SEP–93) for a digital station complementing analogue station Z which has a coverage area (average of all used channels) of 11000 sq km.

No account is taken of interference to the digital service.

Calculations include all stations above 1000 W e.r.p.

No result is shown: for channels which are not available or which are in use by an analogue service in those cases where the coverage is too small to be calculated reliably.

Table 5
Sample results showing possible size of digital coverage area for selected existing stations.

poor, unless extremely low coverages were regarded as acceptable.

4.2. *Coverage for portable receivers*

The case of portable receivers is interesting in that analogue services suffer particularly badly when the receiving antenna has little or no directivity. Digital services offer the opportunity to get good quality on a portable receiver.

There is one very large difference between reception on a portable and reception using a roof–level antenna. This is the loss of signal which occurs. There are many contributory elements to this signal loss but it has been estimated to be about 30 dB between a roof–level antenna and a median position in a house. The impact of this signal loss on the coverage which might be achieved is dramatic. It is estimated that in less than 20% of the area for a 14 dB C/N (that is, variant 1) digital service could a portable receiver work reliably. Of course, if a smaller percentage of locations in each house were set as the target (in practice this means that the viewer would have to select the receiver location with more care) then the size of the service area would be increased. None the less, from a broadcasting point of view, there seems to be relatively little scope for services aimed only at portable receivers during the transition period.

4.3. *Single–frequency networks*

So far only limited studies have been made regarding the coverage possibilities for single frequency networks for television. From these studies only general conclusions can be drawn:

– national SFNs will not be possible in most European countries during the transition period, unless considerable disruption of existing analogue services is regarded as acceptable;

– national SFNs for HDTV seem to present considerable technical difficulty, even after the end of the transition period. This is because of the long guard interval found to be necessary;

– local–area SFNs, consisting either of an existing transmitter location together with its relay (or fill–in) stations or of some form of dense network, seem to offer significant coverage and spectrum economy advantages.

Studies regarding SFNs are less advanced than those involving “conventional” planning primarily because the latter have a wider applicability during the transition period. In the near future, it is to be expected that there will be a considerable increase in the studies of SFN possibilities.

5. *Conclusions*

It is too early to reach anything other than preliminary conclusions. However, it seems that digital television services could be implemented on some channels at some of the existing analogue station sites and could achieve a coverage area comparable to that of the existing analogue services. Such digital services would provide a picture quality which is at least as high as that potentially provided by PAL and SECAM services, but without degradation due to delayed images. However, at least during a transition period in which analogue and digital services would have to co–exist, the coverage achievable by a high definition digital service would be very restricted.