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**Communal Aerial Systems:
Free-to-Air DTV Reception**

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**The Impact of Switchover on
Communal Aerial Systems**



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COMMUNAL AERIAL SYSTEMS: FREE-TO-AIR DTV RECEPTION

The Impact of Switchover on Communal Aerial Systems

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Disclaimer

The analysis in this report is based on a working version of the UK UHF Frequency Plan, which remains subject to change. Where specific cases are mentioned in this report, no reliance should be made on the network being implemented as described.

Neither the Department of Trade and Industry nor the Digital Television Group nor the author will be responsible for any consequences arising from use of specific information concerning transmitter characteristics given in this report.

1 Executive Summary

The current UK Frequency Plan has been analysed to assess its impact on communal aerial systems. The aspect of the Plan that causes most difficulty is the introduction of frequencies at switchover that are not presently in use. 54 of the 80 existing digital terrestrial transmitters will introduce new channels, and while these are predominantly for commercial (COM) multiplexes, at 10 stations at least one Public Service Broadcast (PSB) multiplex is allocated to a new channel. It is estimated that between one third and one half of communal aerial systems use frequency selective components in the headend, and will consequently not be able to handle the new frequencies.

In order to prepare headends to cope with switchover, installers and system designers need to have a clear idea of frequency allocations in the Plan. **Recommendation: information about post switchover frequencies and powers should be released to system designers and installers as soon as possible.**

Equipment manufacturers need to ensure that existing products are suitable for the conditions to be encountered at switchover, and to be given the best opportunity to develop new products. To do this, they too need to see details of the Plan. **Recommendation: information about switchover frequencies and powers should be released to manufacturers as soon as possible.**

A particular issue has been identified with channel changers, which are widely used in London, and to a limited extent elsewhere. As this principally affects PSB multiplexes, it is important to quantify the impact. **Recommendation: research the number of systems affected by channel changers, and raise the awareness of installers in affected areas. Measurements of the phase noise performance of a range of typical channel changers will help installers to understand which equipments are likely to need replacing before switchover.**

Recent survey work has indicated that existing systems, particularly among those that have not yet been upgraded, frequently fail to deliver adequate analogue signal levels. The consequence of this is that when analogue signals are replaced by digital, insufficient signal will be delivered for reliable decoding by the receiver, and in some cases decoding will be impossible. This predominantly affects PSB multiplexes. **Recommendation: carry out further research and surveys to determine more accurately the number of systems that will fail to deliver some or all PSB multiplexes to some or all outlets due to currently delivering too little analogue signal power.**

One of the main impediments to getting systems prepared for switchover is lack of urgency by large numbers of landlords. **Recommendation: landlords who have not begun conversion work nor budgeted for it in 2006-7 should be encouraged to start surveying their systems as soon as possible, so that they are well informed for setting up budgets for 2007-8.**

Availability of key components for upgrading systems could be compromised by demand from other European countries undergoing switchover at the same time. **Recommendation: an investigation should be made into the relative timing and demand for components likely to arise from other European countries, against the capacity for manufacture, with a view to identifying potential shortages in supply.**

2 Introduction

The purpose of this report is to provide an increased level of understanding of the issues that might affect communal aerial systems at switchover, and what might be done about them. A technical analysis of the current UK Frequency Plan (“the Plan”) has been made, and the likely impact of implementation of the Plan on the principal types of shared aerial system has been assessed. Various key individuals have been consulted: systems designers, component distributors, installers, and the members of the DTG’s Reception Group. The author has attempted to integrate their views and experience into this report.

3 Background information

3.1 *Digital Switchover*

At present, digital terrestrial television (DTT) is transmitted from 80 locations throughout the UK, alongside four or five analogue TV transmissions. While analogue transmissions continue, it is not possible to increase the coverage of DTT due to interference limitations. However, by switching off the analogue transmissions, DTT coverage can be increased effectively to the level of the current analogue service.

The process of digital switchover is planned to take place region by region across the whole of the UK, with the first region switching over during 2008, and the last during 2012. Each transmitter site will have extensive engineering work lasting many months. Much of this will be behind the scenes as far as the viewer is concerned. However, the impact of this work will become visible to the public over the period of a few months at each transmitter site, between a caption appearing on BBC2 analogue transmissions warning of the impending changes, and completion of the process.

This report limits itself to aspects of the switchover process that are relevant to the way in which communal aerial systems operate.

The exact process will vary from site to site, but a typical example is illustrated in Figure 1. The visible steps are:

1. Put a caption on BBC2 analogue, channel 62.
2. After a about a month, switch off BBC2, replace it with MUX 1 (formerly on channel 53), and re-name it PSB1. This multiplex will contain BBC2 programmes.
3. Put captions on all the other analogue transmissions.
4. After about a month, in one night move:
 - Mux 2 from channel 57 to channel 59, formerly ITV analogue, and re-name it PSB2
 - Mux A from channel 60 to channel 55, formerly BBC1 analogue, and re-name it PSB3
 - Mux B from channel 63 to channel 53, formerly Mux 1, and re-name it COM4
 - Mux C from channel 66 to channel 57, formerly Mux 2, and re-name it COM5
 - Mux D from channel 56 to channel 60, formerly Mux A, and re-name it COM6

One of the aims of switchover is to release nationwide a total of 14 broadcast channels in two groups: channels 31-40 and 63-68 (note that channels 36 and 38 are used for purposes other than broadcasting). If an analogue transmission is in one of the released

channels, then it cannot be used for DTT after switchover, so a new channel must be found. Similarly, DTT channels currently in the released spectrum must also be moved.

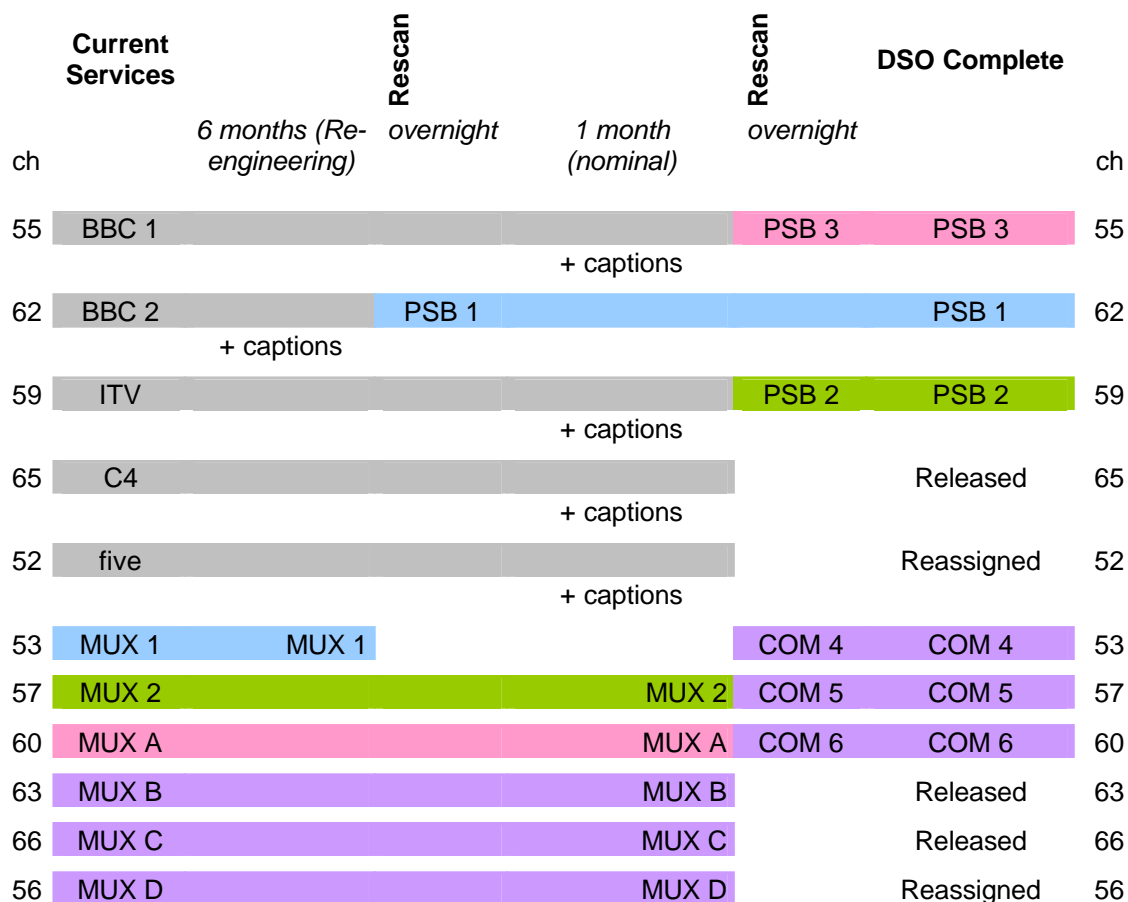


Figure 1: Example migration sequence¹ (Source: Arqiva)

After switchover, the transmitted power levels will generally be increased significantly above their current values. The great majority of PSB multiplexes will be transmitted at -7dB relative to current analogue powers, and COM multiplexes at -10dB. This compares with values of around -17dB at present.

3.2 Communal aerial systems

Communal aerial systems are used to deliver television and radio signals received at a single location to a number of users. Typically, they are found in blocks of flats (anything from about four flats in a two storey block up to a tower block with over 100 flats), housing estates, student halls of residence, prisons, etc.

Communal aerial systems can be partitioned into two categories:

- MATV (Master Antenna TV) systems, which deliver analogue and digital terrestrial television signals;

¹ Channels marked as “released” are in the group of 14 channels to be released for purposes not presently covered by the Frequency Plan for television. Channels marked as “reassigned” are available for use in the Frequency Plan, for other transmitter sites.

- IRS (Integrated Reception Systems), which deliver satellite services as well as terrestrial TV.

An IRS can be regarded as an MATV system with additional components to deal with satellite signals. The satellite components are effectively transparent to terrestrial television signals, so no switchover-related effects should be seen in an IRS that are not also seen in MATV systems. This report therefore says no more about IRS, other than to note that about 90% of communal systems that have been upgraded for DTT reception have been converted to IRS.

MATV systems have two principal parts:

- the headend, in which there is at least one aerial to receive signals off-air, and a launch amplifier to overcome the loss of signal power in the distribution network;
- the distribution network, which is an arrangement of cables and splitters designed to carry signals from the launch amplifier to outlets in each dwelling.

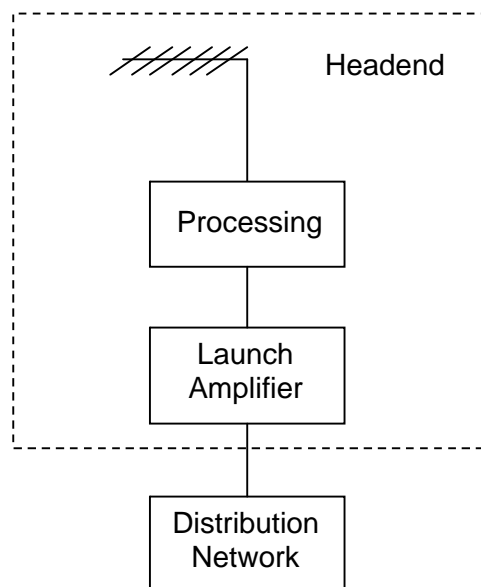


Figure 2: The principal components of a MATV system

MATV headends can themselves also be partitioned into two categories:

- wideband, in which the headend passes all signals from the frequency band used for terrestrial television;
- processed, in which frequency selective components are used, so that the system does not pass all terrestrial television frequencies. These components include equalisers and channel amplifiers, designed to apply different amounts of gain to different channels, and channel changers, designed to move a signal from one channel to another.

As a rule, small MATV systems tend to have wideband headends, and large systems will have processed headends, although this varies somewhat geographically.

Statistics about the numbers and sizes of headends are not readily available. However, one source, dating from about 2000, has been found and is given in

Table 1. Information about the basis for the numbers is no longer available, and no adjustment for new build since 2000 has been made. However, they show that 75% of systems supply fewer than 10 flats, whilst representing only 36% of households using shared aerial systems.

Flats per block		Number of flats		Number of blocks	Average flats per block
less than 10	36%	1,665,000	75%	369,000	4.5
10-20	21%	971,000	16%	79,000	12.3
20-50	25%	1,156,000	7%	34,000	34
50+	18%	832,000	2%	10,000	83
TOTAL:		4,624,000	TOTAL:		492,000

Table 1: Distribution of flats and blocks by numbers of flats on a system

The number of systems or headends has been assumed to be much the same as the number of blocks, on the assumption that the number of cases where more than one block is fed from the same headend is small.

For further information on MATV and IRS, see "Action Plan Task 5.9: Survey of MATV and SMATV systems", J. Ross and P. Barnett, December 2003².

4 Analysis of likely post-switchover frequency assignments

The UK UHF Frequency Plan is still under development, but for the purposes of this report the latest information available has been evaluated for the impact of frequency assignments and powers on communal aerial systems.

Although some of the frequencies cited are likely to be changed, the broad conclusions of the analysis are believed to be likely to remain the same.

The Plan is subject to change for perhaps another year, since it may be affected by the outcome of the ITU Regional Radio Conference in May 2006, and subsequent inter-governmental negotiations with neighbouring administrations such as the Republic of Ireland, France, Belgium and the Netherlands.

The analysis of the Plan covers only the 80 existing digital transmitting stations. Other stations that will transmit digital signals, but only after switchover, are beyond the scope of this report.

4.1 Transmitters where channels move out of aerial group

UHF TV aerials are designed to operate across groups of TV channels, to take advantage of being able to achieve more gain over a narrower range of frequencies. The aerial groups and channels over which they operate are listed in Table 2.

² Available at <http://www.dtg.org.uk/publications/books.html> and http://www.digitaltelevision.gov.uk/publications/pub_archive2003.html

Where grouped aerials have been used in the past, and new channels come into use at switchover that are outside the group, then the new channels may not be received with adequate strength.

<u>Aerial group</u>	<u>Channels</u>
A	21 – 37
B	35 – 53
C/D	48 – 68
E	35 – 68
K	21 – 48
W	21 – 68

Table 2: Aerial groups

Table 3 shows all possible combinations of aerial group change. Boxes with a green background indicate conditions where the group change (if any) is benign, in other words where the change is to a sub-group of the original. Boxes with a red background indicate where the change includes channels that were not covered by the original group.

Table 3 shows that there are four cases where new channels come into use at switchover that are outside the original group (“original group” meaning the group currently required to receive both analogue and digital channels). At Tacolneston³ and Beacon Hill³, there is a change from group C/D to group E. At Craigkelly³, one multiplex is outside the original group (K) by only one channel, and at Bilsdale³, one multiplex is outside group K by just two channels. Although the gain of grouped aerials tends to fall off quite sharply just above their intended frequency range, in areas of good signal strength from these two transmitters, the original group K aerials may work adequately.

		To aerial group					
		A	B	C/D	E	K	W
From aerial group	A	13	0	0	0	0	0
	B	0	7	0	0	0	0
	C/D	0	0	13	2	0	0
	E	0	5	3	4	0	0
	K	3	0	0	0	0	2
	W	8	3	3	3	2	9

Table 3: Numbers of transmitters where aerial groups change at switchover from groups currently required to receive all channels

³ See disclaimer on page 4.

There has been a tendency in recent years towards widespread use of Group W aerials, especially in areas of relatively high signal strength, in anticipation of changes of frequency in the future. However, older systems were more likely to use the narrowest group of aerial that was appropriate for the channels being radiated at the time. Furthermore, a recent survey of over 50 headends in East Anglia revealed numerous cases where small headends have not even been modified to carry DTT on its present channels, and the aerial group is suitable only for the analogue services. Table 4 shows that where aerial groups remain unchanged since the introduction of DTT, the number of cases where the group after switchover is not a subset of the current group increases considerably.

		To aerial group					
		A	B	C/D	E	K	W
From aerial group	A	18	0	0	0	2	6
	B	0	13	0	4	0	0
	C/D	0	1	16	3	0	0
	E	0	1	3	1	0	1
	K	2	0	0	0	0	2
	W	4	0	0	1	0	2

Table 4: Numbers of transmitters where aerial groups change at switchover from groups currently required to receive only analogue channels

The transmitters³ contributing to the red areas of Table 4 are:

- A to K: Lark Stoke, The Wrekin
- A to W: Bilsdale, Chesterfield, Idle, Knock More, Nottingham, Rumster Forest
- B to E: Bristol Kings Weston, Guildford, Hemel Hempsted, Sudbury
- C/D to B: Heathfield
- C/D to E: Beacon Hill, Llanddona, Tacolneston
- E to W: Reigate
- K to W: Craiggelly, Sandy Heath

This appears to present a problem mainly for COM multiplexes. Only one case has been found where a PSB multiplex is outside the analogue-only aerial group: Guildford³, where PSB3 will be three channels above the top of group B.

4.2 Transmitters where new channels are brought into service

One of the major drawbacks of the Plan is that 54 transmitting stations (2/3 of the 80 stations in this analysis) bring one or more new frequencies into use at switchover. The use of new channels is likely to be a problem for processed headends as they are usually

designed to pass only the current channels. Transmissions on new channels will generally result in those channels not being carried with sufficient quality to be usable.

The relative occurrence of the numbers of new channels is shown in Figure 3.

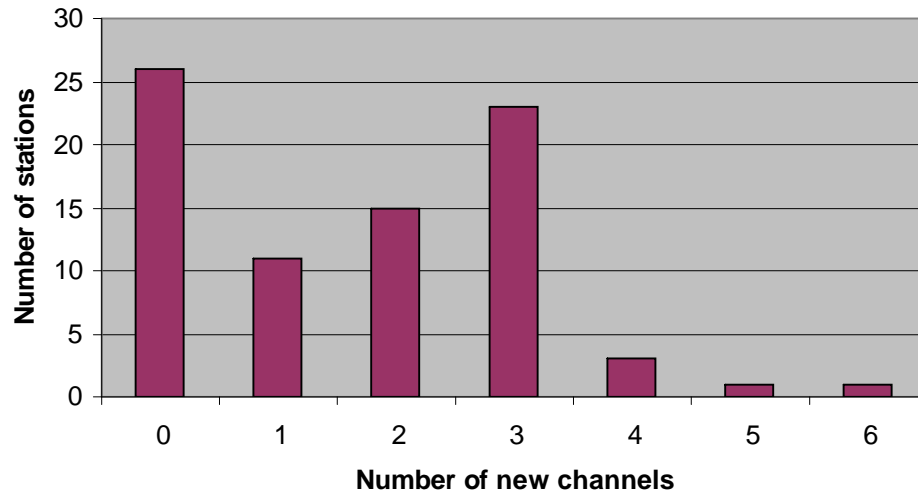


Figure 3: Relative occurrence of new channels across transmitter sites

Where new channels are used, they are predominantly for commercial (COM) multiplexes. However, there are ten sites where at least one public service broadcaster (PSB) multiplex is allocated to a new channel at switchover:

Station ³	Households covered
Bluebell Hill	126,390
Bristol Kings Weston	20,680
Dover	235,191
Guildford	26,270
Hannington	336,971
Lark Stoke	24,096
Malvern	65,000
Pontypool	43,000
The Wrekin	103,349
Tunbridge Wells	58,052

Table 5: Stations with at least one PSB multiplex allocated to a new channel

The distribution of new channels between PSB and COM multiplexes is shown in Figure 4.

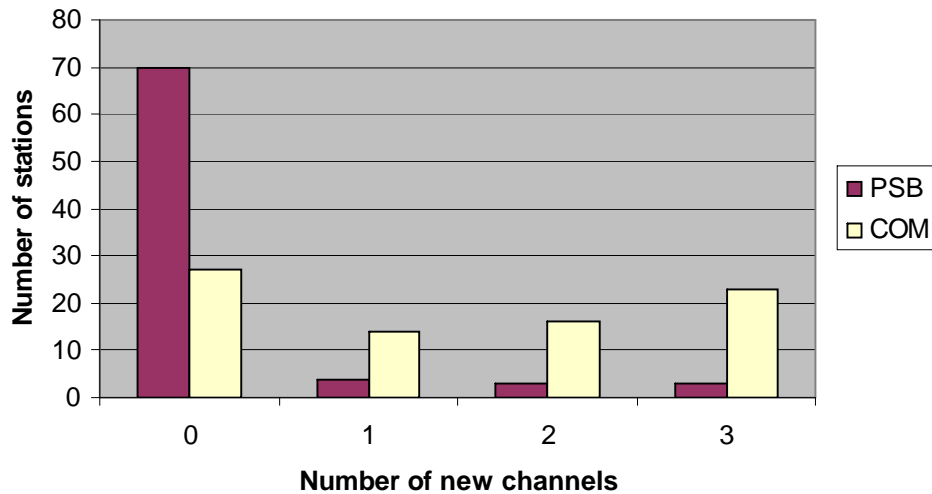


Figure 4: Distribution of new channels to PSB and COM multiplexes

4.3 Transmitter power increases

At all 80 existing stations DTT transmissions will see significant power increases at switchover. In 79 out of the 80 cases, the three PSB multiplexes are all at the same power after switchover (the exception is Chesterfield³), and in 79 cases the three COM multiplexes are at the same power (the exception this time is Belmont³). In the great majority of cases, the transmitter power levels are -7dB relative to current analogue powers for PSB multiplexes, and -10dB for COM multiplexes.

PSB multiplex powers range from 0dB to -8.5dB, with COM multiplex powers from -3dB to -17dB. The distribution of power levels is shown in Figure 5.

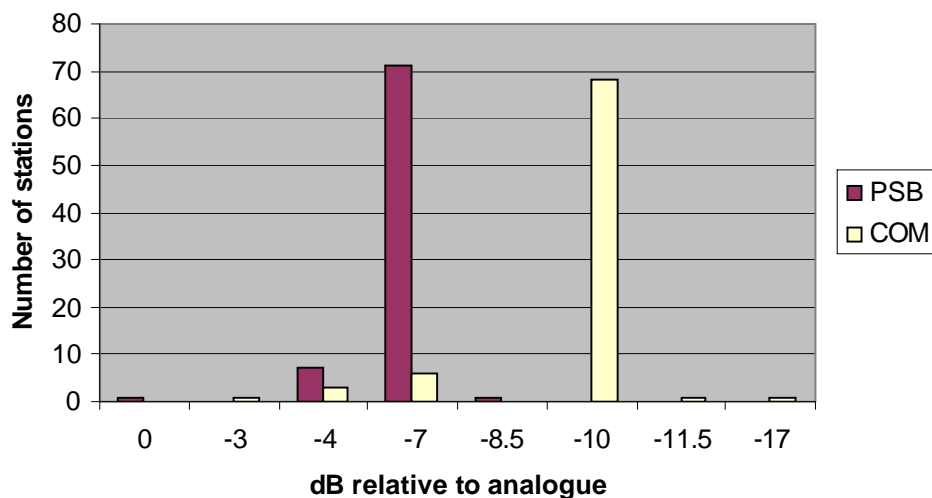


Figure 5: Distribution of multiplex power levels post switchover

5 Impact of the Plan on MATV headends

5.1 Effects of transmitter power increases

In most cases, the increase in transmitted power levels at switchover, from typical current values in the region of -17dB relative to analogue peak sync. power will lead to an increase in the quality (i.e. C/N and C/I ratios) of received signals. However, in MATV systems, the presence of the launch amplifier means that attention must be paid to signal levels.

Launch amplifiers are commonly operating at power levels where nonlinearity becomes important. Nonlinearity is encountered in all amplifiers when the output level is so high that the amplifier can no longer accurately reproduce the intended signal. The result is that a range of unwanted signals is created, and these can interfere with the TV receiver's ability to decode correctly.

A previous report⁴ examined typical launch amplifiers operating under conditions that are likely to be encountered post switchover. It showed that if a launch amplifier is properly handling analogue signals at present, then replacing these with six digital multiplexes at -7dB will not cause unacceptable levels of distortion. It also showed that multiplexes can be raised to somewhere in the range -3dB to 0dB before intermodulation becomes significant.

The report assumed that digital signal levels would not exceed -7dB relative to analogue. Analysis of the Plan has shown that while this should generally be the case, there will be cases within the 80 existing digital stations where this is exceeded – even one case (Hastings) where the PSB multiplexes will be at 0dB, and the COMs at -3dB. On the face of it, this should not be a problem, but the use of equalisers or channel amplifiers may cause difficulties in some circumstances.

Table 6 shows the powers currently in use for the six multiplexes, relative to analogue, for stations where the PSB multiplexes will be transmitted at levels higher than -7dB relative to analogue. It also shows the maximum increase in power that is expected for the six multiplexes at switchover. In the case of Sudbury, multiplexes C and D will increase in level by nearly 20dB.

Station ³	Mux 1	Mux 2	Mux A	Mux B	Mux C	Mux D	PSB	COM	Max. incr.
Belmont	-20	-17	-17	-17	-21	-21	-4	-10	16
Dover	-20	-20	-20	-20	-20	-20	-4	-10	16
Hastings	-10	-7	-7	-7	-7	-7	0	-3	7
Rowridge	-14	-14	-14	-14	-14	-14	-4	-10	10
Sudbury	-15.5	-14.9	-17	-15.2	-22.2	-23.6	-4	-4	19.6
Tacolneston	-14	-14	-17	-17	-17	-17	-4	-4	13
Tunbridge Wells	-20	-20	-20	-20	-20	-20	-4	-4	16
Whitehawk Hill	-20	-17	-20	-10	-14	-14	-4	-10	10

Table 6: Multiplex powers (dB w.r.t. analogue) pre- and post- switchover, and maximum power increases (dB) for stations where the power will be more than -7dB w.r.t. analogue

If a multiplex with a large increase in DTT power at switchover, and that does not change channel, is received at a headend where a channel amplifier gives it additional gain over

⁴ "MATV System Component Testing", P. Barnett, January 2005, available at <http://www.dtg.org.uk/publications/books.html>

other channels, then the launch amplifier might be presented with excessive signal. At least one manufacturer of equalisers and channel amplifiers has been advising installers to set digital levels at -12dB to -15dB relative to analogue. Another has automatic levelling that sets DTT signals at -10dB.

Taking this last example of automatic levelling to -10dB, if an incoming multiplex is at -17dB, the equaliser will provide 7dB gain. If then at switchover, the multiplex remains in the same channel, increases in power to -4dB, and the equaliser is not reset, then this multiplex will be amplified to +3dB. This is unlikely to cause problems to the launch amplifier if there is only one multiplex to which this happens. It is an illustration how unexpected levels may come about.

Note that some transmit aerials have shaped patterns to meet adjacent area protection requirements. This could further increase the likelihood of channel amplifiers being used, as a result of reduced ERP. Relatively few multiplexes, perhaps ten, are carried on such aerials. It is planned to replace these shaped pattern aerials with omni-directional aerials at switchover, which could make the increase in power in some directions larger than the nominal increase.

Table 7 shows the way that channels are allocated to the stations in Table 6. Note that no PSB multiplexes are on former DTT channels; they all either move to former analogue channels or to new channels. Of the COM multiplexes that are radiated at -4dB or higher, only Tunbridge Wells has one that is on a former DTT channel. We can conclude therefore that problems with equalisers providing too much signal to launch amplifiers are likely to be quite rare.

Station ³	PSB to former analogue	PSB to former DTT	PSB to new	COM to former analogue	COM to former DTT	COM to new
Belmont	3	0	0	0	2	1
Dover	2	0	1	0	1	2
Hastings	3	0	0	0	0	3
Rowridge	3	0	0	0	1	2
Sudbury	3	0	0	0	0	3
Tacolneston	3	0	0	0	0	3
Tunbridge Wells	1	0	2	2	1	0
Whitehawk Hill	3	0	0	0	1	2

Table 7: Allocation of channels at switchover to stations in Table 6

5.2 Systems taking signals from more than one region

In many areas of the UK receiving signals from more than one transmitter is widespread. Examples are found predominantly along the Welsh/English border and at boundaries between ITV regions. The motivation is generally access to additional programmes.

Receiving signals from more than one region is not officially supported, and no guarantee of performance is given. However, it often works well, because adjacent regions naturally avoid use of common frequencies to ensure acceptable levels of interference.

The main limitation is that the signal levels from the neighbouring area can be low. There are expected to be cases where viewers are tolerating rather poor analogue pictures from the adjacent region at present, and will find they have no reception of these out of area signals at all after switchover. However, the DTT power increases at

switchover should probably ensure that this is not widespread, even though reception will tend to be more prone to disturbance from impulsive interference due to the low signal levels.

A region where use of signals from two transmitter areas is widespread is along the Welsh border where signals from both Wenvoe and Mendip are used. Figure 6 shows the channel allocations pre- and post-switchover for these two transmitters.

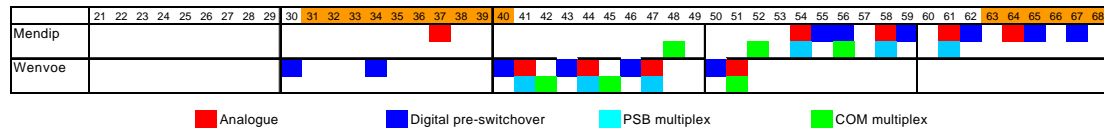


Figure 6: Channel allocations for Mendip and Wenvoe (provisional)³

MATV systems make use of signals from more than one region in much the same way as individual dwellings. Two aerials are used, one for each transmitter. The outputs from the two aerials are filtered to avoid reception of reflected signals causing ghosting on analogue. This is illustrated in Figure 7, where the aerial receiving from transmitter A also receives a substantial signal from transmitter B via a reflection. The path length from transmitter B is longer via the reflection than the direct path, so without filtering, a second image would be seen on analogue receivers, displaced to the right.

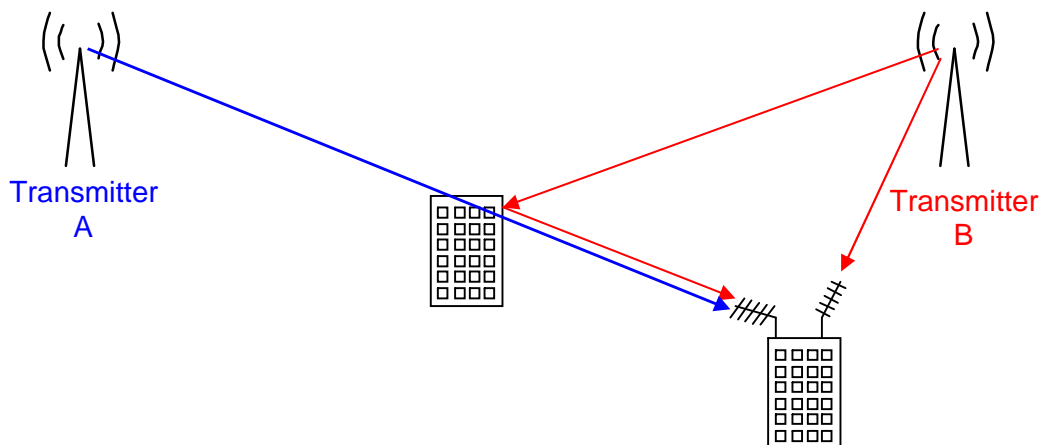


Figure 7: Reception from two transmitters

In the case of Mendip and Wenvoe, the analogue signals from each station are well separated in frequency, so the aerial filtering is straightforward.

After switchover, the frequencies of the multiplexes from Mendip and Wenvoe are interleaved, and so filtering that currently exists may prevent reception of some of the multiplexes. If the path length difference between the direct and reflected signals is less than about 2km (i.e. 7µs, the guard interval of the DTT signal) or sufficiently low in level, then the filters can be removed without serious impairment to the DTT signals, and a full set of multiplexes should then be receivable. These conditions will have to be determined on a case by case basis.

A headend carrying services from two regions will have more channel amplifiers or equaliser sections than a single region headend. The regional rollout timetable may

mean that the two regions switch over at different times, but the channel amplifiers or equalisers can be prepared in advance. However, there appear to be three options for the aerial filters:

- removal when the headend is prepared for switchover, with the risk that analogue services may be degraded by ghosting for some period of time
- removal close to switchover, which will reduce the amount of time analogue services are degraded, but will require an additional visit
- leave the filters in place, which may prevent certain multiplexes from being received.

The most appropriate option will have to be determined on a case by case basis.

5.3 Results of recent surveys

5.3.1 High rise properties

A recent survey of five high rise blocks in the Midlands highlights some typical problems. The systems had been installed in the late 1960s, and modified to carry Channel Five. Very strong signals from Sutton Coldfield were received at the headend, and measurements were made at ground or first floor outlets, among the most distant points from the headends on the distribution networks. All headends were fitted with filters to pass only the analogue services, and digital signals were unusable. Figure 8 shows the ranges of analogue signal levels that were recorded on nine outlets among the five high rise buildings. Ideally, analogue signal levels should lie between 60dB μ V and 80dB μ V. Only one outlet actually achieves this for all signals, although two others come close. However, six outlets fall seriously short. It was not clear whether they have developed faults, or whether they have always been like this.

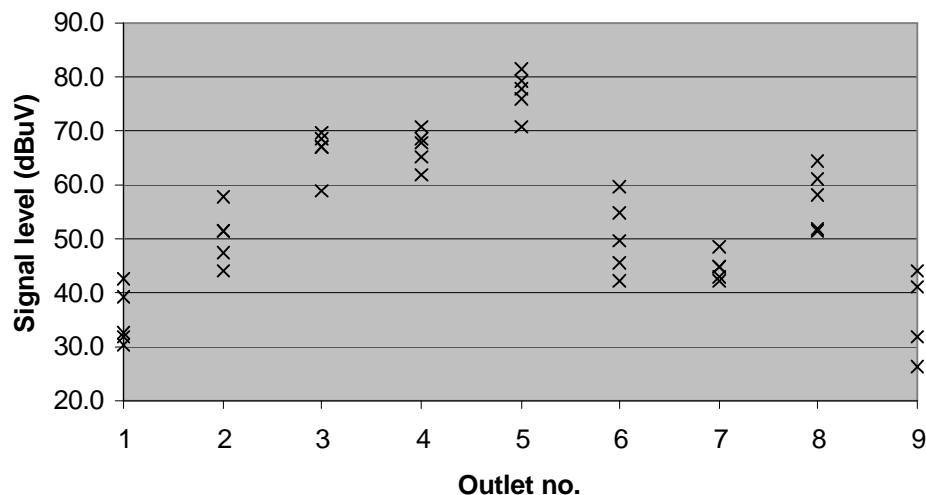


Figure 8: Analogue signal levels recorded at tower blocks in the Midlands

If a system is currently delivering less than 50dB μ V of analogue signal, then when these convert to digital at -7dB, they will deliver less than 43dB μ V of digital signal. This is considered marginal at best, and reception is likely to be affected by impulsive interference. We can therefore say that in this small sample, five outlets across three systems will deliver inadequate levels of at least some PSB multiplexes.

5.3.2 Low rise properties

A recent survey of about 50 systems in East Anglia shows a large number of systems failing to carry digital signals at present, and a large variety of reasons why, including:

- 9 systems were receiving from a local relay that does not carry DTT. Some of these systems were in areas where the coverage from a DTT transmitter is good, according to the postcode database on the DTG web site.
- 18 systems had problems attributed to the aerial system. This included wrong group, poor positioning, and excessive feeder loss (probably due to water ingress).
- 13 systems had problems with insufficient launch amplifier levels, amplifier overload or excessive distribution network loss.

Only nine systems were considered to be delivering satisfactory digital signals. All but seven were delivering sufficient analogue signal level that they should be expected to carry the PSB multiplexes at switchover, but the majority will not deliver COM multiplexes.

No channel filters or equalisers were found in this survey.

It was obvious that the quality of installations was variable: a few were good, most were shoddy. Amplifiers were lying loose on loft insulation, cables were poorly terminated, resulting in connections that failed when the cable was moved. Only one site had safety earthing to modern standards. Many could be improved by relatively simple modification. This implies that the installers, or in some cases people who had subsequently modified the systems, had not been trained to a reasonable level of workmanship.

5.4 Channel amplifiers and equalisers

Channel amplifiers are used to change the level of individual channels. Some use simple RF tuning, and others convert to a low intermediate frequency and use a SAW filter, which provides a high degree of selectivity. Channel amplifiers without SAW filters should not be used with signals where the adjacent channel is used, because the frequency response is not sharp enough to avoid affecting adjacent channels. In many instances, channel amplifiers with SAW filters can be used with adjacent channels.

A number of channel amplifiers can be connected in tandem to provide the desired response for the specific configuration of signals at that headend.

Cluster amplifiers are designed to operate with a number of adjacent channels, which are handled as a single block. It is generally not possible to change the level of individual channels within a cluster by using a cluster amplifier.

Equalisers are available in two types: passive and active. Passive equalisers use UHF filters to provide the desired frequency selectivity over one or more channels. One sample measured provided about 17dB slope across the channel adjacent to the desired one. Multiple filters can be provided in one unit, and the insertion loss of each filter can be adjusted so that signals are brought to broadly the same levels. The filters are fixed tuned, and cannot be adjusted (in frequency) on site using equipment typically available to installers. They must be returned to a suitably equipped workshop if they are to be re-tuned.

Electronically tuned equalisers are available, and one model in particular is fairly widely used. With an integral launch amplifier, it is available for about £170. The UHF filters are configurable from front panel controls, or via a control port to which a computer can

be connected. A total of ten filters are available, each of which can be tuned from 1-7 channels wide, and the gain of each filter can be adjusted individually in 1dB steps.

The selectivity of this device is rather less than the passive equaliser described above. Filter slope was measured at about 10dB per 8MHz channel. This type of filter therefore affords less protection to unwanted signals, such as TETRA (Terrestrial Trunked Radio) transmissions below 470MHz. However, it is very flexible, and can be configured rapidly on site, requiring only the type of equipment normally carried by installation teams (e.g. spectrum analyser and level meter).

In testing, it was discovered that the filters in this equaliser can be set up in a way that gives a very poor response: if two filters are tuned to cover just one channel each, and placed on adjacent channels, the filters interact to cause major distortion of the frequency response. However, once the filters are widened to two or more channels, placing them adjacent to each other is no longer a problem. Optimally flat frequency response seems to be achieved at about 5 channels width for each filter. A fairly good response over fifteen channels, for example, can be obtained by placing three such filters end to end. No guard channels are needed between filters in this case.

A more advanced form of electronically tuned filter/amplifier is available. This uses a SAW filter in each of eight, eleven or fourteen filters to provide very high selectivity, and can operate in blocks of adjacent channels, providing the ability to adjust the level of each channel individually. This advanced performance comes at a price: the eleven filter model costs about £550.

5.5 Channel changers

In areas of particularly high field strength there can be a problem with direct reception of analogue TV signal via the fly lead or outlet plate interfering with signals from the headend. The result is a pre-echo or unwanted image to the left of the wanted picture, as the direct reception path is shorter than that via the headend, as depicted in Figure 9.

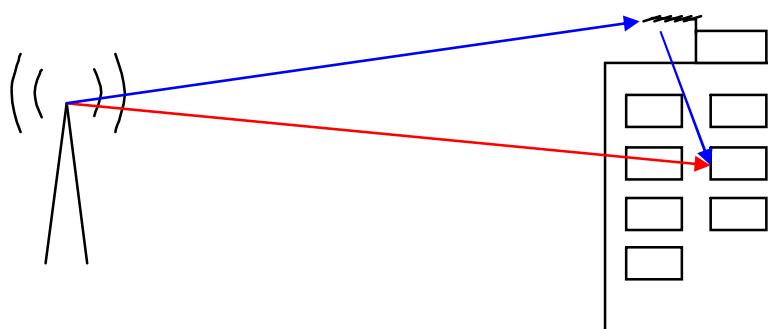


Figure 9: Direct reception interfering with signals from the headend

To avoid this problem, headends use channel changers to move the analogue signals to new channels not occupied by other signals.

Channel changers are widely used in London, because the transmitter at Crystal Palace is within Greater London, resulting in very high signal levels at buildings within a few miles of the transmitter. Unfortunately, many installers chose output channels one below the incoming, and these were subsequently used for DTT. Rather than change the output channels, and have to re-tune all the televisions on these systems, they then decided to install more channel changers for the digital services.

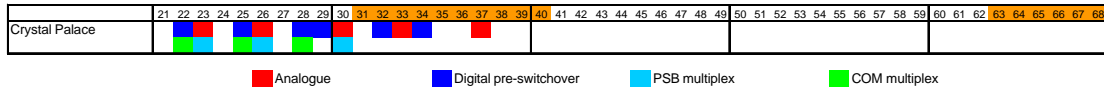


Figure 10: Channel allocations for Crystal Palace (provisional³)

At switchover, channel changers currently carrying analogue signals will have to carry digital. Those channel changers that have not been replaced in recent years are reported to have poor phase noise performance, to the extent that the phase noise they impress on DTT signals actually prevents decoding. The multiplexes that will fail in this way are all PSB.

Whilst there is agreement in the trade that this problem will be widespread in London, and that it may occur in a few other places as well, the extent of the problem has not been quantified. In addition, it is not known if the phase noise problem applies to all models of channel converter designed prior to the introduction of DTT, nor whether all models installed during headend upgrades in the last few years will be suitable for DTT.

Recommendation: As PSB multiplexes will be affected, it is important to quantify the impact of channel changers, and find ways of overcoming the problems, such as by raising the awareness of installers in affected areas. Measurements of the phase noise performance of typical channel changers will help installers to understand which equipments are likely to need replacing before switchover.

5.6 Automatic level control

Received signal levels can vary with time, particularly over longer paths, sea paths, and paths with reflections from moving objects, such as gasometers, vehicles, etc. Automatic level control (ALC) could be used to reduce incoming signal level variations to negligible levels. However, its adoption has not been widespread. Only one model using ALC has been identified, and it ceased being sold in the early 1990s. It has not been possible to determine how many of these are still in service.

The potential problem with ALC is the way in which it has been implemented to work with analogue signals. The average power of the vision signal varies with picture content, so the ALC circuit uses a peak detector to determine the level of the signal. In contrast, the average power of a DTT signal is constant (as a function of content), and has a peak to mean ratio of about 12dB. Therefore, a peak detector might be expected to hold the mean level of a digital signal at -12dB relative to analogue, which should be satisfactory. However, the behaviour of the ALC circuit in the presence of a digital signal remains unknown.

ALC should not be confused with automatic level setting, a feature available on some electronic equalisers and channel amplifiers. Automatic level setting is a process where the device detects the level of signal in each channel, and sets the gain of the channel appropriately. Thereafter, the gain is fixed.

6 Planning for switchover

Chaos is likely to result if making changes to headends is generally left until around the time of switchover. Switchover is not a single event at any one location, but is a series of actions taking place over some weeks (see Figure 1). Inevitably, a headend requiring attention during switchover would leave viewers without some or all television services for significant periods of time. In addition, considerable strain would be placed on both installers and the supply of equipment.

The best strategy is to plan wherever possible to make headends cope with switchover without intervention, and to carry out the work well ahead of switchover.

The main factor identified in this report that will prevent existing systems from carrying digital services is the introduction of new channels at switchover, which happens at 54 of the 80 existing digital transmitting stations. To cope with this, many installers are fitting electronically tuned equalisers, so that they can readily be configured to pass all the channels that will be used both before and after switchover. However, as they do not yet have information about post-switchover channels, they will have to re-visit each headend once this information becomes available.

Looking at channels in use either side of switchover, the Plan shows that the biggest block of adjacent channels without any gaps is 13 channels wide. The most widely used equaliser is able to deal with this, but there is another model on the market where this may cause a problem. The manufacturer is examining this aspect at the time of writing.

There is general agreement that manufacturers, designers and installers of communal systems should be planning for switchover now. However, they are severely hampered by the unavailability of information about the switchover frequency plan. A limited amount of information about switchover has been released to the trade via CAI Roadshows, but it does not give a full enough picture.

Recommendation: Release information about post switchover frequencies and powers to manufacturers as soon as possible, so that they can understand the implications for their existing products, and have a better chance to identify opportunities for new products. Even if there are subsequent changes to the Plan, these should cause little impact on manufacturers.

Recommendation: Release information about post switchover frequencies and powers to designers and installers as soon as possible. This information will need to be qualified with comments about the possibility of changes, as use may be made of specific cases. Recipients should be recorded, so that further information, including changes, can be sent to them once the final version of the Plan is confirmed.

6.1 Scale of work

There is no single reason why systems as they are at present will not carry all six digital signals at switchover. The main reasons for problems include:

- New frequencies coming into use at switchover, and these frequencies being suppressed by filters and equalisers. This predominantly affects COM multiplexes, but some PSB multiplexes are affected as well.
- Systems currently delivering very low levels of analogue signals to some or all outlets. When digital signals replace them, they will be at too low levels to decode reliably, or at all. This affects both PSB and COM multiplexes.
- Aerial problems, including wrong group (affects mainly COM multiplexes) and excessive feeder loss (affects all multiplexes).

6.1.1 Estimation of the number of systems that will fail to carry at least one PSB multiplex due to filtering

10 of the 80 DTT transmitter sites use a new frequency for at least one PSB multiplex. Weighting for the coverage of each of these, this represents about 3.5% of households.

Assuming a uniform distribution, and using the figures from Table 1, about 17,200 headends (3.5% of 492,000) would come into this category.

It has been estimated that channel filters and equalisers are used at between one third and one half of all sites. Furthermore, they tend to be used more often on larger systems than on smaller ones. The East Anglian survey referred to above did not find any filters or equalisers, but this will vary from location to location. For example, heavier use of filters tends to be made where there are large numbers of potentially interfering signals, both broadcast and non-broadcast. One city with a strong military presence is reported to have upgraded over 500 headends in the last few years, and specified fixed-tuned equalisers to provide high levels of protection. As the transmitter serving that area will bring into use two new frequencies, both for COM multiplexes, they are likely to have to tolerate the absence of two multiplexes, or replace all the equalisers.

As filtering is used less in smaller systems, and smaller systems make up about 75% of the total number of systems, the actual number of systems that will not carry all six multiplexes due to filtering is much smaller than 17,200, perhaps in the region of 8,000. Note that there is a fairly large uncertainty on this figure, due to not knowing the distribution of system sizes using filtering.

6.1.2 Estimation of the number of systems that will fail to carry all six multiplexes due to filtering

54 of the 80 DTT transmitter sites use one or more new frequency at switchover. Weighting these sites for their coverages, this represents about 56% of households.

As above, assuming a uniform distribution, and using the figures from Table 1, about 275,000 headends (56% of 492,000) would come into this category. Using the same assumptions as above, the actual number of systems that will not carry all six multiplexes due to filtering is much smaller than this, perhaps in the region of 140,000. Note that there is a fairly large uncertainty on this figure, due to not knowing the distribution of system sizes using filtering.

Systems that have already been upgraded are assumed still to be in this category. Those that are equipped with electronically tuned filters should be removed from this category by a brief visit to re-configure the filter. Those with fixed tuned filters will require a longer visit and hardware to be changed.

6.1.3 Estimation of the number of systems not delivering adequate analogue signals to allow sufficient DTT signal level at switchover

It has been estimated that about 1.3m flats have already been converted to IRS. The assumption is that converted systems will deliver adequate signal, and are therefore excluded. Using the data from Table 1, this represents about 28% of the total of 4.6m flats, with 72% or 3.3m still to be converted.

From the East Anglian survey of 50 low rise properties, 14% did not deliver sufficient analogue signals. For the high rise survey, three out of five buildings tested had outlets giving below 50dB μ V of analogue signal level. Obviously, these two surveys are very small and take no account of variations that may occur across the country. However, if we assume that 20% of systems have some outlets that fail to deliver sufficient signal, then there would be about 100,000 systems in this category. There is clearly a very large degree of uncertainty about this figure, and there would be value in refining it.

Recommendation: carry out further research and surveys to determine more accurately the number of systems that will fail to deliver some or all PSB multiplexes to some or all outlets due to currently delivering too little analogue signal power.

6.2 Screening systems

Screening systems to determine whether they will successfully carry either all three PSB multiplexes, or alternatively all six PSB and COM multiplexes, requires each system to be surveyed.

The extent of the survey depends on what is found, and whether the objective is to carry only PSB, or PSB and COM, multiplexes. It also requires knowledge of the switchover frequency allocations.

The main barrier to being able to ensure that at least PSB multiplexes will be carried is seen as lack of urgency by landlords. It is reported that many Local Authorities have no budget in place for 2006-7 for upgrade work, so the earliest that they could carry out the upgrades would be in 2007-8.

Recommendation: Landlords who have not begun conversion work nor budgeted for it in 2006-7 should be encouraged to start surveying their systems as soon as possible, so that they are well informed for setting up budgets for 2007-8.

6.2.1 Carriage of PSB multiplexes

Headends taking signals from local relays are likely only to have access to PSB multiplexes, since COM multiplexes will be carried on a maximum of 200 of the 1154 transmitters. Although no analysis of these stations has been carried out, it is still important to ensure that systems will receive the three PSB multiplexes.

It should be noted that the East Anglian survey referred to above found some cases where the headend took signals from a local relay, even though adequate DTT signals were available from elsewhere. At switchover, this would often result in only PSB multiplexes being available, when the full set could be received from another transmitter. This can only be resolved on a case by case basis by the installer.

To check for proper carriage of PSB multiplexes:

- Test a number of outlets, including at the furthest reaches of the distribution network. If analogue signal levels are in excess of about 57dB μ V, and the carrier to noise ratio is better than about 30dB, and if all the PSB multiplexes transfer to former analogue channels, they should be carried satisfactorily.
- If any PSB multiplexes transfer to new channels, inspect the headend for the presence of any channel amplifiers or equalisers. If there are any, they will probably have to be replaced or re-configured. Check the aerial group, and that signal levels are as expected.

6.2.2 Carriage of all six multiplexes

To check for proper carriage of all six multiplexes:

- If all PSB multiplexes transfer to former analogue channels, and all COM multiplexes remain on former DTT channels, then test a number of outlets for satisfactory signal levels: better than 55dB μ V for analogue and 43dB μ V for digital. (Note: this assumes

a 7dB increase in signal level at switchover, taking the level to 50dB μ V. If the increase is lower than 7dB, the test threshold should rise accordingly.)

- If any multiplexes transfer to a new channel, inspect the headend for the presence of any channel amplifiers or equalisers. If there are any, they will probably have to be replaced or re-configured. Check the aerial group, and that signal levels are as expected.

An experience installer, properly equipped with a suitable spectrum analyser/level meter should fairly rapidly be able to assess the likely performance of a system at switchover by following these steps.

6.3 Installation materials

Large volumes of equalisers and channel amplifiers are going to be needed for upgrading headends for switchover. Electronically tuned equipment is favoured for its flexibility. There is also possibly room for innovation in the design of new products specifically able to cope with the range of circumstances likely to be encountered at switchover.

Discussions with distributors revealed no specific concerns about the supply of components, other than this: much of the components used are manufactured in mainland Europe, and there may be competition from other countries also switching over to digital. If a country were to attempt a shorter programme than the UK is planning, then demand for certain components, such as equalisers, may be very high, resulting in shortages and delay in supply to the UK.

Recommendation: Undertake an investigation into the relative timing and demand for components likely to arise from other European countries, against the capacity for manufacture, with a view to identifying potential shortages in supply.

6.4 Summary of minimum tests, upgrades and resources required to ensure delivery of PSB multiplexes

To achieve a high level of certainty that a system will carry PSB multiplexes at switchover, it should be surveyed as described in section 6.2.1, to determine that:

- analogue signals are delivered adequately;
- frequency sensitive headend components will not prevent PSB multiplexes on new frequencies from being carried.

It is probably safe to assume that systems that have been upgraded since the start of DTT will provide adequate level, but may have difficulty carrying new frequencies. Installation companies may be able to provide information from their records about which of these systems will need attention.

If analogue signals are inadequate, the cause must be found, and could include any or all of the following:

- Insufficient signal from the aerial: corroded, damaged or mis-pointed aerial, water ingress into the feeder. Remedy: replace the aerial and feeder system.
- Insufficient gain or output power from the launch amplifier. Remedy: install a pre-amplifier or replace the launch amplifier.

- Excessive loss in the distribution network, due either to a fault or poor design.
Remedy: correct the fault, insert a new amplifier at a suitable point in the distribution network, or replace the distribution network.

If frequency sensitive components will prevent PSB multiplexes from being carried, then:

- If an electronically tuned equaliser is fitted, it should be re-programmed to include the new channels.
- If separate channel amplifiers are fitted, then these could be added to with channel amplifiers for the new channels, or replaced with an electronically tuned channel amplifier or equaliser, depending on local conditions.

A survey taking 1-2 hours by a qualified installer should identify the appropriate course of action. The survey should also assess the general condition of the system, as it may be appropriate to replace the entire system rather than patch up one part of it.

Local conditions vary considerably, and require the skills of the installer to evaluate them. Remedies range from re-configuring an electronically tuned equaliser, which could take a few minutes, to replacing the entire system, which could be a week's work for an installation team.

If remedial action is taken, its goal should be to enable the system to handle all multiplexes, rather than just PSB. The incremental cost of doing so should in most cases be small.

7 Conclusions and recommendations

Study of the UK Frequency Plan and of some surveys of existing systems has shown that there are two main problems that will arise with communal aerial systems, unless action is taken to avoid them:

1. The Plan shows that new channels come into use at 54 of the 80 existing DTT stations at switchover. The 54 stations provide coverage to about 56% of households. The majority of these new channels are used for COM multiplexes, but at 10 stations, representing about 3.5% of households, new channels are used for PSB multiplexes.

Between about one third and one half of communal aerial systems use frequency selective equipment in the headend. Where such equipment is used, new channels will almost certainly not be carried acceptably. These systems will require modification or reconfiguration before they will carry multiplexes on new channels.

2. The results of two small surveys in East Anglia and the Midlands have shown that the levels of analogue signals being delivered can be sufficiently poor that when the analogue signals are replaced by digital, receivers will not be able to decode services reliably, if at all. The number of headends affected may be around 100,000, but as there is a considerable degree of uncertainty, we are recommending further survey work to establish this figure more accurately.

Some proportion of these headends will be upgraded before switchover. To ensure that the upgrade work puts the headend in a state that allows it to cope with switchover requires that system designers and installers have access to information about the channels that will be used at switchover. It is by no means clear what proportion of them

will be upgraded in time; there are large numbers of small systems, and many landlords of all sizes have yet to act.

7.1 Recommendations

This section summarises the recommendations made throughout this report.

1. As PSB multiplexes will be affected, it is important to quantify the impact of channel changers, and find ways of overcoming the problems, such as by raising the awareness of installers in affected areas. Measurements of the phase noise performance of typical channel changers will help installers to understand which equipments are likely to need replacing before switchover.
2. Release information about post switchover frequencies and powers to manufacturers as soon as possible, so that they can understand the implications for their existing products, and have a better chance to identify opportunities for new products. Even if there are subsequent changes to the Plan, these should cause little impact on manufacturers.
3. Release information about post switchover frequencies and powers to designers and installers as soon as possible. This information will need to be qualified with comments about the possibility of changes, as use may be made of specific cases. Recipients should be recorded, so that further information, including changes, can be sent to them once the final version of the Plan is confirmed.
4. Carry out further research and surveys to determine more accurately the number of systems that will fail to deliver some or all PSB multiplexes to some or all outlets due to currently delivering too little analogue signal power.
5. Landlords who have not begun conversion work nor budgeted for it in 2006-7 should be encouraged to start surveying their systems as soon as possible, so that they are well informed for setting up budgets for 2007-8.
6. Undertake an investigation into the relative timing and demand for components likely to arise from other European countries, against the capacity for manufacture, with a view to identifying potential shortages in supply.

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