R&D White Paper

WHP 002

July 2001

Validation of interference reduction techniques used in planning the UK DTT network

J. Middleton

Research & Development
BRITISH BROADCASTING CORPORATION

BBC Research & Development
White Paper WHP 002

The validation of interference reduction techniques used in planning the UK DTT network

J. Middleton

Abstract

Allocating spectrum for DTT channels in the UK has required very careful planning to avoid causing interference to existing analogue TV viewers both in the UK and in adjacent continental countries. Some of the transmitting antennas have radiation patterns with power restrictions in the vertical as well as the horizontal plane to minimise potential outgoing interference without sacrificing coverage. It was not certain how well this would work over long-distance signal paths which involve tropospheric propagation mechanisms. To help to answer this, a series of UHF propagation studies have been carried out over sea and land-sea paths with particular reference to assessing the level of DTT signals radiated towards Holland and France. This document gives the results

Given at the International Broadcasting Convention (IBC 2001), Amsterdam, 13-18 September. Conference Publication.

Key words: Interference reduction, DTT network planning

White Papers are distributed freely on request.

Authorisation of the Head of Research is required for publication.

The validation of interference reduction techniques used in planning the UK DTT network

J. Middleton

BBC R&D, UK

ABSTRACT

Allocating spectrum for DTT channels in the UK has required very careful planning to avoid causing interference to existing analogue TV viewers both in the UK and in adjacent continental countries. Some of the transmitting antennas have radiation patterns with power restrictions in the vertical as well as the horizontal plane to minimise potential outgoing interference without sacrificing coverage. It was not certain how well this would work over long-distance signal paths which involve tropospheric propagation mechanisms. To help to answer this, a series of UHF propagation studies have been carried out over sea and land-sea paths with particular reference to assessing the level of DTT signals radiated towards Holland and France. This document gives the results

INTRODUCTION

UHF transmitting antennas are directional in the vertical plane such that the radiated power is concentrated in a narrow beam. For example, the -3 dB beam-width for an antenna with a 16 λ aperture is 3.2°. Under normal meteorological conditions, UHF signals do not propagate far beyond the horizon so, to optimise coverage and minimise interference to other co-channel stations, this narrow beam is usually angled below the horizontal by a few degrees. Typically, the beam-tilt is adjusted so that the -3 dB point of the vertical radiation pattern (VRP) is at 0° to the horizontal. The actual beam tilt used at a particular site will depend on the site and antenna heights, as well as the aperture, but it is usually between 0.5 and 2°.

Under certain meteorological conditions, variations in the refractive index of the troposphere can lead to the formation of ducting layers [1]. These enable radiowaves to propagate far beyond the horizon and can cause interference to distant co-channel services. Ducts can be classified as surface ducts, which extend from the earth's surface up to about 200 metres, and elevated ducts which have a lower limit of about 100 metres and can extend up to 1 km in height. Anticyclonic weather can result in large-area elevated ducts, often visible as 'inversion layers' due to the trapping of atmospheric pollutants. Elevated ducts are more prevalent in Northern Europe than surface ducts, occurring for 5 to 10% of the time. However, their effect on radiowave propagation is usually less than this (i.e. for smaller percentages of time), owing to the relationship between path geometry and the ducting layers.

Because of this abnormal propagation, it is likely that broadcasters will be required to reduce the radiation from their transmitters in the direction of those co-channel services that may suffer interference. This is usually achieved by shaping the horizontal radiation pattern (HRP) accordingly. However, an HRP which is not omni-directional results in reduced coverage unless it is near the coast, so these reductions in radiated power may be the subject of negotiation at international co-ordination meetings.

In the case of the DTT transmissions from the UK transmitter at Crystal Palace, a reduction in radiated power of 10 dB was required to the south to meet co-ordination requirements with France. However, if this were to be achieved through shaping of the HRP, there would be significant coverage problems to the south of the transmitter[1]. Consequently, an alternative approach was used which was to increase the beam-tilt to the south so that the signal at 0° to the horizontal was about -10 dB.

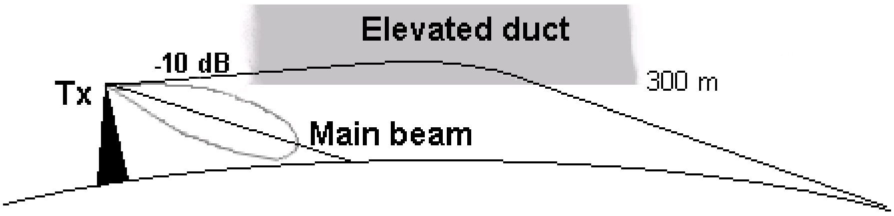


Fig. 1

The height of the transmitting antenna is approximately 300 metres above sea level so, for the technique to work, any tropospheric ducts must be predominately above this height as demonstrated in Fig. 1 (vertical scale exaggerated for clarity). Otherwise, if surface ducts are the main propagation mechanism, then power from the main beam would be propagated beyond the horizon and the expected reduction in signal would not be achieved. To confirm that this method of reducing potential interference has the desired effect and is not compromised by the existence of surface ducts, two receiving sites were set up in France at Guilmécourt and Calais. These monitored analogue TV and DTT transmissions from Crystal Palace over periods of 12 months or more.

In addition, another site was set up at Texel in Holland. This site receives analogue TV and DTT signals from transmitters at Belmont and Tacolneston. Both these transmitters have significant power restrictions towards Holland but these are achieved mainly through HRP reductions. Since they are both located in rural areas and near the coast, this causes relatively little loss of coverage.

The site locations are shown in Fig. 2 and this paper gives the results of the analysis of field strength data gathered between September 1999 and April 2001.

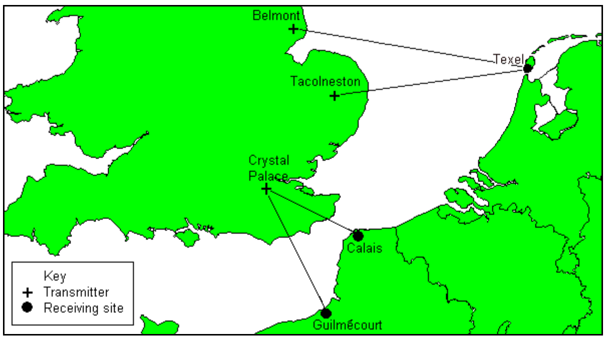


Fig. 2 Map showing propagation paths

[1] The chosen antenna at Crystal Palace consists of many panels arranged around a relatively wide mast structure. This results in an HRP which has 6 dB minima at every 15° of azimuth. Reducing the ERP by 10 dB over a particular arc, to restrict radiation towards France, would result in signal reductions of 16 dB in the direction of the minima with resulting coverage problems in certain areas.

RESULTS

At each receiving site, a calibrated field strength measuring receiver is linked to a PC which logs field strength data at approximately 5 second intervals. Every hour, mean levels, standard deviations, percentiles and cumulative level bins are generated and saved to disc. These are built up over a 24 hour period to provide a complete statistical summary for that day contained in a relatively small file which can be rapidly downloaded using a modem and telephone.

Both a DTT transmission and an analogue television transmission from the same transmitting site are measured. This is because the field strength measuring receiver[2] has a bandwidth of 120 kHz and, when measuring a 7 MHz-wide DTT signal, only 1.7% of the signal power is available. By measuring an analogue television transmission[3] from the same transmitting site at the same time, a much greater range of field strength variation can be observed (signals were observed for at least 50% of time). Then, during periods of abnormal propagation, the DTT signal should be sufficiently above the noise floor to enable valid comparison to be made with the analogue signal[4]. Fig. 3 shows an example of the daily field strength variation at Calais of the analogue TV and DTT transmissions from Crystal Palace. It can be seen that, for part of the day, the DTT signal is below the noise floor of the receiver but, during periods of abnormal propagation, clearly indicated by the 35 dB increase in level of the analogue signal, the DTT signal also becomes apparent. The difference in level between the two signals, which is subsequently analysed statistically over a period of several months, is then compared with the expected difference in the Effective Radiated Power (ERP) in that direction.

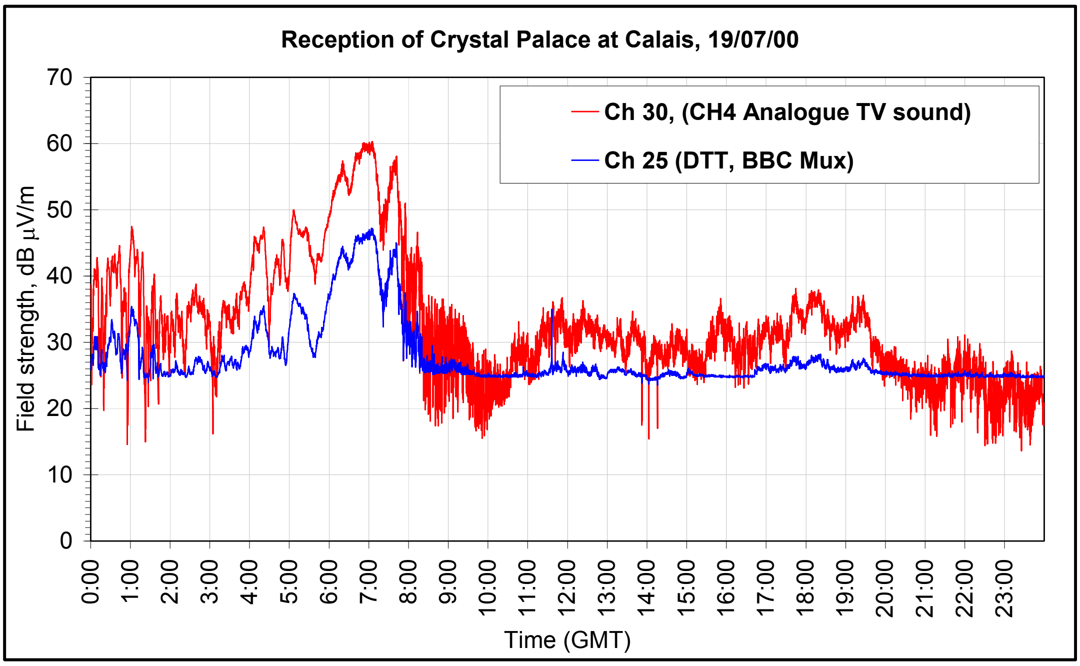


Fig. 3 Typical daily signal variation during a period of abnormal propagation

---

[2] At the time the measurements were started, a wide-band receiver, suitable for measuring DTT signals, was not available.

[3] The analogue transmission used is the sound carrier.

[4] However, when measuring a relatively narrow-band sample of the DTT signal, the assumption must be made that it is representative of the full 7 MHz transmission and that propagation effects do not cause significant frequency selective variations.

Expected ERP differences

All the transmissions have reduced radiation in the direction of the respective receiving sites. Table 1 gives the relevant ERPs and their derivation, based on helicopter measurements made during the last 3 years [2]. The final column lists the expected difference between the Analogue TV and DTT transmissions from each transmitter. In estimating the VRP corrections, it has been assumed that the signals leave the antenna at 0° to the horizontal.

Table 1

Receiving site	Transmitter and channels	Nominal ERP (dBkW)	Bearing from Tx (ETN)	Beam tilt on specified bearing(° below horizontal)	Tx ERP correction (dB)	Tx HRP correction towards Rx site (dB)	Tx VRP correction towards Rx site (dB)	ERP towards Rx site (dBkW)	Expected difference between Analogue TV and DTT transmissions (dB)
Texel	Belmont Ch22(Analogue TV sound) Ch48(DTT)	14.0 10.0	92.9 93.7	0.5 1.2	0.2 -0.5	-4.0 -7.0	-0.9 -1.0	9.3 1.5	7.8
Texel	Tacolneston Ch65(Analogue TV sound) Ch63(DTT)	11.0 10.0	74.5 74.5	0.7 1.5	-2.3 -1.4	-2.5 -6.9	-0.6 -3.0	5.6 -1.3	6.9
Guilmécourt	Crystal Palace Ch30(Analogue TV sound) Ch25(DTT)	17.0 10.0	148.5 148.5	1.0 3.0	-0.8 0.0	-1.7 -3.6	-1.3 -12.0	13.2 -5.6	18.8
Calais	Crystal Palace Ch30(Analogue TV sound) Ch25(DTT)	17.0 10.0	110.1 110.1	1.0 2.8	-0.8 0.0	-3.2 -5.8	-1.3 -10.0	11.7 -5.8	17.5

In the case of the Crystal Palace transmissions to Guilmécourt and Calais, which have much greater VRP reduction at 0° to the horizontal (due to the increased beam tilt), it is assumed that elevated ducts are the main propagation mechanism for low percentages of time. However, if surface ducts predominate, then signals which leave the antenna at angles below the horizontal (hence with less VRP reduction) will be propagated beyond the horizon and the differences shown in Table 2 will not be realised.

Measured ERP differences

The propagation data were analysed in terms of the levels exceeded for 0.1, 1, 5, 10, 25, 50, 75 and 90% of time and the results are plotted in Figs. 4, 5, 6 and 7. The differences in level between the analogue and DTT transmissions for 0.1% and 1% of time are clearly seen. For greater time percentages the DTT level soon falls below the noise floor as described above but the analogue signals remain valid for at least 50% of time.

Fig. 4 Measured field strength of
Belmont transmissions at Texel
April 2000 to March 2001

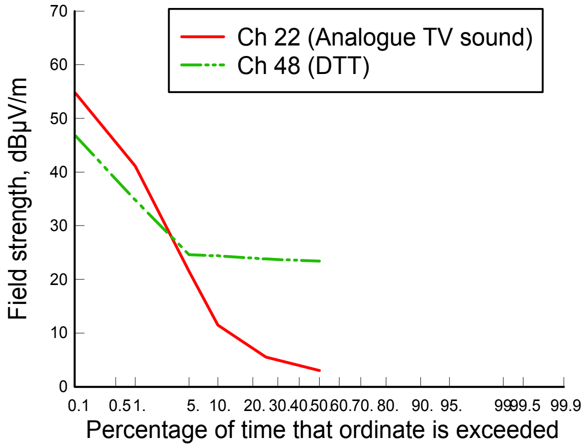


Fig. 5 Measured field strength of
Tacolneston transmissions at Texel
April 2000 to March 2001

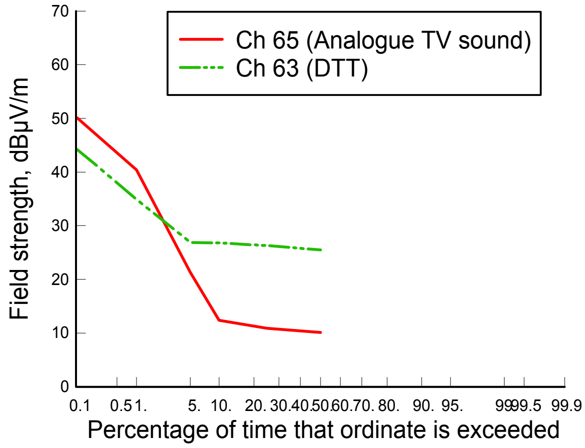


Fig. 6 Measured field strength of
Crystal Palace transmissions at Guilmecourt
September 1999 to August 2000

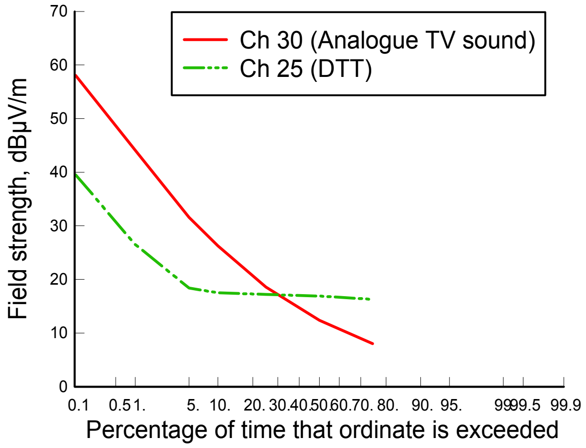
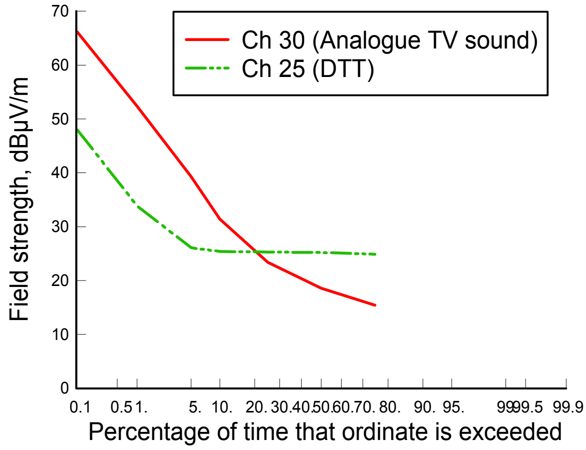


Fig. 7 Measured field strength of
Crystal Palace transmissions at Calais
July 2000 to April 2001



Whilst the differences between the Analogue TV sound and the DTT plots in Figs. 4 to 7 can be clearly seen for 1% of time or less, it could be argued that they do not accurately represent the near instantaneous differences of the actual signals, i.e. they are not correlated in time. A better approach would be to compare the hourly medians for the two signals over the whole period, for those times when the DTT signal is 6 dB or more above the noise floor. Table 2 shows the measured differences, calculated in this way, compared with the expected values derived in Table 1.

Table 2

Receiving site	Transmitter and channels	Measurement period	Differences between Analogue TV and DTT transmissions: Expected difference (dB)	Differences between Analogue TV and DTT transmissions: Measured difference (dB)
Texel	Belmont Ch22(Analogue TV sound), Ch48(DTT)	April 2000 - March 2001 (12 months)	7.8	6.0
Texel	Tacolneston Ch65(Analogue TV sound), Ch63(DTT)	April 2000 - March 2001 (12 months)	6.9	5.1
Guilmécourt	Crystal Palace Ch30(Analogue TV sound), Ch25(DTT)	Sept. 1999 - August 2000 (12 months)	18.8	17.4
Calais	Crystal Palace Ch30(Analogue TV sound), Ch25(DTT)	July 2000 - April 2001 (10 months)	17.5	16.8

It can be seen from Table 2 that, for all the paths, there is good agreement between the expected and measured field strength differences[5]; i.e. the reduction of the DTT signals towards Holland and France is as expected. In the case of the Crystal Palace transmissions to Guilmécourt and Calais, the fact that the expected differences are achieved is good news and implies that, during the combined 20 month measurement period, there were no surface ducts and that any elevated ducts were generally higher that 300 metres.

CONCLUSIONS

The measurements of Belmont, Tacolneston and Crystal Palace transmissions, made over 10 to 12 month periods, show that directional HRPs and specifically increased beam tilt are working as expected in reducing outgoing, potentially interfering signals to Holland and France. In the case of Crystal Palace, the results indicate that the use of significantly more beam tilt than usual can be a useful alternative to a directional HRP in reducing the interference potential of a broadcasting service.

REFERENCES

1. Hall, M. P., Barclay, L. W. and Hewitt, M. T., 1996. Propagation of Radiowaves, The Institution of Electrical Engineers. pp. 116 to 123.

2. Middleton, J., 2000. The use of a helicopter-based antenna measurement technique to evaluate DTT transmitting antennas. Proceedings of 2000 International Broadcasting Convention. pp. 33 to 38.

[5] Errors in the receiving system calibration and in estimating the expected ERPs give an overall uncertainty of about ±2 dB.