Digital Dividend: Interference from DVB-H into DVB-T

Technical Note for OFCOM

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ÆGIS spectrum engineering

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1 BACKGROUND

A brief analysis of DVB-H interference into DVB-T systems was carried out in the study concerning the early release of Channel 36 (Ref: Final Report on Channel 36 Issues, 1913/DD/R/5.0, November 2007).

This technical note summarises a further work undertaken by Aegis Systems on the impact of interference from DVB-H transmitters into DVB-T receivers for a range of assumed protection ratios. This additional work is intended to inform discussions regarding the definition of SUR[1] in released spectrum that would be necessary to protect DTT services at the edges of the retained spectrum (channels 30 and 41).

2 MODELLING APPROACH

The modelling approach is the same as that used in the Channel 36 study. Failure rates within the DVB-H coverage area are derived for a number of DVB-H and DVB-T TX separation distances using the '*probabilistic*' approach where wanted (C) and interference (I) power levels are calculated at uniformly distributed random points within the simulation area over a number of Monte Carlo trials. At each point, variations in C and I are obtained from a log-normal distribution representing uncorrelated joint location variability of wanted and interfering signals.

Overall failure rates are then calculated on the basis of an integration over the entire DVB-T coverage area assumed to be populated by households. The results provide pessimistic failure estimates as the entire DVB-T coverage area is unlikely to be covered by households. More realistic failure estimates are derived by using household/population databases in Section 4.

Modelling has been undertaken for DVB-H interference into both main and relay stations. While the population coverage of relays is relatively small, some such transmitters cover significant urban areas (e.g. Tunbridge Wells, Hemel Hempstead), and provide services that may be more vulnerable to DVB-H interference owing to the use of vertical polarisation.

[1] Spectrum Usage Rights

3 ANALYSIS OF INTERFERENCE FROM DVB-H INTO DVB-T

The assumed parameter values are summarised in the following table.

DVB-H TX Frequency	554 MHz (Channel 31)
DVB-H TX EIRP	32.15 dBW/8MHz (1 kW ERP, Vertical Polarisation)
DVB-H TX Height (a.g.l)	30 m
DVB-H Coverage Requirements	90 dBμV/m median wanted field strength at 10 m
DVB-T RX Frequency	546 MHz (Channel 30)
DVB-T Wanted TX EIRP	52.15 & 35.15 dBW/8MHz (100 kW ERP Horizontal Polarisation & 2 kW ERP Vertical Polarisation)
DVB-T Wanted TX Height (a.g.l)	100 m
DVB-T Victim RX Height (a.g.l)	10 m
DVB-T Victim RX Antenna Max Gain	12.9 dBi
DVB-T Victim RX Antenna Pattern	ITU-R BT 419-3 (Band V)
DVB-T Victim RX Feeder Loss	3.6 dB
DVB-T Victim RX Polarisation Discrimination	16 dB (100 kW TX), 0 dB (2 kW TX) (Ref: RRC Report Chapter 3)
DVB-T Coverage Requirements	57 dBμV/m median wanted field strength at 10 m (Ref: Technical Parameters and Planning Algorithms, Joint Frequency Planning Project, Document JPP/MB/1, Version 2, July 2003)
Outdoor Propagation Variation	Log-normal (μ = 0 dB, σ = 5.5 dB) (Ref: ETSI TR 102 377 V1.2.1)
Building Penetration Loss	Log-normal (μ = 11 dB, σ = 6 dB) (Ref: ETSI TR 102 377 V1.2.1)
Median Path Loss Models	Rec.1546 (DVB-T Wanted Path) COST 231 Urban Hata (DVB-H Wanted Path) COST 231 Urban Hata (Interference Path)
Protection Ratio	-30, -36, -42, -48 & -54 dB

Table 1: Assumed Parameters

Scenarios have been simulated for two different DVB-T TXs. Initially, it is assumed that the DVB-T TX generates 100 kW horizontally polarised signals while the DVB-H TX uses 1 kW vertically polarised signals. For these scenarios, a polarisation discrimination of 16 dB is applied. In the second set of simulations, the DVB-T TX is assumed to operate with 2 kW ERP (representing a relay station) using a vertical polarisation. In these scenarios, no polarisation discrimination is applied.

3.1 100 kW Horizontal Polarisation

The following figure illustrates the failure rates within the DVB-H coverage area for a number of DVB-H and DVB-T TX separation distances for the assumed protection ratios. For the assumed parameter values, the DVB-T coverage area radius is 45.96 km.

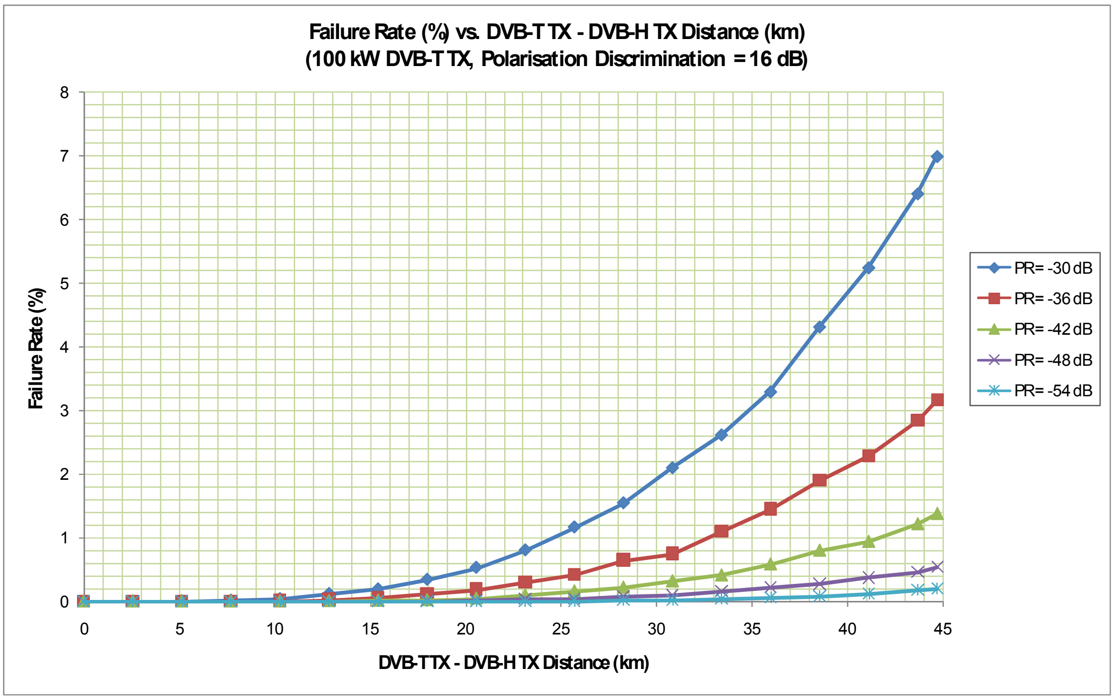

Figure 1: Failure Rates (100 kW, Horizontal Polarisation)

Using the above results, the overall failure rates corresponding to the integration of the calculated failure rates over the entire DVB-T coverage area are calculated for the assumed protection ratios.

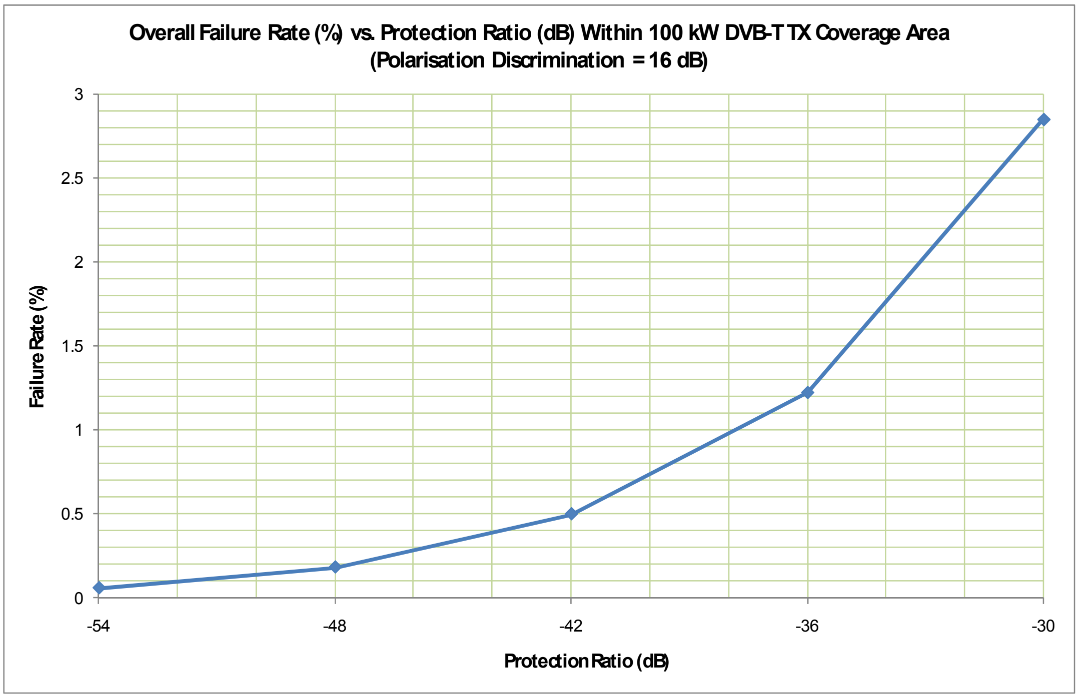

Figure 2: Overall Failure Rates (100 kW, Horizontal Polarisation)

3.2 2 kW Vertical Polarisation

As in the previous case, the failure rates within the DVB-H coverage area for a number of DVB-H and DVB-T TX separation distances have been calculated for the assumed protection ratios. For the assumed parameter values, the DVB-T coverage area radius is 22.55 km.

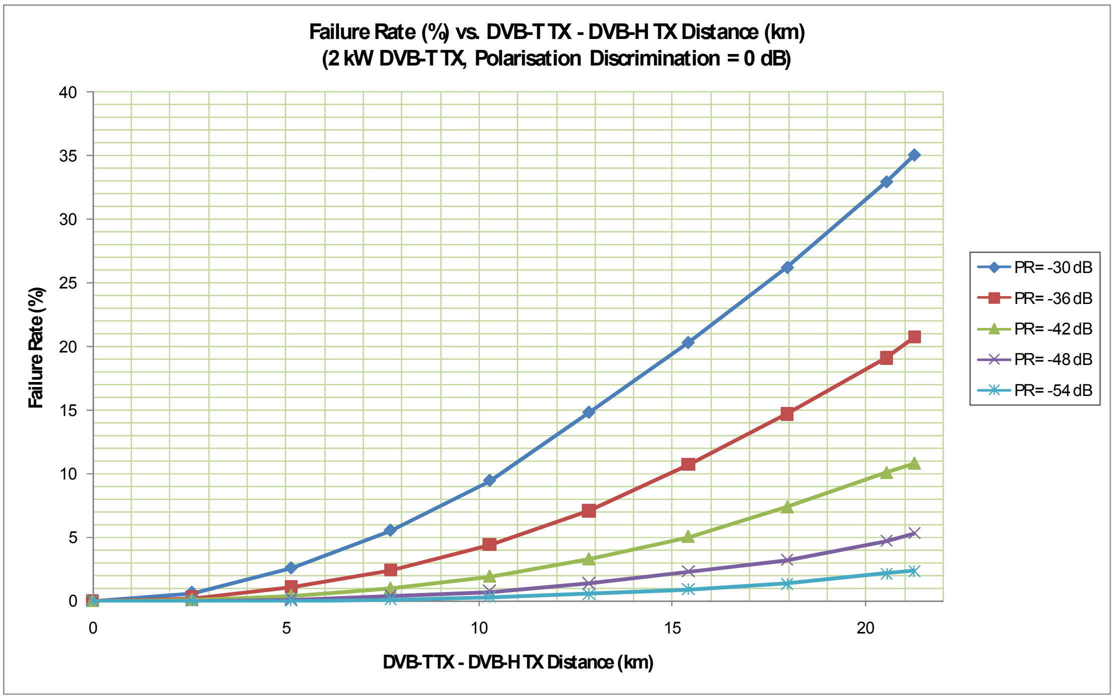

Figure 3: Failure Rates (2 kW, Vertical Polarisation)

The variation of the overall failure rate with the assumed protection ratio is shown in the following figure.

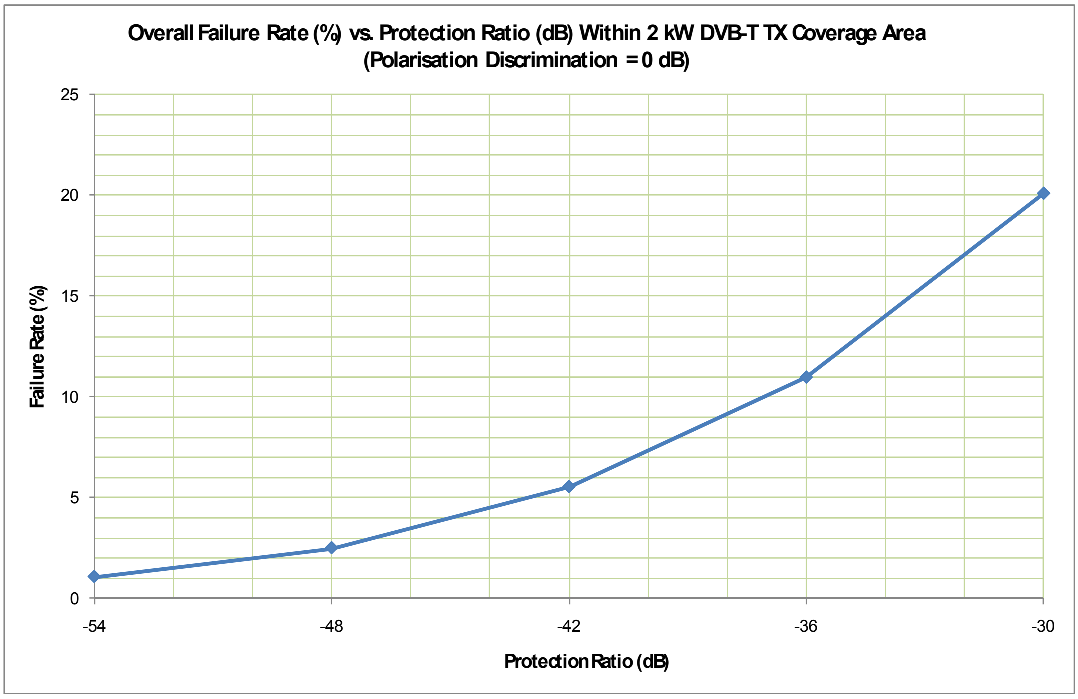

Figure 4: Overall Failure Rates (2 kW, Vertical Polarisation)

3.3 DVB-T TX ERP Sensitivity

Failure rates have been calculated for a range of DVB-T TX ERPs. It is assumed that the DVB-T TX is the main transmitter (i.e. Polarisation discrimination is 16 dB) and the protection ratio is -30 dB.

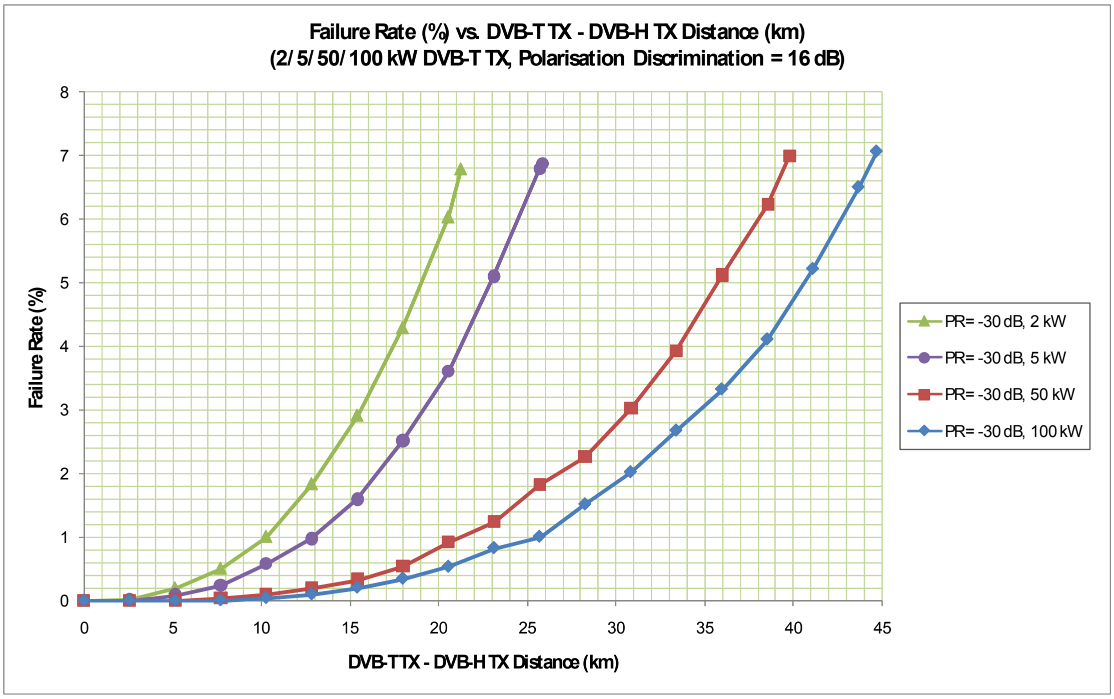

Figure 5: Failure Rates for 2/5/50/100 kW DVB-T TX ERPs

The edge of coverage for the different transmitter powers is defined as the same field strength in all cases. The same failure rate at edge of coverage might reasonably be expected given that the DVB-H coverage area behaviour (i.e. distribution of interference levels) is also the same in all cases. However the DVB-T field strength behaviour (i.e. distribution of wanted signal levels) across the DVB-H coverage area situated at the DVB-T edge of coverage will differ because the signal decay is different and is some function of distance.

The above failure rates have been integrated over the corresponding DVB-T TX coverage areas to calculate the overall failure rates. Although the failure rate changes as a function of the DVB-T transmit power the percentage change is not high.

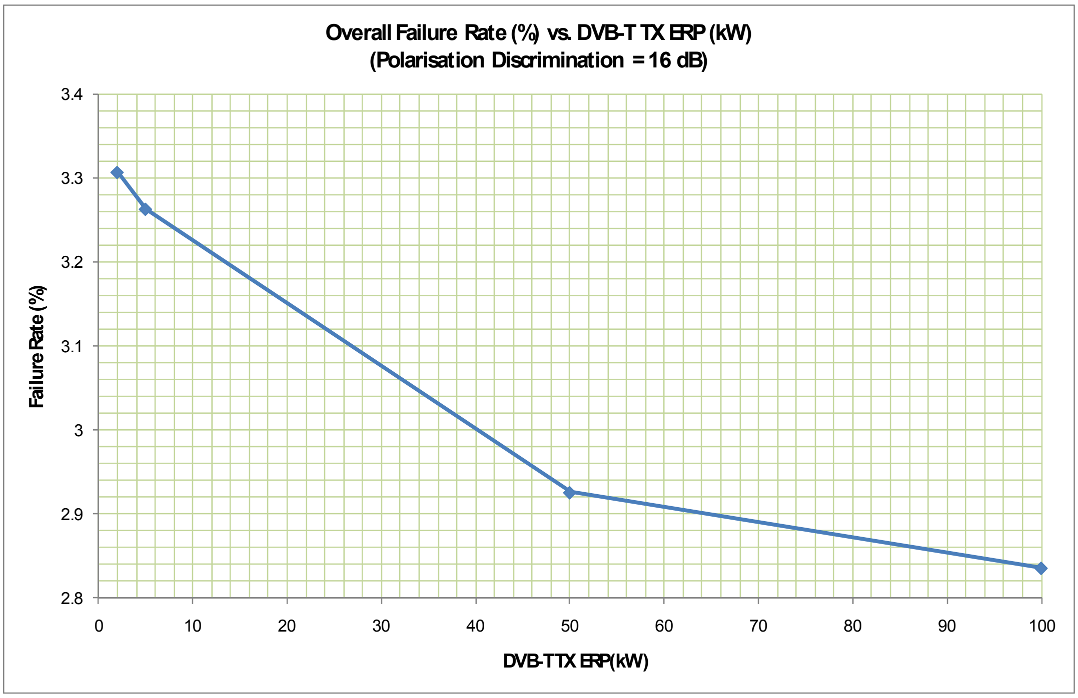

Figure 6: Overall Failure Rates for 2/5/50/100 kW DVB-T TX ERPs

4 IMPACT ON POPULATION

Overall failure rates calculated on the basis of an integration over the entire DVB-T coverage area provide pessimistic failure estimates as the entire DVB-T coverage area is unlikely to be covered by households. Therefore, the implications of DVB-H interference into DVB-T households and population have been examined further with a view to obtaining more realistic failure estimates by applying a household/population database approach used in the Channel 36 study. The following steps outline the approach employed.

- Distance (between the DVB-T wanted transmitter and the interfering DVB-H transmitter) vs. failure rate statistics are converted into wanted field strength vs. failure rate statistics. Wanted field strengths are calculated using real world coverage plots. The area resolution for wanted field strengths is a 1 km square.
- Wanted field strengths are converted into failure rates using wanted field strength vs. failure rate statistics calculated earlier. The minimum DVB-T wanted field strength is assumed to be 57 dBμV/m. Five sets of wanted field strength vs. failure rate statistics are derived for the protection ratios of -30, -36, -42, -48 and -54 dB.
- Household and population statistics are derived from the UK database for every 1 km square in assumed DVB-T coverage areas.
- Total household/population failure rates are calculated by integrating the product of the failure rate and household/population at each 1 km square over a DVB-T coverage area.

- A number of household/population threshold values are used to decide whether any of 1 km squares in a DVB-T coverage area is served by a DVB-H transmitter or not. If the number of household/population is below the assumed threshold the corresponding area is excluded from the total household/population failure rate calculation.

Four potential DVB-T coverage areas have been considered. These are the same as those used in the Channel 36 study. It is assumed that each coverage area is served by a main DVB-T TX with 100 kW ERP. Results are presented in the following tables. It should be noted that interference from other transmitters, which would effectively reduce the size of the coverage area, has not been taken into account.

Coverage Area	Total Household Covered	Household Threshold	Failure Percentage (Household)				
			PR = -30 dB	PR = -36 dB	PR = -42 dB	PR = -48 dB	PR = -54 dB
Croydon	5,831,070	0	0.5923	0.2506	0.0960	0.0357	0.0094
		500	0.4873	0.2056	0.0786	0.0291	0.0076
		1000	0.3876	0.1630	0.0621	0.0228	0.0059
Mendip	1,918,636	0	0.4998	0.2121	0.0822	0.0287	0.0092
		500	0.3363	0.1423	0.0548	0.0190	0.0061
		1000	0.2112	0.0884	0.0338	0.0115	0.0037
Blackhill	1,184,664	0	0.4590	0.1929	0.0761	0.0263	0.0082
		500	0.3677	0.1537	0.0604	0.0207	0.0064
		1000	0.2480	0.1027	0.0400	0.0135	0.0041
Lichfield	3,836,983	0	0.8593	0.3763	0.1494	0.0564	0.0165
		500	0.6757	0.2957	0.1174	0.0443	0.0130
		1000	0.5036	0.2198	0.0870	0.0328	0.0095

Table 2: Results of Analysis with Household Database

Coverage Area	Total Population Covered	Population Threshold	Failure Percentage (Population)				
			PR = -30 dB	PR = -36 dB	PR = -42 dB	PR = -48 dB	PR = -54 dB
Croydon	11,391,080	0	0.6026	0.2549	0.0976	0.0363	0.0095
		500	0.5463	0.2307	0.0882	0.0327	0.0085
		1000	0.4947	0.2087	0.0798	0.0295	0.0077
Mendip	3,737,143	0	0.5003	0.2124	0.0823	0.0288	0.0093
		500	0.3980	0.1687	0.0653	0.0227	0.0073
		1000	0.3287	0.1389	0.0534	0.0185	0.0059
Blackhill	2,248,462	0	0.4631	0.1949	0.0770	0.0267	0.0083
		500	0.4192	0.1762	0.0695	0.0240	0.0075
		1000	0.3639	0.1522	0.0598	0.0205	0.0064
Lichfield	7,534,122	0	0.8551	0.3744	0.1486	0.0560	0.0164
		500	0.7470	0.3270	0.1297	0.0490	0.0144
		1000	0.6627	0.2898	0.1150	0.0434	0.0127

Table 3: Results of Analysis with Population Database

Household and population failure percentages given in the preceding tables are plotted as a function of the protection ratio in the following figures.

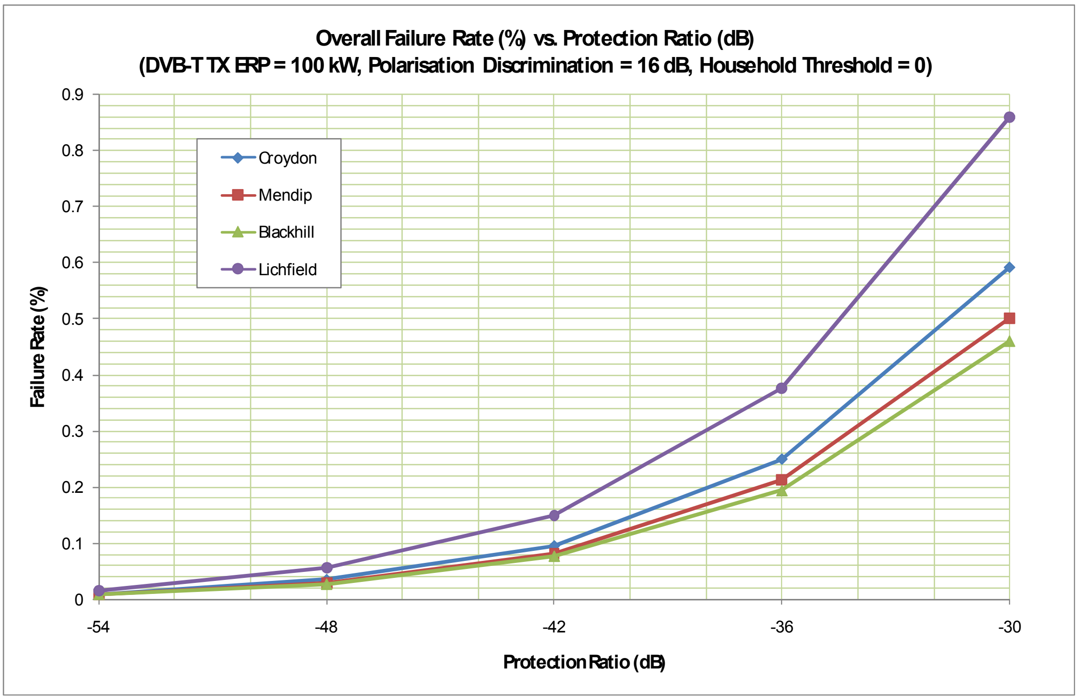

Figure 7: Failure Percentages (Household Threshold = 0)

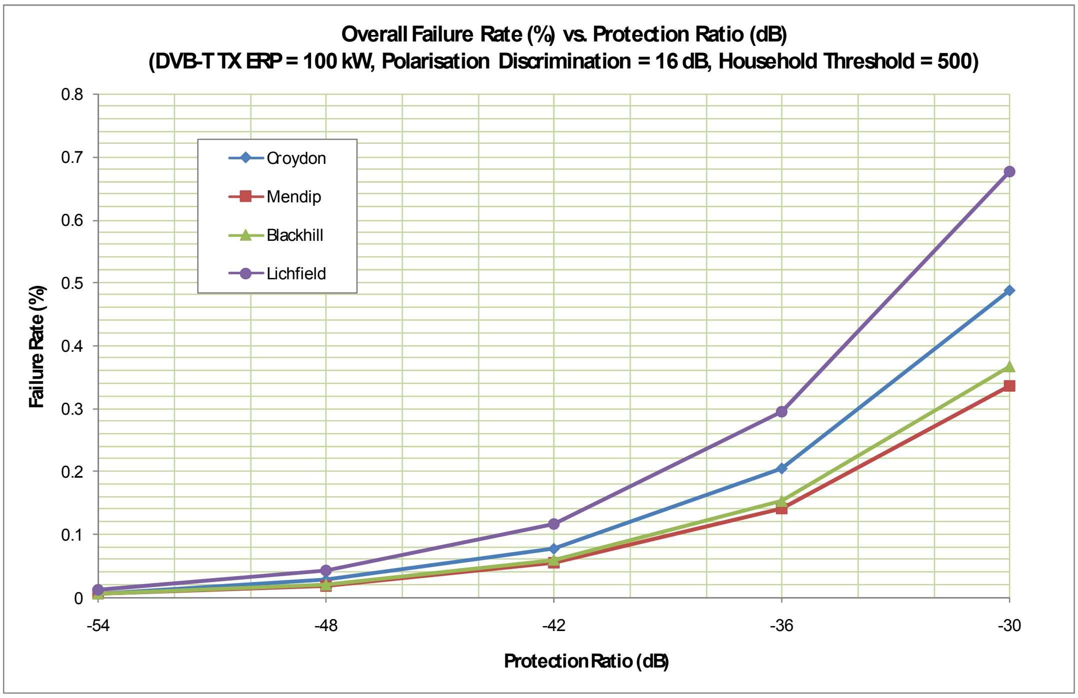

Figure 8: Failure Percentages (Household Threshold = 500)

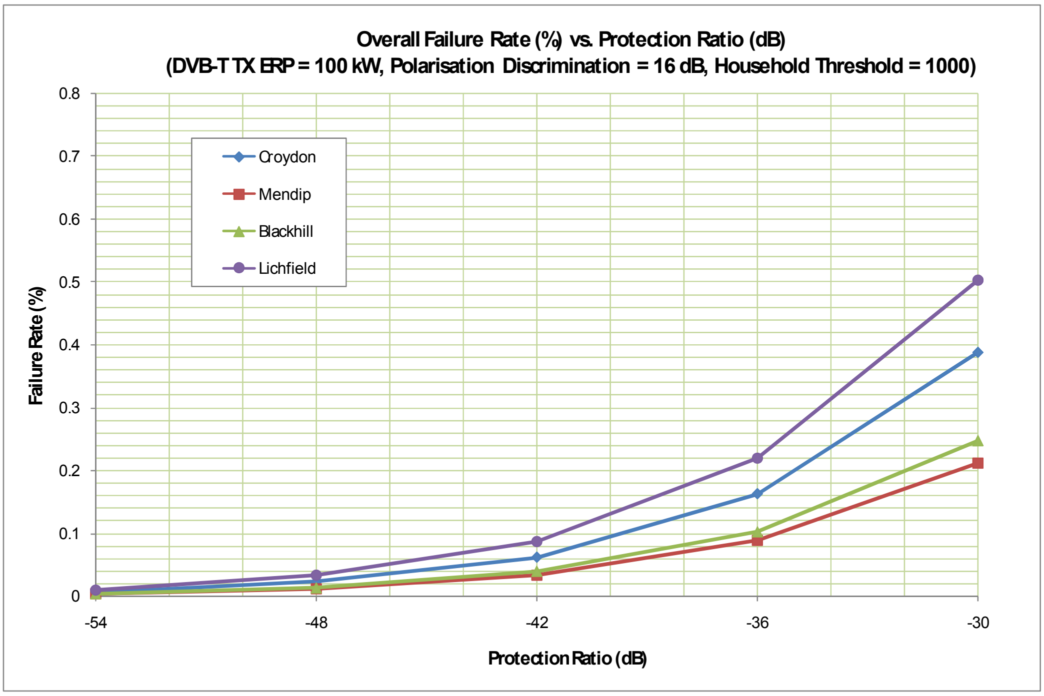

Figure 9: Failure Percentages (Household Threshold = 1000)

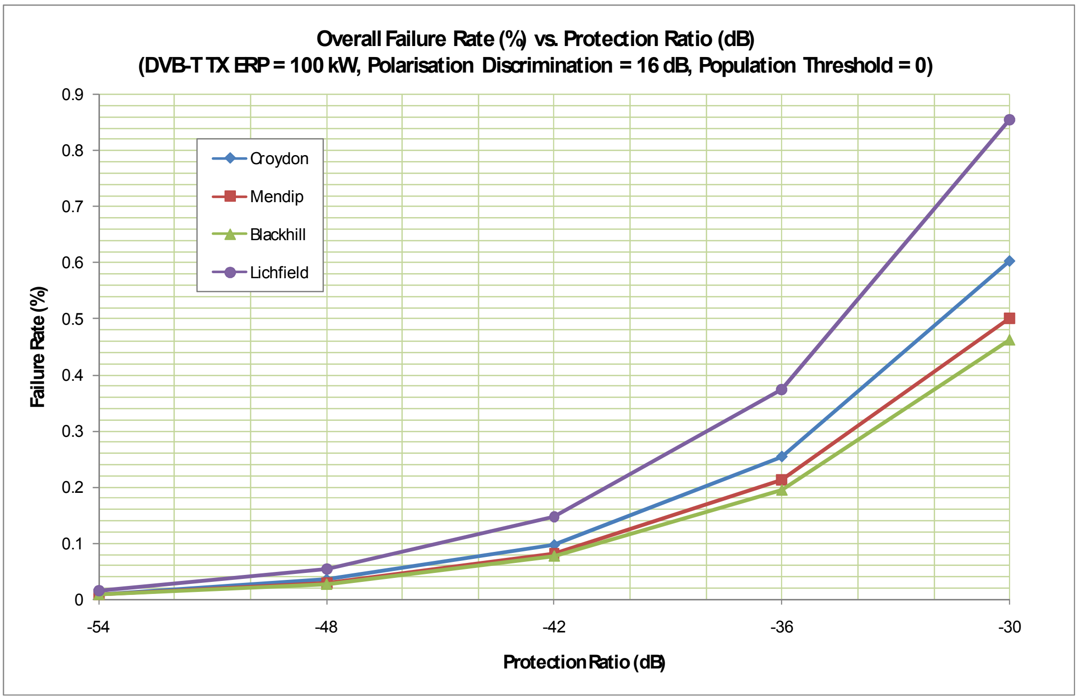

Figure 10: Failure Percentages (Population Threshold = 0)

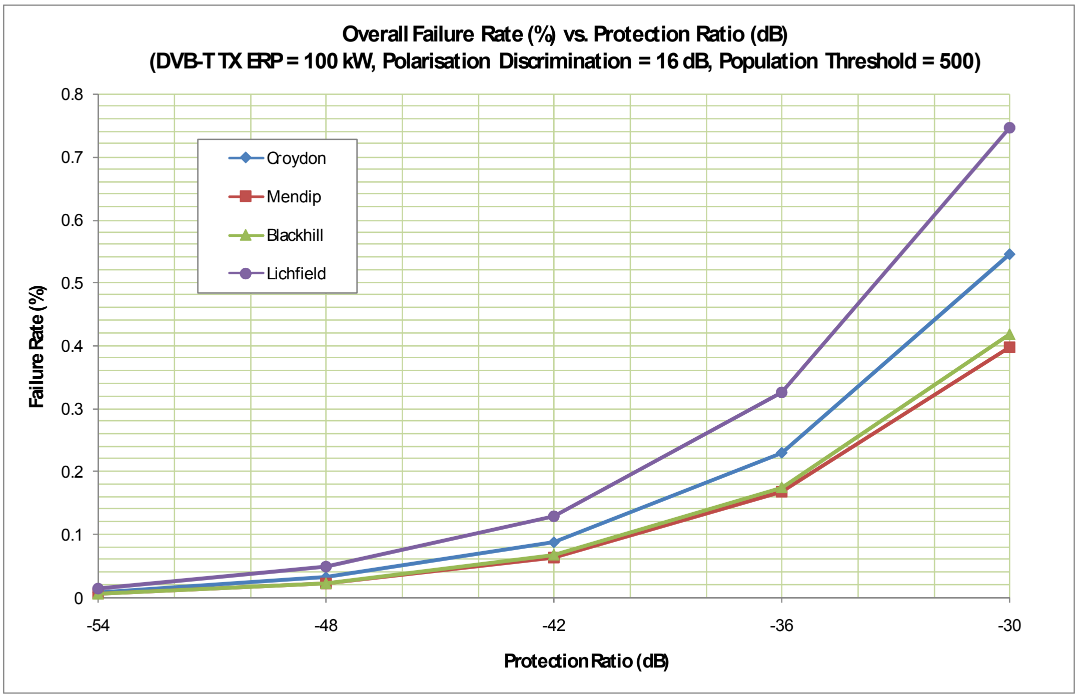

Figure 11: Failure Percentages (Population Threshold = 500)

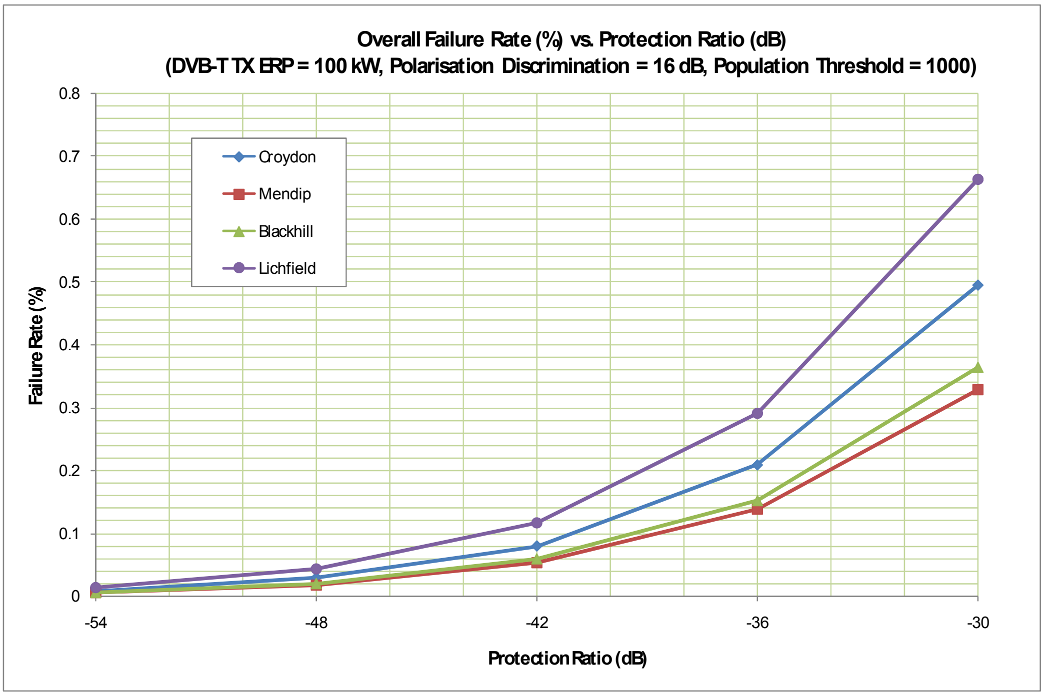

Figure 12: Failure Percentages (Population Threshold = 1000)

5 CONCLUSIONS

Results show that interference into low power DVB-T TXs operating as relay stations (with the polarisation the same as that used by the interfering DVB-H TX) is more severe than interference into high power main DVB-T TXs (with the polarisation opposite to that used by the interfering DVB-H TX).

For the main DVB-T TXs, the overall failure rates averaged across the coverage area of the DVB-T TX reduce from 2.85% to 0.06% when the protection ratio is varied from -30 dB to -54 dB, for example by introducing guard bands. For the DVB-T relay stations, the overall failure rates reduce from 20.1% to 1.1% when the protection ratio is varied from -30 dB to -54 dB. The higher failure rates for relays would make it more desirable than the main TX case for the DVB-H TX to be either co-located with the relay TX or separated by a guard band that may allow a high protection ratio to be achieved.

The results of the sensitivity analysis indicate that the overall failure rate is reduced slightly with an increasing DVB-T TX ERP.

The results of the analysis of DVB-H interference on DVB-T population/household show that the overall failure rates are in the range of 0.21% - 0.86% when the protection ratio is -30 dB. The failure rate range is 0.004% - 0.017% when the protection ratio is assumed to be -54 dB.