A minus sign means that either co-siting or the indicated separation is OK. Classes VU and VL have protected coverage equivalent to full power NTSC stations in the upper or lower VHF bands respectively, i.e. 82 or 89 km. Channel -1 means lower first adjacent.
A separation of zero means that interference is unlikely at any separation. Protection was assessed in both directions and the greater separation distance was used.

TABLE D.3.8

UPPER VHF BAND TABOOS - NTSC -> DTV

Int.	A	B	C	LP	VU	A	B	C	LP	VU	A	B	C	LP	VU
Prot.	A	A	A	A	A	B	B	B	B	B	C	C	C	C	C
CHAN.															
-1	-28	-46	-71	-27	-83	-48	-51	-73	47	-85	73	-76	-82	72	-89
0	93	138	206	64	243	113	146	206	84	240	138	171	231	121	264
1	-27	-46	-71	-27	-83	-47	-50	-72	47	-84	72	-75	-81	72	-87

Int.	A	B	C	LP	VU	A	B	C	LP	VU	A	B	C	LP	VU
Prot.	LP	LP	LP	LP	LP	VU	VU	VU	VU	VU	VL	VL	VL	VL	VL
CHAN.															
-1	-25	-45	-70	-14	-82	84	88	-94	84	-100	92	95	-101	91	-107
0	97	150	218	70	254	150	183	243	155	276	166	190	250	178	283
1	-25	-45	-70	-14	-82	84	87	-93	84	-99	91	94	-100	91	-106

TABLE D.3.9

LOWER VHF BAND TABOOS - NTSC -> DTV

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	A	A	A	A	A	A	B	B	B	B	B	B	C	C	C	C	C	C
CHAN.																		
-1	-30	-50	-75	26	-87	-94	47	-55	-80	46	-92	-99	72	74	-93	71	-105	-112
0	93	116	171	82	198	214	137	157	191	136	218	234	193	213	238	194	250	259
1	-29	-49	-74	26	-86	-93	47	-53	-78	46	-90	-97	72	74	-88	71	-100	-107

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	LP	LP	LP	LP	LP	LP	VU	VU	VU	VU	VU	VU	VL	VL	VL	VL	VL	VL
CHAN.																		
-1	-27	-47	-72	-14	-84	-91	84	86	-103	83	-116	-123	91	93	111	90	123	-130
0	70	109	172	47	199	216	227	247	272	230	284	291	249	269	294	253	306	313
1	-27	-47	-72	-14	-84	-91	84	86	-96	83	-108	-115	91	93	102	90	114	-121

D.4 Proposed Canadian Tables (90,90 Service Availability)

TABLE D.4.1

UHF BAND TABOOS - DTV -> DTV (90,90/10,10) Separation distances in km

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	A	A	A	A	A	A	B	B	B	B	B	B	C	C	C	C	C	C
CHAN.																		
-1	-27	-47	72	-26	84	91	-47	-51	-75	46	87	94	72	-76	-87	71	-98	-105
0	112	194	296	124	363	386	194	175	277	207	344	367	296	277	287	309	340	359
1	-27	-47	72	-26	84	91	-47	-51	-76	46	88	95	72	-75	-87	71	-99	-106

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	LP	LP	LP	LP	LP	LP	VU	VU	VU	VU	VU	VU	VL	VL	VL	VL	VL	VL
CHAN.																		
-1	-26	46	71	-13	83	90	84	88	-99	83	-110	-115	91	95	-106	90	-117	-122
0	124	207	309	88	375	398	363	344	340	375	352	371	386	367	359	398	371	378
1	-26	46	71	-13	83	90	84	87	-98	83	-110	-117	91	94	-105	90	-115	-122

A minus sign means that either co-siting or the indicated separation is OK.
Classes VU and VL have protected coverage equivalent to full power NTSC stations in the upper or lower VHF bands respectively, i.e. 82 or 89 km.
Channel -1 means lower first adjacent.
Protection was assessed in both directions and the greater separation distance was used.

TABLE D.4.2

UPPER VHF BAND TABOOS DTV->DTV (90,90/10,10) Separation distances in km

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	A	A	A	A	A	A	B	B	B	B	B	B	C	C	C	C	C	C
CHAN.																		
-1	-27	-47	72	-26	84	91	-47	-49	-74	-46	86	93	72	-74	-81	71	-92	-99
0	100	156	224	109	265	291	156	160	223	168	260	284	224	223	248	236	285	309
1	-27	-47	72	-26	84	91	-47	-49	-74	-46	86	93	72	-74	-81	71	-93	-100

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	LP	LP	LP	LP	LP	LP	VU	VU	VU	VU	VU	VU	VL	VL	VL	VL	VL	VL
CHAN.																		
-1	-26	-46	71	-13	83	90	84	86	-93	83	-100	-105	91	93	-100	90	-107	-111
0	109	168	236	76	277	303	265	260	285	277	297	321	291	284	309	303	321	328

1	-26	-46	71	-13	83	90	84	86	-92	83-100-107	91	93	-99	90-105-111			

TABLE D.4.3

LOWER VHF BAND TABOOS DTV->DTV (90,90/10,10) Separation distances in km

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	A	A	A	A	A	A	B	B	B	B	B	B	C	C	C	C	C	C
CHAN.																		
-1	-28	-48	73	-27	85	92	-48	-52	-77	-47	-89	96	73	-77	-86	72	-97	-104
0	132	191	249	130	286	309	191	211	269	191	306	329	249	269	294	252	331	354
1	-28	-48	73	-26	85	92	-48	-52	-77	-46	-89	96	73	-77	-86	71	-98	-105

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	LP	LP	LP	LP	LP	LP	VU	VU	VU	VU	VU	VU	VL	VL	VL	VL	VL	VL
CHAN.																		
-1	-26	-46	71	-14	83	90	85	-89	-98	84-105-111			92	96-105		91-112-118		
0	130	191	252	95	290	315	286	306	331	290	343	366	309	329	354	315	366	373
1	-27	-47	72	-14	84	91	85	-89	-97	83-105-112			92	96-104		90-111-118		

TABLE D.4.4

UHF BAND TABOOS DTV->DTV (90,90/50,10&50,90/10,10) Separation distances in km

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	A	A	A	A	A	A	B	B	B	B	B	B	C	C	C	C	C	C
CHAN.																		
-1	-26	-46	71	-25	83	90	-46	-48	-73	45	85	92	71	-73	-81	70	-92	-99
0	75	153	249	86	307	386	153	136	231	165	289	368	249	231	246	261	296	359
1	-26	-46	71	-25	83	90	-46	-48	-73	45	85	92	71	-73	-81	70	-93	-100

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	LP	LP	LP	LP	LP	LP	VU	VU	VU	VU	VU	VU	VL	VL	VL	VL	VL	VL
CHAN.																		
-1	-25	45	70	-12	82	89	83	85	-93	82-101-106			90	92-100		89-108-112		
0	86	165	261	53	319	398	307	289	261	320	308	371	330	312	315	342	327	378
1	-25	45	70	-12	82	89	83	85	-92	82-101-108			90	92	-99	89-106-112		

TABLE D.4.5

UPPER VHF BAND TABOOS DTV->DTV (90.90/50.10 & 50.90/10.10) Separation distances in km

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	A	A	A	A	A	A	B	B	B	B	B	B	C	C	C	C	C	C
CHAN.																		
-1	-26	-46	71	-25	83	90	-46	-48	-72	-45	84	91	71	-73	-77	70	-88	-95
0	83	123	189	85	227	292	123	137	190	135	226	284	189	190	215	200	251	309
1	-26	-46	71	-25	83	90	-46	-48	-73	-45	85	92	71	-72	-77	70	-89	-96

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	LP	LP	LP	LP	LP	LP	VU	VU	VU	VU	VU	VU	VL	VL	VL	VL	VL	VL
CHAN.																		
-1	-25	-45	70	-12	82	89	83	85	-89	82	-93	-99	90	92	-96	89	-100	-105
0	82	134	200	52	239	303	227	226	251	239	263	321	252	249	274	264	286	328
1	-25	-45	70	-12	82	89	83	84	-88	82	-93	-100	90	91	-95	89	-99	-105

TABLE D.4.6

LOWER VHF BAND TABOOS DTV->DTV (90.90/50.10 & 50.90/10.10) Separation distances in km

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	A	A	A	A	A	A	B	B	B	B	B	B	C	C	C	C	C	C
CHAN.																		
-1	-27	-47	72	-26	84	91	-47	-50	-75	-46	-87	94	72	-75	-81	71	-92	-99
0	107	157	214	99	249	272	157	177	234	158	269	292	214	234	259	216	294	317
1	-27	-47	72	-26	84	91	-47	-50	-75	-46	-87	94	72	-75	-81	71	-93	-100

Int.	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL	A	B	C	LP	VU	VL
Prot.	LP	LP	LP	LP	LP	LP	VU	VU	VU	VU	VU	VU	VL	VL	VL	VL	VL	VL
CHAN.																		
-1	-26	-46	71	-13	83	90	84	-87	-93	83	-98	-104	91	94	-100	90	-105	-109
0	99	158	216	66	253	276	249	269	294	253	306	329	272	292	317	276	329	336
1	-26	-46	71	-13	83	90	84	-87	-92	83	-98	-105	91	94	-99	90	-104	-109

Appendix 1

Figure of Merit Derivation Method

$$E_{RX}(dBV/m) = \Phi(dBW/m^2) + 10\log(120\pi)\ (dB)$$
$$C/N(dB) = \Phi(dBW/m^2) - G_i(1m^2) + G_A/T_e - K - B_{rf}$$

$$E_{RX}(dB\mu V/m) = \Phi(dBW/m^2) + 145.8(dB)$$
$$= 145.8 + C/N + 10\log k + 10\log B + G_i(1m^2) - G_A + T_e$$

E_{RX}	required field strength at the receive system antenna
Φ	power flux density at the receive system antenna
C/N	carrier to noise ratio
k	Boltzmann's constant
B	system bandwidth
$G_i(1m^2)$	gain of 1 metre squared
G_A/T_e	G/T of the receive system
G_A	gain of the receive system (isotropic)
Te	effective noise temperature

Receive System Figure of Merit

$$G_A / T_e = (G - A_L) / (\alpha T_a + (1 - \alpha)T_0 + (n - 1)T_0)$$
$$(G - A_L) / (\alpha T_a + T_L + T_{rx})$$

Receiver Noise Temperature

$$T_{rx} = (10^{nf/10} - 1)*290°K$$

Transmission Line Loss

$$A_L = -10\mathrm{Log}(\alpha)$$

α Numeric ratio of transmission line attenuation

Transmission Line Noise Temperature

$$T_L = (1 - 1/10^{A_L/10})*290°K$$

Antenna Noise Temperature

$$T_a = 10^{(6.63-2.77(F))}*290°K$$

reference ITU-R Report 258-5

Antenna Noise Temperature (referred to receive input)

$$\alpha T_a = T_a(10^{-A_L/10})$$

System Noise Temperature

$$T_e = \alpha T_a + T_L + T_{rx}$$

Gain of 1 metre squared

$$G_{1m}^2 = 10\log(4\pi/\lambda^2)$$

Time Availability Factor

$$\Delta T(90) = ((F(50,10) - F(50,50))/1.282)*(-1.282)$$

This method is described in chapter 6 of the Television Engineering Handbook.

Location Availability Factor

$$\Delta L(90) = -7.1 \text{ dB}$$

This value is from Figure 12 of ITU-R Recommendation P370-7 for digital systems and applies over a range of frequencies which include the UHF TV band.

Appendix 2

SERVICE AVAILABILITY

Introduction

A characteristic of Digital TV systems which impacts on the planning factors is the sharp degradation between the point when picture impairment is first visible and the point when the picture is unusable. With this degradation factor in the order of 1 dB, a critical review of planning criteria in terms of service availability and quality of service may be necessary in light of the objective to duplicate existing NTSC coverage to the extent possible.

Service availability in location and time are factors which must be chosen to provide the required DTV service in an efficient and viable manner. The transmission and reception characteristics of a digital TV system differ from an analog system and it is believed that better location and time availability than that used for analog service planning will be required to provide an acceptable DTV service.

Discussion

The coverage requirement for DTV was identified as that matching the Grade B contour of existing NTSC services in the VHF/UHF TV bands. The Grade B service is defined as the signal level providing an acceptable picture at 50% of the locations for 90% of the time. This implies that reliable service be provided to all locations presently served and that the quality of service be maintained throughout the coverage area.

Quality objectives for DTV service with the sharp degradation nature of digital system have little or no range available. In comparison, based on figures from 1974 FCC tests, NTSC picture quality can change gradually from Fine to Passable (Acceptable) and from Passable to Poor (Outage) over ranges of 10 and 13 dB respectively. DTV with a differential in the order of only 1 dB between just noticeable impairment and unusable picture virtually eliminates any range of picture quality. The only choices may be excellent quality service or no service at all.

A question that needs to be resolved in the coverage planning of Digital TV is what Service Availability objectives should be at or near the edge of the protected coverage area (i.e. Grade B contour) that would correspond to an "equivalent" availability as provided by NTSC service. Whereas NTSC is planned on the basis of a specified performance for at least 50% of locations and 90% of the time, the gradual degradation characteristic of the analog service results in a considerably higher service availability statistic at or near the edge of the Grade B contour. If it is the goal to duplicate the coverage with an DTV station, then a higher propagation margin would need to be considered due to the abrupt nature of the threshold to service outage exhibited

by Digital TV compared to NTSC.

The NTSC Grade B coverage is based on passable or acceptable picture quality service to fixed receivers with an external directional antenna at 10 metres above ground. Location and time availability are 50 and 90 percent respectively. The location variability of 50% was considered adequate because of the gradual degradation nature of NTSC picture quality and the assumption that the viewer had some degree of latitude to choose a good receiving location. The 90% time availability was achieved by including a factor to convert from the F(50,50) signal value. Using the F(50,50) and F(50,10) propagation curves for the UHF TV band and the standard Grade B contour distance of 70 km, the 90% time availability factor is 6.2 dB. Under these conditions with the gradual degradation to outage, the overall availability will be greater than that given by the (50,90) criteria. If a margin of 12 dB between passable and outage and the location availability curve Figure 12 of ITU-R Rec. P370-7 for analog systems is used, the NTSC service availability, i.e. service to outage, becomes 90% for location and 90% for time.

In DTV service with its sharp degradation characteristic, service will change from available to unavailable within 1 dB. Human nature being what it is, viewers may tolerate poorer quality for short periods (the NTSC case) but will not tolerate loss of service for the same periods. Thus to match NTSC service with a comparable DTV service, the abrupt failure characteristic of DTV may necessitate a minimum availability of (90, 90) for location and time.

Service Availability can affect the level of the transmitter power required to establish the desired availability at the required coverage distance. Using location availability values for digital systems given ITU-R Rec. P370-7, Table A shows the change in ERP required for digital TV systems for some different values of availability when a VHF channel is used as a replacement.

Table A

Transmitted ERP Increase

vs

Service Availability

(High VHF Channel Replacement)

Grade B Distance (km)		89	82	70	45	25	12
Service Availability (%)		Transmitted ERP Increase dB					
Location	Time						
50	50	0	0	0	0	0	0
50	90	6	5.2	4.4	2.2	0.9	0
70	50	2	2	2	2	2	2

Grade B Distance (km)		89	82	70	45	25	12
70	90	8	7.2	6.4	4.2	2.9	2
90	50	6.1	6.1	6.1	6.1	6.1	6.1
90	90	12.1	11.3	10.5	8.3	7	6.1

Table B shows the change in ERP for some different values of availability when a UHF channel is used as a replacement.

Table B
Transmitted ERP Increase
vs
Service Availability
(UHF DTV Channel Replacement)

Grade B Distance (km)		89	82	70	45	25	12
Service Availability (%)		Transmitted ERP Increase dB					
Location	Time						
50	50	0	0	0	0	0	0
50	90	9.5	8.7	6.4	3.1	1	0
70	50	2.6	2.6	2.6	2.6	2.6	2.6
70	90	12.1	11.3	9	5.7	3.6	2.6
90	50	7.1	7.1	7.1	7.1	7.1	7.1
90	90	16.6	15.8	13.5	10.2	8.1	7.1

A parameter to note, particularly for its economic impact, is the transmitter power required to establish the ERP for a specified level of service availability. The transmitter power increases directly with the ERP of a service when the availability parameter is increased.

Conclusions

The service availability of the DTV service influences the transmitted ERP and the separation

distances between DTV and NTSC services. As the service availability is increased in either Location or Time, the required transmitted ERP increases and the separation distances required for interference protection between DTV and NTSC services increase. The development of availability planning factors to optimize the provision and implementation of DTV service needs careful consideration.

Appendix 3

DTV Emission Mask Study
Communications Research Centre

1. Background

An emission mask is used to limit the spectral out-off-band spill-over to control the interference into the adjacent channels. An interfering first adjacent DTV signal will degrade the picture quality of the desired NTSC signal more than any other types of interference. Therefore, interference from the first adjacent DTV into NTSC is the limiting factor in the design of the DTV emission mask. This is because the NTSC threshold of visibility (TOV) is around C/N = 50 dB, while the DTV TOV is about C/N = 16 dB. This document analyzes the first adjacent channel DTV to NTSC interference, assuming exact co-location as well as 5-mile (8 km) antenna separation. A NTSC spectrum weighting function is used in the interference calculation. Two emission masks are proposed: a "loose-mask" for exact co-location and a "tight-mask" for 5-mile separation

2. Exact co-location case and loose-mask

A typical transmitter high power amplifier (HPA) output spectrum (unfiltered) is shown in Figure 1 [1] (RES BW 500 kHz). The output back off (OPBO) of the amplifier is about 6-7 dB and there is no attempt to linearize the amplifier. At the band edge, the spectrum is about 35 dB down relative to the flat portion of the DTV spectrum. Generally, the band edge spectrum never exceed a 39 dB drop relative to the in-band spectrum, except when a large value of OPBO is used [1]. An NTSC signal RF subjective weighting curve, Figure 2 [1], is used in the interference calculation. Figure 2 shows that the NTSC visual signal between 1.5 and 2.5 MHZ is the part most sensitive to the interference

In Figure 1, it is assumed that the NTSC peak sync. power is 0 dB and the DTV signal average power is -12 dB (D/N = -12 dB). Since a measurement bandwidth of 500 kHz is used, the DTV spectrum in-band flat portion should be $10\log_{10}(0.5/6)$ @ -11 dB below the DTV power level, or -12 - 11 = -23 dB below the NTSC peak sync level. The DTV band edge spectrum is -23 - 35 = -58 dB. This value is used in the spectrum mask calculation, see Equation 1.

It is assumed that the NTSC signal TOV is 50 dB (for random noise uniformly distributed across the 6 MHZ channel). This value, when expressed as a noise density in twelve 500 kHz bands, is $-50 + 10\log_{10}(0.5/6)$ @ -61 dB. In Figure 1, when placing the NTSC RF

weighting curve's top portion at the -61 dB level in the upper adjacent channel, it coincidentally crosses the spectrum plot. This means the unfiltered spectrum plot, shown in Figure 1, meets the lower adjacent channel DTV to NTSC interference requirement with 0 dB implementation margin. This result is confirmed in the laboratory test [3], where the measured lower adjacent channel DTV to NTSC interference margin is less than 1 dB.

It should be pointed out that the TOV for NTSC is very "soft". Even if the DTV to NTSC interference temporally exceeds the threshold, the viewer can only see "just noticeable" disturbance on the NTSC receiver. This is because a NTSC TOV of C/N = 50 dB is assumed. It is equivalent to CCIR Grade 4.5. Most of the existing analog TV transmission systems (Cable, terrestrial and analog satellite DTH) can not provide this service quality.

From Figure 1, the calculated upper adjacent channel DTV (unfiltered) to NTSC interference has a margin of -68 - (-61) = 7 dB. It is much relaxed than that of the lower adjacent channel case.

Also marked in Figure 1, at a power level of -44 dB, is the NTSC Threshold of Audibility (TOA) for the upper and lower adjacent channel, where a TOA with S/N = 68 dB is assumed. From Figure 1, the N-1 TOA margin is 14 dB and the N+1 margin is 34 dB. In both cases, no additional spectrum attenuation is required.

Although the above calculation demonstrated that, for the exact co-location case, unfiltered spectrum (see Figure 1) meets the adjacent channel DTV to NTSC interference requirement, there should be a limit for the spurious emission in the second adjacent channel. ITU-R SG-1 recommends an attenuation of 60 dB for spurious emission limit for broadcast television service. Since the DTV spectrum band edge has an attenuation of 35 dB, an additional 25 dB attenuation should be achieved at the edge of the first adjacent channel. Based on this assumption an emission mask is defined (This is the same emission mask adopted by the FCC Sixth Report and Order [2]).

For a DTV spectrum mask, the out-of-band emission measured in a 500 kHz resolution bandwidth centered Df MHZ from the edge of the assigned channel shall be attenuated below the average DTV transmitted power according to the following schedule:

For 0.25 MHZ $\leq \Delta f \leq$ 6 MHZ:

$$\textbf{Attenuation in dB} = 58 + (D/N) + [(\Delta f)^2 / 1.44] \qquad (1)$$

The effects of the 500kHz measurement bandwidth and the "smearing" effect of the

measurement bandwidth at the channel edge are considered. In Equation 1, Δf is the deviation in MHZ of the center of the 500 kHz measurement bandwidth from the edge of the assigned 6 MHZ DTV channel, and

(D/N) dB = 10 $\log_{10}$ (Average power of the DTV signal / Peak sync power of the adjacent channel NTSC signal)

The emission mask, Equation 1, is plotted in Figure 1.

For $\Delta f \geq 6$ MHZ:

$$\textbf{Attenuation in dB} = 83 + (D/N) \qquad (2)$$

3. Tight-masks for 5-mile separation

Table 1 shows the differences, in dB, between the F(50,10) and F(50,90) curves at the end of the Grade B coverage for different class of stations and frequency bands. ITU-R P370 model was used. The assumed transmitter antenna separations are 5-mile and 10-mile, respectively. It should be pointed out that the differences listed in Table 1 could be an over-kill when used for adjacent channels, since the adjacent channels signal strengths might have high correlation.

From Table 1, for 5-mile separation, an UHF Class C station require a protection ratio of 12.67 dB and an UHF Low Power (LP) station requires 27.39 dB. The LP case might not be relevant, since its coverage radius is only 12 km and it is, therefore, unlikely to require 5-mile (8 km) separation.

From the field strength differences listed in Table 1, the attenuation factor α (dB/MHZ), can be calculated. From Figure 1, the DTV band edge spectrum is -58 dB, while the NTSC weighting curve flat top is centered at 2 MHZ from the edge, where the DTV unfiltered spectrum level is -61 dB. Thus, the α factor can be calculated as:

$$[\text{Field Strength Difference} + (-58+61)] \times 0.5 \qquad \text{(dB/MHZ)}.$$

The calculated α factors are listed in Table 2.

VHF Class of Station	Low VHF	High VHF
Grade B Distance (km)	89	82
5-mile Separation (dB)	10.78	9.92

10-mile Separation (dB)	12.32		12.66	
UHF Class of Station	C	B	A	LP
Grade B Distance (km)	70	45	25	12
5-mile Separation (dB)	12.67	10.61	12.55	27.39
10-mile Separation (dB)	16.66	16.27	26.47	-

Table: 1: Field strength differences between F(50,90) and F(50,10) curve with 5-mile and 10-mile transmitter separation.

VHF Attenuation factor α	Low VHF		High VHF	
5-mile Separation (dB)	6.89		7.46	
10-mile Separation (dB)	7.66		7.83	
UHF Attenuation factor α	Class C	Class B	Class A	LP
5-mile Separation (dB)	7.84	6.81	7.78	-
10-mile Separation (dB)	9.83	9.64	14.74	-

Table 2: Required attenuation factor α.

VHF Attenuation factor α	Low VHF		High VHF	
5-mile Separation (dB)	7.5			
10-mile Separation (dB)	7.8			
UHF Attenuation factor α	Class C	Class B	Class A	LP
5-mile Separation (dB)	7.5			
10-mile Separation (dB)	9.8			

Table 3: Suggested attenuation factor α.

For 5-mile separation, the low and high VHF α factors are 6.89 dB and 7.46 dB. An α

factor of 7.5 is recommend. For UHF Class A, B and C, $\alpha = 7.8$ dB meets the requirement. Considering the UHF adjacent channels are likely to have high correlation, the α factor is trimmed to 7.5 dB to be the same as the VHF case.

For 10-mile separation case, $\alpha = 7.8$ dB can be used for VHF and $\alpha = 9.8$ dB for UHF. Again UHF Class A is unlikely to have 10-mile (16km) separation, since its coverage radius is only 25km.

From Table 3, $\alpha = 7.5$ dB meets all the requirements for up to 5-mile separation. It is also quite close to 10-mile separation case for VHF.

A "tight" emission mask is developed using $\alpha = 7.5$ dB, see Figure 3 (RES BW 500kHz). From Figure 2, the 0.5 MHZ at both ends of the spectrum is the least sensitive part to the interference. The roll-off can, therefore, be slow in that range. The critical point is at 2 MHZ from the band edge, where a 15 dB attenuation must be achieved. After 3 MHZ from the band edge, the mask can level off at a slower roll-off rate to reach -88 dB, or -65 dB from the in-band flat portion, at the 6 MHZ point.

A filtered DTV spectrum is also presented in Figure 3, using the filter presented in Figure 4. The filter was built by Micro-Communications Inc, and was used for the field trial in Charlotte U.S.A. The filter has about 17 dB attenuation at 2 MHZ from the band edge, which is 2 dB better than the 15 dB requirement. The filtered spectrum is about 1-2 dB below the mask.

This "tight-mask" can also be used for co-located mixed class of stations. Since the "tight-mask" requires an additional 12 dB attenuation on the upper adjacent channel NTSC visual carrier location, the DTV power level can be increased by 12 dB, or the NTSC power can be reduced by 12 dB. This will allow DTV and NTSC transmitting at the same power level, D/N = 0 dB. For the lower adjacent channel interference into NTSC, based on the calculation in Section 2, the limiting factor is the interference into the audio carrier. Since the mask can not provide much filtering on the audio carrier location, the margin remains close to the 14 dB. This means that the lower adjacent channel NTSC station can reduce power by up to 14 dB, or that the DTV power can increase by 14 dB. In order to prevent DTV pilot interference into NTSC, exact carrier frequency offset might have to be used, where the DTV pilot should be offset 5.082139 MHZ above the NTSC visual carrier.

4. Adjacent DTV-DTV interference

From Figure 1, the unfiltered DTV spectrum out-of-band (unweighted) power level is at -51 dB [1]. Assuming that the adjacent and co-channel DTV station transmit the same

power level, the desired DTV average power level is at -12 dB. In this case, the desired DTV power to undesired adjacent DTV spill-over power ratio is -12 - (-51) = 39 dB! It is much lower than the 15.2 dB C/N threshold measured by the ATTC laboratory test [2]. As an engineering approach, if the noise/interference level is 10 dB below the noise threshold level, the impact to the system performance will be very limited. This calls for a adjacent DTV spill-over tolerance level of 25 dB, which results in a 39-25 = 14 dB margin. This margin is higher than the 12.67 dB protection ratio required for 5-mile transmitter separation, see Table 1. The above analysis is based on the unfiltered DTV spectrum, The filtered DTV spectrum should have no problem to meet adjacent DTV-DTV interference requirement for 5-mile separation. For the exact co-location case, a DTV/DTV adjacent channel power level difference of up to 14 dB is allowed.

It should be pointed out that the DTV threshold is very "sharp". A few tenth of dB below the threshold will result in picture freeze and lost of sound. Every effort should be made to maintain the DTV interference level below the threshold.

5. Conclusions

Two emission masks have been proposed, see Figure 5. A "loose-mask" is used for DTV/NTSC exact co-location case. The other, "tight-mask", is designed for up to 5-mile separation between the transmitters. The tight-mask might also be used for exact co-location mixed class implementation. No polarization discrimination is assumed in the development of the masks and the DTV signal average power is 12 dB below the NTSC peak sync power.

References

[1] Carl G. Eilers, "The development of a high definition television (HDTV) terrestrial broadcasting emission mask," IEEE Transactions on Broadcasting, vol. 41, no. 4, Dec. 1995.

[2] FCC, "Sixth Report and Order," MM Docket No. 87-268, adopted April 3, 1997, FCC 97-115 (released April 10, 1997), pp. 90.

[3] Stanley J. Salamon, "Adjacent channel interference revisited," ATTC Report, 1996

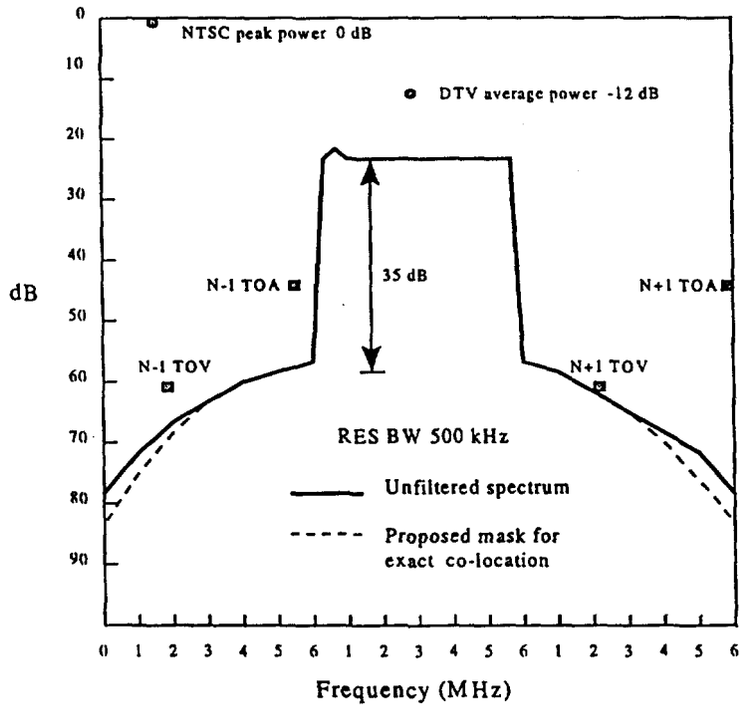

Figure 1: Unfiltered DTV spectrum and proposed "loose-mask" for exact co-location

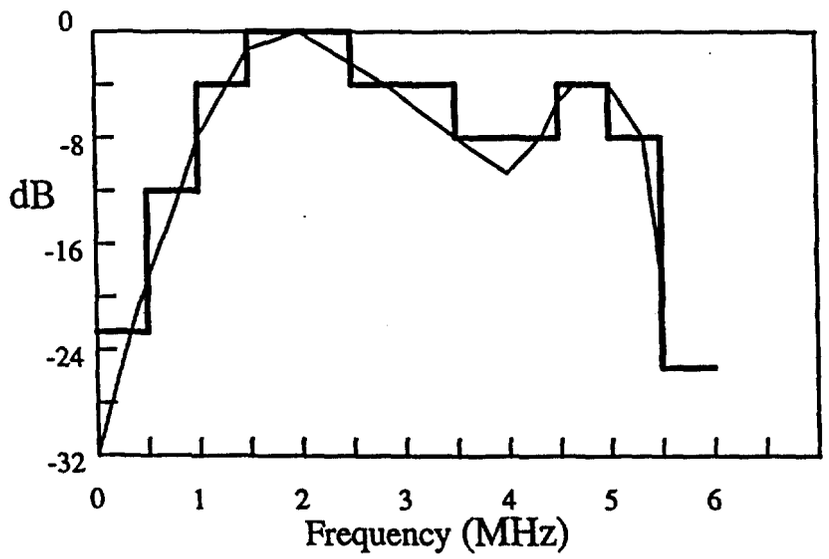

Figure 2: NTSC signal RF subjective weighting curve

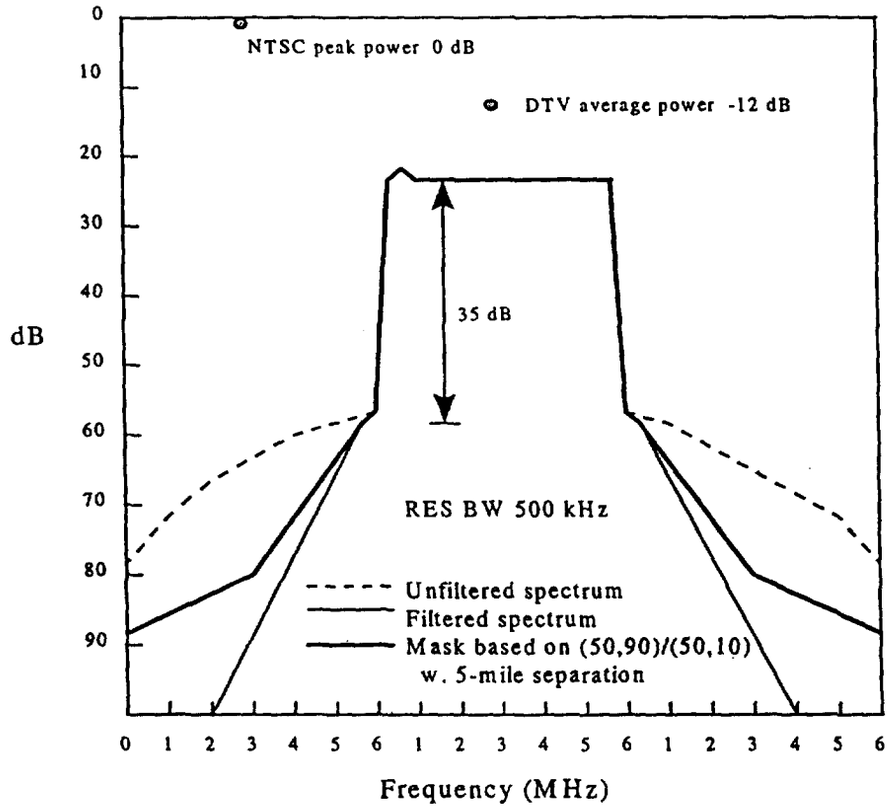

Figure 3: Proposed "tight-mask" for 5-mile separation and filtered spectrum

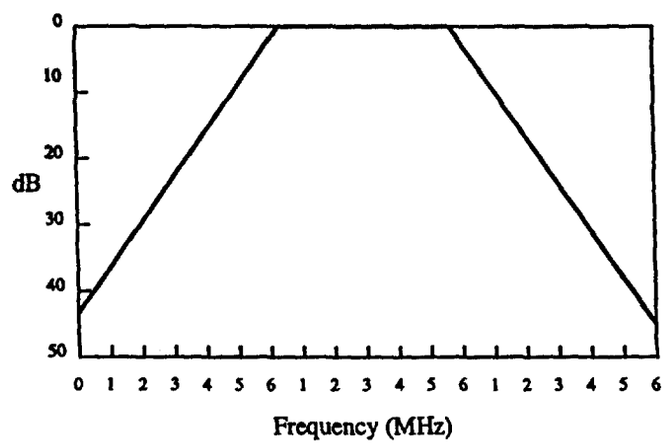

Figure 4: Charlotte field test transmitter filter response

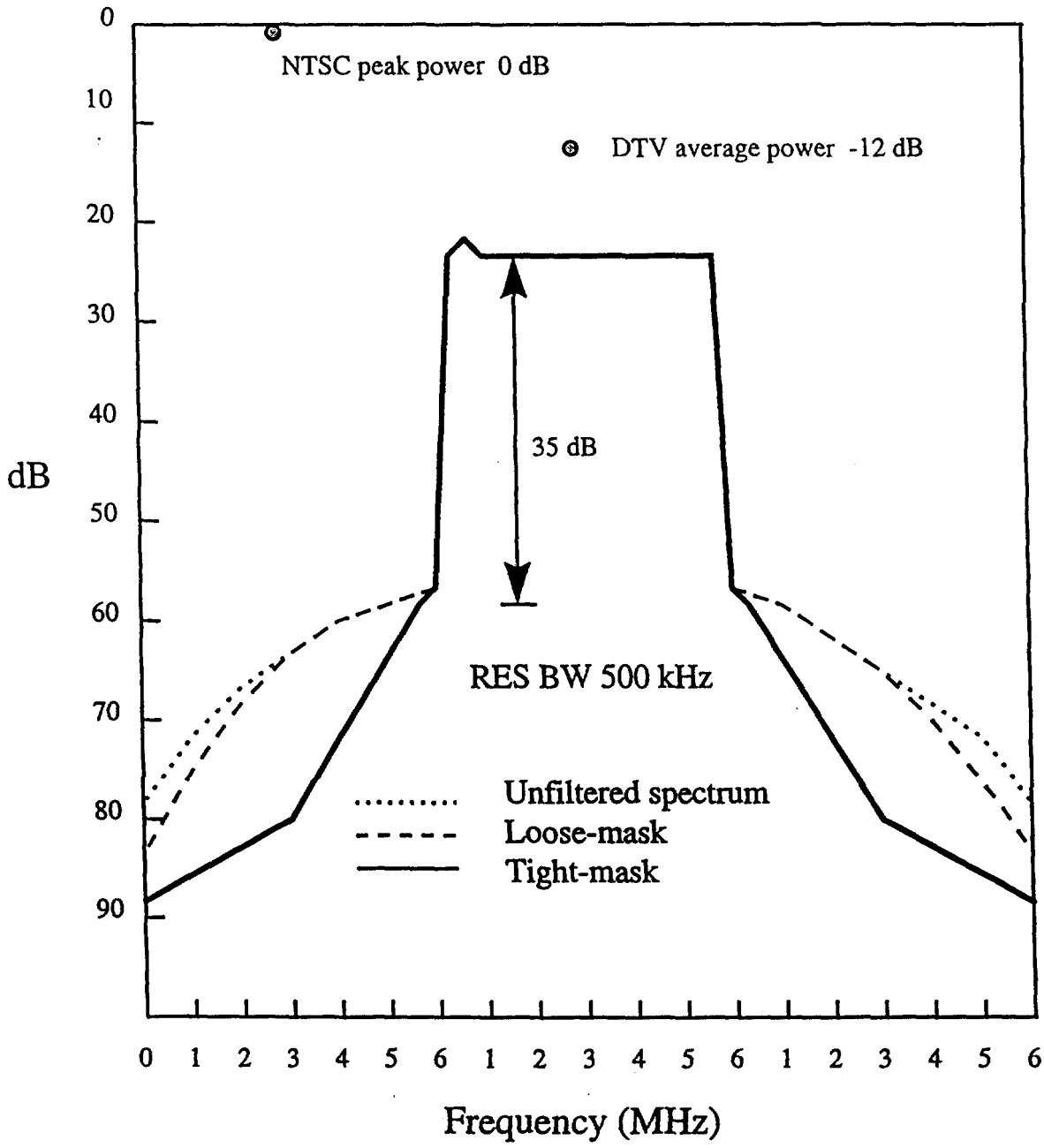

Figure 5: Proposed emission masks

Impact of Mixing Transmitter Classes on Flexibility Distance for First Adjacent Channel DTV-DTV and DTV-NTSC Interference

Communications Research Centre

July 9, 1997

Premises and Methodology

This study on adjacent channels is investigating the possibilities of mixing DTV/DTV and DTV/NTSC transmitter classes and the effect it would have on the permissible distance (flex) between the co-located transmitters.

Computer simulations were conducted based on the propagation model CCIR 370, in the Low VHF, High VHF and UHF frequency band. For all stations, the maximum ERP and antenna height in each class and frequency band were used. In the case of DTV, six classes in each frequency band (L-VHF, H-VHF, UHF) were used, see Tables 1 to 3. In the case of NTSC, six classes were used: L-VHF, H-VHF, UHF-C, UHF-B, UHF-A, and LP, see Table 4 to 6. The median frequency of each band was selected for the simulation. The desired signal propagation curves used was F(50,90) and the undesired signal propagation curve was (50,10).

DTV into DTV:

In the document "DTV Emission Mask Revisit", if relaxed emission masks are used, there is a 14 dB margin for adjacent channel DTV-DTV interference. This 14 dB margin can be used for possible mixed classes operation. The simulation results are listed in Tables 1 to 3.

DTV into NTSC:

For adjacent channel DTV interference into NTSC, the relaxed DTV emission mask provides no margin for mixed classes operation. However, if the tight emission mask is used, there would be 12 dB additional attenuation on the adjacent channel NTSC signal visual carrier. This 12 dB margin can be allocated for possible mixed classes operation. The simulation results are presented in Tables 4 to 6.

NTSC into DTV:

For a given class of transmitter, the ERP of DTV station is typically 12 dB lower than the adjacent NTSC station. When a lower class DTV station is mixed with a higher class NTSC station, it is very likely to result in a saturation of DTV reception, especially when a LNA is used, because the desired DTV signal, in this case, is much lower than the undesired adjacent NTSC signal. The inter-modulation products, due to front-end over-load, may be the limiting factor. The performance will depend on the dynamic range of receiver front-end or LNA.

Results of simulations

Table 1: L-VHF : DTV to DTV Separation Distance Between Different Classes (assuming relaxed emission masks are used).

	L-VHF	L-VHF-HV	L-VHF-C	L-VHF-B	L-VHF-A	LP
L-VHF	18km	11 km	0	X	X	X
L-VHF-HV		19 km	7 km	X	X	X
L-VHF-C			20 km	X	X	X
L-VHF-B				18 km	X	X
L-VHF-A					11 km	X
LP						12 km

Table 2: H-VHF : DTV to DTV Separation Distance Between Different Classes (assuming relaxed emission masks are used).

	H-VHF-LV	H-VHF	H-VHF-C	H-VHF-B	H-VHF-A	LP
H-VHF-LV	18 km	11 km	0 km	X	X	X
H-VHF		19 km	7 km	X	X	X
H-VHF-C			20 km	X	X	X
H-VHF-B				18 km	X	X
H-VHF-A					11 km	X
LP						12 km

Table 3: UHF: DTV to DTV Separation Distance Between Different Classes (assuming relaxed emission masks are used).

	UHF-LV	UHF-HV	UHF-C	UHF-B	UHF-A	LP
UHF-LV	6 km	0 km	X	X	X	X
UHF-HV		7 km	X	X	X	X
UHF-C			10 km	X	X	X
UHF-B				13 km	X	X
UHF-A					9 km	X
LP						4 km

Table 4: L-VHF : DTV to NTSC (assuming tight emission mask is used).

	NTSC L-VHF (dB)	Flex Distance (km)
L-VHF	8.69	11
L-VHF-HV	5.46	14
L-VHF-C	0.07	34
L-VHF-B	-10.77	69
L-VHF-A	-22.99	74
LP	-34.19	> 89

Table 5: H-VHF : DTV to NTSC (assuming tight emission mask is used).

	NTSC H-VHF (dB)	Flex Distance (km)
H-VHF-LV	10.52	1
H-VHF	7.65	10
H-VHF-C	-0.15	26
H-VHF-B	-9.19	50
H-VHF-A	-20.99	66
LP	-33.45	> 82

Table 6 UHF: DTV to NTSC Separation Distance Between Different Classes (assuming tight emission masks are used).

	NTSC UHF-C (km)	NTSC UHF-B (km)	NTSC UHF-A (km)	NTSC LP (km)
UHF-LV	X	X	X	X
UHF-HV	X	X	X	X
UHF-C	8	X	X	X
UHF-B		12	X	X
UHF-A			8	X
LP				3

<u>Recommendation</u>

Avoid mixing transmitters classes, as much as possible. When absolutely necessary respect the flex distance given in Tables 1 to 6. Practically, adjacent stations, whether DTV-DTV or NTSC-DTV, should be in comparable classes. When mixing classes, ensure that it is a valid combination and that the sites chosen respect the flex distance, Tables 1-6.

Annex:

DTV-DTV Interference

Presented in the Annex are the difference in field strength between the desired signal and the interfering signal at the equivalent grade B contour.

Table A1: L-VHF :DTV- DTV 0 mile separation (in dB)

(assuming relaxed emission masks are used).

	L-VHF	L-VHF HV	L-VHF-C	L-VHF-B	L-VHF-A	LP
L-VHF	8.63	10.50	14.21	24.79	37.46	51.90
L-VHF-HV	8.60	7.48	11.18	21.76	34.43	48.82
L-VHF-C	-0.03	1.79	5.50	16.08	28.75	43.19
L-VHF-B	-10.55	-9.03	-5.22	3.84	15.47	30.63
L-VHF-A	-22.07	-20.73	-17.66	-8.88	2.20	17.05
LP	-35.21	-34.04	-31.75	-24.28	-13.43	0.44

Table A2: H-VHF : DTV- DTV 0 mile separation (in dB)

(assuming relaxed emission masks are used).

	H-VHF LV	H-VHF	H-VHF-C	H-VHF-B	H-VHF-A	LP
H-VHF-LV	8.60	10.50	14.22	24.79	37.47	51.91
H-VHF	8.61	7.48	11.19	21.76	24.44	48.88
H-VHF-C	-0.03	1.79	5.50	16.07	28.75	43.19
H-VHF-B	-10.53	-9.03	-5.45	3.86	15.48	30.64
H-VHF-A	-22.10	-20.72	-17.66	-8.85	2.20	17.05
LP	-35.21	-34.04	-31.75	-24.22	-13.43	0.44

Table A3: UHF : DTV- DTV 0 mile separation (in dB)
(assuming relaxed emission masks are used).

	UHF-LV	UHF-HV	UHF-C	UHF-B	UHF-A	LP
UHF-LV	11.98	14.35	19.00	31.29	45.72	61.36
UHF-HV	8.78	11.14	15.80	28.09	42.52	58.15
UHF-C	2.14	4.50	9.16	21.45	35.88	51.51
UHF-B	-10.82	-8.77	-4.81	6.03	19.66	36.05
UHF-A	-24.94	-23.12	-19.54	-9.34	3.89	20.09
LP	-35.35	-32.94	-31.23	-23.23	-11.45	4.58

Table A4: UHF: DTV to NTSC Interference Between Different Classes
(assuming tight emission masks are used).

	NTSC UHF-C (dB)	NTSC UHF-B (dB)	NTSC UHF-A (dB)	NTSC LP (dB)
UHF-LV	18.91	31.20	45.63	61.27
UHF-HV	15.84	28.13	42.56	58.20
UHF-C	9.19	21.48	35.91	51.55
UHF-B	-5.16	5.79	19.41	35.81
UHF-A	-19.73	-9.53	3.70	19.90
LP	-30.35	-22.35	-10.58	5.46