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TECHNICAL SERVICES DIVISION

REPORT NO. 34

TITLE: The Sharing of Television Channels

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TECHNICAL REPORT NO. 34

TITLE: The Sharing of Television Channels

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The Sharing of Television Channels

Summary and Conclusions

1. This report first outlines the required relationships between television channels used in the same or adjacent areas to enable them to operate without mutual interference, in accordance with standards for quality of service and permissible interference levels laid down by the International Telecommunication Union.

2. It goes on to examine whether the sharing of television channels with narrow-band services would be subject to fewer restrictions, with particular reference to possible FM sound broadcasting services within the 88-108 MHz band. It is deduced that only a small number of low-power FM stations (up to 1 kW erp radius of coverage 7 - 15 miles) are possible within a television channel in a given area if a high-power television station is operating on that channel in an adjacent area.

3. The report then analyses the restrictions on narrow band 88-108MHz services due to the operation of television stations on channels outside this band in the same area. It is shown that the existing population of 3 million Australian TV receivers, which, unlike their European and American counterparts, were developed and manufactured in the absence of FM transmissions, are much more susceptible to interference from transmissions at harmonics or sub-harmonics of the television frequencies. Thus co-existence of VHF FM and TV services observed in other countries cannot be assumed acceptable here without detailed verification.

4. The above limitations are then applied in turn to each of the 40 main television areas in Australia, to determine the number of high and low power FM services which could be provided while maintaining the present TV allocations.

In Melbourne this would provide 8 high-power plus 4 low-power FM channels.

In Sydney this would provide 2 high-power plus 15 low-power channels.

Taking all the capital cities together, a number of listeners equal to only 11% of the total Australian population served by TV would have more than 10 FM channels available, 32% from 6 to 10, and 33% would have fewer than 6 FM channels available.

Taking the other 32 main TV areas of Australia, listeners representing only 12% of the total population would have more than 10FM channels available, 2% from 6 to 10, and 10% would have fewer than 6 FM channels available.

5. The report then considers the improved situation for FM service if all stations on television Channel 5 were closed down and not replaced by other VHF TV channels. This would improve the Sydney situation to permit 9 high-power plus 8 low-power FM stations with Melbourne unchanged at 8 high-power plus 4 low-power FM stations. In all the capital cities together, 11% of the total TV served would have more than 10 FM channels available, and the remaining 65% from 6 to 10 channels. In other areas, 12% would have more than 10 FM channels available, and the remaining 12% of the population between 6 and 10 channels.

6. Finally, the report considers the consequences of closing down Channel 5 TV services. Replacement by the best available alternative VHF TV channel would in most cases result in appreciable degradation of existing TV service within the area and the overlap with adjacent areas; to maintain the existing standards, while providing the FM services indicated, transfer of the Ch. 5 TV services to the UHF band would be necessary.

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The Sharing of Television Channels

1. Most of the populated area of Australia receives television service from two or more cosited high-power stations, so that the coverage may be represented by a series of overlapping circles of typically 60 miles radius (although there may be unserved areas within the circles, due to rough terrain).

Sharing of TV Channels among TV Stations

2. In planning the allocation of TV channels to these areas the following limitations apply to the use of channels by TV stations :-

2.1 Allocations in the one area must be separated by approx. 1 TV channel (limited TV receiver selectivity).

Channel numbering does not show separations which are as follows :-

Channel 0 - 1	4 MHz
1 - 2	Adjacent
2 - 3	15 MHz
3 - 4	2 MHz
4 - 5	Adjacent
5 - 5A	29 MHz
5A - 6	30 MHz
6 - 7	Adjacent
7 - 8	Adjacent
8 - 9	Adjacent
9 - 10	6 MHz
10 - 11	Adjacent

2.2 Channels cannot be used if the local oscillator radiation from TV receivers tuned to another channel in the same area falls within them.

This excludes Ch. 5 when Ch. 2 is in use
Ch. 10 when Ch. 6 is in use
Ch. 11 when Ch. 7 is in use

There is also a less serious problem with Ch. 4 when Ch. 1 is used, and this should be avoided in future.

2.3 Two channels whose frequency difference falls within the intermediate frequency band-width of receivers (30-38 MHz) cannot be used in the same area. Thus Ch. 5 and 5A cannot be used in same area. 5A and 6 cannot be used in same area.

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2.4 The same channel cannot be used again for high-power stations until a distance of 200-250 miles (depending on terrain) is reached. If a smaller spacing is necessary, the powers in the direction of the co-channel station must be reduced, e.g. by the use of directional aerials (Ballarat and Shepparton). Thus high-power channels cannot be used again in adjacent areas.

2.5 Channels whose vision or sound carriers are harmonically related cannot be used in the same area (beat generation in receivers). This excludes the combination Ch. 4 and Ch. 8 and to some extent (3rd harmonic relation) Ch. 2 and Ch. 8. Ch. 0 and Ch. 1 combination is excluded because of the relation (2 Ch. 0 sound = Ch. 0 vision + Ch. 1 vision).

3. Melbourne TV Allocations

The channel allocation situation in Melbourne is then as follows -

Table I

	Prohibition
Channel 0 - In use	
Channel 1	In use, Bendigo, Albury
Channel 2 - In use	
Channel 3	In use, Ballarat, Shepparton, Launceston
Channel 4	In use, Latrobe Valley
Channel 5	Not with Channel 0 or Channel 2
Channel 5A - Available	
Channel 6	In use, Ballarat, Shepparton
Channel 7 - In use	
Channel 8	In use, Bendigo
Channel 9 - In use	
Channel 10	In use, Latrobe Valley
Channel 11	Not with Channel 7

Thus all available channels except Channel 5A are in use.

4. Sydney TV Allocations

The channel allocation situation in Sydney is as follows -

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Table II

	Prohibition
Channel 0 - Available	
Channel 1	Not with Channel 2 In use, Orange, Taree
Channel 2 - In use	
Channel 3	In use, Newcastle
Channel 4	In use, Wollongong
Channel 5	In use, Newcastle
Channel 5A	In use, Wollongong
Channel 6	Not with Channel 7
Channel 7 - In use	
Channel 8	Not with Channel 7, 9 In use, Orange, Taree
Channel 9 - In use	
Channel 10 - In use	
Channel 11	Not with Channel 7

Thus all available channels except Ch. 0 are in use.

5. Sharing of TV Channels with narrow-band services

It may be possible to employ parts of TV channels not used for TV in a given area for relatively narrow-band services, such as mobile, or FM broadcasting, to a greater extent than for other TV channels. The limitations on such use may be considered under two headings

- limitations due to interactions with TV stations operating in adjacent areas on the same channel.

- limitations due to interactions with TV stations operating in the same area on different channels.

6. Co-channel interaction with adjacent areas

6.1 Required TV protection ratio

CCIR report 306 gives inter alia, values for the protection ratio required by colour TV transmissions on the Australian 625 line PAL system.

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Table III

Frequency of Interference		Protection in dB			
TV - 1.5 MHz		0 dB			
- 1.25	(Band Edge)	14 dB			
- 1.0		28 dB			
- 0.5		40 dB			
0 MHz	TV carrier	50 dB			
+1		50 dB			
+2.8		33 dB			
+3.9	Colour Sub-Carrier	45 dB			
+4.9	Colour Sub-Carrier	45 dB			
+5.2		15 dB			
+5.4	Sound Carrier	12 dB	Mono	30 dB	CCIR Report 462
+5.5	Sound Carrier	36 dB	Mono	45 dB	Stereo CCIR Report 462
+5.6	Sound Carrier	12 dB	Mono	30 dB	CCIR Report 462

Viewers in the nearer part of the adjanent area will have their aerials directed away from the interfering station, so that there will be a reduction of interference to them due to aerial directivity. This is set at 6 db by CCIR Rept. 419.

6.2 Permissible narrow-band field-strength at boundary of TV service

The greatest interference with the adjacent TV service is at the boundary of the service area. When the programme interfered with is available from stations in both service areas (e.g. National stations Melbourne, Channel 2 and Latrobe Valley, Channel 4; Sydney, Channel 2 and Wollongong, Channel 5A) the coverage to the rural limit of service 50 dBu is not necessary in the overlap area. Where the service is different (e.g. commercial station Newcastle Channel 3 interfered with by Sydney narrow band service) protection to the rural limit of 50 dbu will be required to avoid complaints. We may thus set out the permissible field strength of the narrow-band service at the appropriate limit of the adjacent TV service area as follows (taking the mono figure for interferenct to TV sound).

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Table IV

Frequency	Permissible FS in dbu at 50 dbu limit	at 60 dbu limit
TV -1.5	56 dbu	66 dbu
-1.25	42	52
-1	24	34
-0.5	16	26
0	6	16
+1	6	16
+2.8	23	33
+3.9	11	21
4.9	11	21
5.2	41	51
5.4	44 dbu	54
5.5	20	30
5.6	44 dbu	54

(dbu = db above 1 microvolt/metre at 9 metres)

The above fields are the maximum which the narrow-band service may produce at the boundary of the adjacent television area.

6.3 Permissible power of narrow-band service

The field strength which e.g. a 1 KW e.r.p. Band II, FM transmitter with an effective height of 200' above surrounding terrain would produce is

Table V

Distance in miles	10	20	30	40	50 miles
Field strength in dbu	59	46	38	31	25 dbu

For heights above 200', both the wanted field strength and the interference to TV will increase proportionately with height (e.g. by 14 db for 1,000' effective height) so that an appropriate power decrease will restore the 200' situation.

Thus the maximum e.r.p. in db relative to 1 KW for an FM station sharing a channel with a TV station in an adjacent area may be derived from Tables IV and V, giving Table VI, which is for protection of the TV service to the 60 dbu boundary. For protection to the normal TV limit of 50 dbu, 10 db lower FM erps are necessary.

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Maximum e.r.p. of FM station co-channel with TV.

Frequency within TV channel	Distance of FM station from boundary of adjacent TV area				
	10 miles	20 miles	30 miles	40 miles	50 miles
Vision carrier -1.5MHz (outside channel)	+7dbKW	+20	> 20	> 20	> 20
-1.25MHz (channel edge)	-7	+6	+14	> 20	> 20
-1.0MHz		-12	=4	+3	+9
-0.5	negligible (- -30)	-20	-12	-5	+1
0	neg.	-30	-22	-15	-9
+0.5	neg.	-30	-22	-15	-9
+1.0	neg.	-30	-22	-15	-9
+2.8	-26	-13	-5	+2	+8
+3.9	neg.	-25	-17	-10	-4
+4.9	neg.	-25	-17	-10	-4
+5.2	-8	+5	+13	+20	> 20
+5.4	-5	+8	+16	> 20	> 20
+5.5 (TV sound carrier)	neg.	-16	-8	-1	+5
+5.6	-5	+8	+16	> 20	> 20

6.4 Coverage radius for narrow-band co-channel service

CCIR report No. 462 defines the following minimum field-strength for stereo FM coverage

quiet rural	54 dbu
to urban	66 dbu

If we take the mean figure of 60 dbu as representing avarage suburban coverage, then from Table VI we may compute the coverage radius of co-channel FM service as follows -
(in some cases the coverage is limited by TV interference to the low-power FM service, rather than the signal strength limit - these are marked *)

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Table VII - FM Coverage Radius

Frequency within TV Channel	Distance of FM station from boundary of adjacent TV area				
	10 miles	20 miles	30 miles	40 miles	50 miles
Vision Carrier					
-1.5MHz (outside channel)	14 miles	28	> 28	> 28	> 28
-1.25MHz (channel edge)	6 miles	13	20	> 28	> 28
-1.0MHz	2.1 miles	4.5	7	11	16
-0.5	negligible	2.9	4.5	7	9
0	neg.	1.6	1.7*	1.8*	2.2*
+0.5	neg.	1.6	2.6.	2.5	5.5
+1.0	neg.	1.6	2.6	2.5	5.5
+2.8	2.0 miles	4.2	7	10.5	15
+3.9	neg.	2.1	3.5	5	6*
+4.9	neg.	2.1	3.5	5	6*
+5.2	6 miles	12	20	28	> 28
+5.4	7 miles	15	20	> 28	> 28
+5.5 (TV sound carrier)	neg.	1.5*	2.0*	2.0*	5*
+5.6	7 miles	15	20	> 28	> 28

6.5 Conclusion

Only low-power FM stations may be used at frequencies within the channel of a high-power TV station in an adjacent television area. High-power FM stations may be used immediately below or above the channel. Frequencies close to vision, colour and sound carrier frequencies of the TV station are not usable.

Frequencies approximately 2.8 or 5.3 MHz. above the vision carrier frequency are most favourable and can give stereo FM coverage of 10 to 15 miles radius with effective radiated powers of the order of one kilowatt. (Under quite rural conditions range could extend to 20 miles; under busy urban situations to less than 7 miles). Co-channel interference limits specified by CCIR Report 462 would require such stations to be spaced about 80 miles apart if using the same channel. (This severe restriction is due to the susceptibility of the pilot-tone stereo system to co-channel interference. For monophonic FM services the spacing could be reduced to 50 miles).

7. Interaction of narrow-band services in the frequency range 88-108 MHz. with TV stations on other channels in the same area.

7.1 With TV Channel 0. (Melbourne, Brisbane, Cooma, Wagga. See also 2.5)

The limitation here is by interference to TV from services operating at double the frequency of Ch. 0 transmissions. This is not due to second harmonic radiation from the Ch. 0 TV transmitters, which can be filtered as effectively as desired, but to the generation of this second harmonic or equivalent non-linear

mixing in the tuner of the TV receiver tuned to Ch. O. An interfering service near this harmonic frequency which enters the tuner will cause a visible beat pattern at the difference frequency on the Ch. O receiver screen. Therefore the magnitude of the interference will vary from receiver to receiver. Laboratory tests of a limited number of receivers suggest that this interference may be worse with solid-state than with valve tuners.

U.K. and U.S. TV receivers were developed at a time when FM transmissions were on the air, and are therefore designed to minimise this problem; no such constraint was applied in the design period of the present 3 million Australian TV receivers.

A typical Australian receiver installation showed the following interference behaviour with a Ch. O input field strength of 60 dbu, and a single frequency interfering signal whose level was adjusted to be respectively "perceptible" or "annoying".

Table VIII

Interference to Ch. O TV reception from double-frequency signals.

Frequency of interfering signal.	90.5MHz	91.5	92.5	94.5	95.5	96.5	97.5	98.5
Relation to TV frequency (vision carrier).	2(TV-1)	2(TV-0.5)	2TV	2(TV+1)	2(TV+1.5)	2(TV+2)	2(TV+2.5)	2(TV+3)
Signal level for "perceptible" interference.	70 dbu	63	52	50	51	53	55	56
Signal level for "annoying" interference.	82 dbu	78	70	62	62	63	66	70

Fields of over 80 dbu were required to disturb Ch. O sound channel, so this is no problem, though it would be desirable to avoid FM stations on exactly double the colour sub carrier (i.e. 101.36 MHz) and sound carrier (103.5 MHz).

As useful FM field strength will range from 60 dbu to 80 dbu in the coverage area of high or low power stations, the resulting annoying interference would appear to prohibit the use of low or high-power FM stations between approximately 92-99 MHz in areas using Ch. O TV - more extensive measurements would be necessary to establish exact limits.

This leaves 85-92 and 99-108 MHz available for FM.

7.2 With Ch. 1 (Southern Downs, Manning River, Orange, Bendigo, Mt. Gambier, Spencer Gulf)

In this case the limitation is one of interference to FM by local oscillator radiation from TV receivers tuned to Ch. 1. This is largely distributed

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by and radiated from the power reticulation network, and constitutes a uniform "fog" of radiation, detectable by aircraft up to 1,000' above a suburban area, of intensity about 50 dbu. Much higher values would be encountered by an FM receiver in close proximity to an individual TV receiver, but this is probably not so important, as the stability of TV receiver local oscillators, though adequate for their purpose, is poor by narrow-band standards, and any individual TV local oscillator would drift enough not to remain within the FM pass-band for very long.

The local oscillators of TV receivers tuned to Ch. 1 will be operating normally on 93.25 MHz or 94.125 MHz depending on the intermediate frequency in use. The tuning range is about ± 1 MHz, so that interference would be expected to high or low power FM services between 92.5 MHz and 95 MHz approx. leaving 85-92 and 95-108 MHz available. To 'drown' this interference, FM signal strengths of 80-100 dbu would be necessary, which would reduce the FM service area (otherwise defined say by 60 dbu limit) to about 1/10 of the value.

7.3 With Ch. 2 (all capitals except Canberra, Grafton-Kempsey, Wagga, Broken Hill, Mt. Barker)

The limitation here is exactly similar to that for Ch. 1 - oscillator radiation from TV receivers, 7 MHz higher in frequency than for Ch. 1, preventing the use of high or low power FM services between 99.5 and 102 MHz approx. leaving 85-99.5 and 102-108 MHz available.

7.4 With Ch. 3 (Canberra, Newcastle, Darling Downs, Rockhampton, Townsville, Shepparton, Ballarat, Launceston, Bunbury, Illawarra - medium power)

Assuming that FM receivers will have their local oscillators 10.7 MHz above the operating frequency (and this is the case for all receivers examined so far in Australia) there will be no TV interaction from FM stations outside the TV channel 3, leaving 92-108 MHz available.

7.5 With Ch. 4 (Illawarra, Latrobe Valley, Mackay, Southern Downs, Albury, Mildura, Spencer Gulf, Mawson).

Local oscillator radiation from FM receivers operating between 85 and 90.3 MHz will fall in Ch. 4 and cause unacceptable beat pattern interference to TV receivers.

This leaves 90.3 - 94 MHz and 101-108 MHz available for FM.

7.6 With Ch. 5 (Newcastle, Dubbo, Bunbury, Darling Downs low power)

Local oscillator radiation from FM services operating between 90.3 and 97.3 MHz will fall in Ch. 5 and cause unacceptable beat pattern interference to TV receivers. This leaves 85-90.3 MHz and 97.3-101 MHz for FM.

7.7 With Ch. 5A (Illawarra)

No interactions are expected.

7.8 With Ch. 6 (Hobart, Richmond-Tweed, Wide Bay, Mackay, Dubbo, Bega, Ballarat, Shepparton)

The limitation here is similar to that applying to Ch. 0. The second

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harmonics of FM transmissions between 87 and 90.5 MHz fall within Ch. 6. The protection ratios given in Table III (Ch.1) will apply, to spurious radiation from the transmitters, but, as with Ch. 0 this can be reduced as much as is desirable; the problem is the generation of the second harmonic or equivalent non-linear mixing in the first stage of the TV tuner operating on Ch. 6, which then beats with the TV vision carrier to produce an interference pattern. The magnitude of the problem varies considerably among TV receivers, and is not severe as that for Ch. 0. On the evidence available it would seem desirable to avoid 87 to 90.5 MHz for randomly sited high power FM stations and 87.3-89.2 MHz, 89.5-90.1 and 90.35-90.4 MHz for high power FM stations cosited with Ch. 6 TV and all low power FM stations. As for the co-channel interference (Sec.6) frequencies (related to vision carrier) of +2.8 MHz, and +5.3 MHz appear most advantageous i.e. 89.02 MHz and 90.26 MHz within this range 87-90.5, leaving in addition 90.5-108 MHz clear for FM.

7.9 With Ch. 7 (all capital cities except Hobart, Townsville, Rockhampton, Upper Namoi, Griffith, Broken Hill)

The limitation here is similar to that for Ch. 6 - interference due to generation of the second harmonics of the FM carrier for frequencies between 90.5 and 94 MHz, in the TV tuner. Thus this frequency range should be avoided for randomly sited high power FM and the frequencies (90.8-92.7), (93.0-93.6) and (93.85-93.9) MHz for low power FM, and high power cosited with Ch. 7 TV; most advantageous frequencies would be 92.52 and 93.76 MHz, within the range 90.5-94 MHz, leaving in addition 85-90.5 and 94-108 MHz clear for FM.

It may be noted that this analysis is confirmed by experience when Ch. 7 commenced transmitting TV in Melbourne in 1955. The experimental FM transmitter at Jolimont operating on 91.1 MHz with about 6 kW e.r.p., blanketed Ch. 7 TV reception with beat pattern interference for a radius of between 1 and 2 miles. It was eliminated by shifting the FM station frequency to 90.4 MHz.

7.10 With Ch. 8 (Richmond-Tweed, Orange, Bendigo, Wide Bay, Manning River, Bega/Cooma, Mildura, Mt. Gambier).

The limitation is again similar to Ch. 6 - interference due to generation of the second harmonic of the FM carrier frequencies between 94 and 97.5 MHz, in the TV tuner. Thus this frequency range should be avoided for randomly sited high power FM and the frequencies (94.3-96.2), (96.5-97.1) and (97,35-97.4) MHz for low power FM, and high power FM cosited with Ch. 8 TV; most advantageous frequencies would be 96.02 and 97.25 MHz within the range 94-97.5 MHz, leaving in addition 85-94 and 97.5-108 MHz clear for FM.

7.11 With Ch. 9 (all capital cities except Canberra, Hobart, Launceston, Cairns, Upper Namoi, Griffith, Mt. Barker)

The limitation is again similar to Ch. 6 - interference due to generation of the second harmonic of the FM carrier for frequencies between 97.5 and 101 MHz, in the TV tuner. Thus this frequency range should be avoided for randomly sited high power FM and the frequencies (97.8-99.7), (100-100.6) and (100.85-100.9) MHz for lower power FM and high power FM cosited with Ch. 9 TV; most advantageous frequencies would be 99.52 and 100.76 MHz within the range 97.5-101 MHz, leaving in addition 85-97.5 and 101-108 MHz clear for FM.

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7.12 With Ch. 10 (Sydney, Adelaide, Darling Downs, Latrobe Valley, Cairns, Cooma)

The limitation is again similar to Ch. 6 - interference due to generation of the second harmonic of the FM carrier for frequencies between 104 and 107.5 MHz, in the TV tuner. Thus this frequency range should be avoided for randomly sited high power FM and the frequencies (104.3-106.2), (106.5-107.1) and (107.35-107.4) MHz for low power FM and high power FM cosited with Ch. 10 TV; most advantageous frequencies would be 106.02 and 107.26 MHz within the range 104-107.5 MHz, leaving in addition 85-104 and 107.5-108 MHz clear for FM.

7.13 With Ch. 11 (Grafton-Kempsey, Swan Hill)

The limitation is again similar to those above, but applies only to FM frequencies between 107.5 and 108 MHz, leaving the rest of the 85-108 MHz band clear for FM.

8. Limitations on FM operation 88-108 MHz in Melbourne

The limitations set out in Sections 6 or 7 above may be applied to the Melbourne situation, where -

TV channels in use - 0, 2, 7, 9

TV channels in adjacent areas - 1, 3, 4, 6, 8, 10

as follows :-

		High-power FM	Low-power FM
Limitations due to Ch.	0 (Sec.7.1)	Not 92 - 99 MHz	Not 92 - 99 MHz
	2 (Sec.7.3)	Not 99.5 - 102 MHz	Not 99.5 - 102 MHz
	3 (Sec.6)	Not 85 - 92 MHz	Usable (see Table VII)
	4 (Sec.6)	Not 94 - 101 MHz	Usable (see Table VII)
		Randomly sited	Also high-power FM cosited with TV
	7 (Sec.7,9)	Not 90.5 - 94	Not 90.8 - 92.7
			Not 93.0 - 93.6
			Not 93.85 - 93.9
	9 (Sec.7,11)	Not 97.5 - 101	Not 97.8 - 99.7
			Not 100 - 100.6
			Not 100.85 - 100.9

This leaves, for high power FM stations (random or cosited) - 102 - 108 MHz (most of Ch. 5)

and for low power FM stations 88 - 90.8 (avoiding 90.68) and 102 - 108 MHz.

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At the closest spacing used overseas of 0.8 MHz between FM channels in the same area (0.8 MHz in U.S.A., vs 2.2 MHz in U.K., Germany)

this provides 8 channels for high power FM

plus 4 additional channels for low-power FM

9. Limitations on FM operation 88 - 108 MHz in Sydney

The limitations set out in Section 6 and 7 above may be applied to the Sydney situation, where -

TV channels in use - 2, 7, 9, 10

TV channels in adjacent areas - 1, 3, 4, 5, 5A, 8

as follows :-

	High-power FM	Low-power FM
Limitations due to Ch. 2 (Sec.7.3)	Not 99.5 - 102 MHz	Not 99.5 - 102 MHz
3 (Sec.6)	Not 85 - 92	Usable (see Table VII)
4 (Sec.6)	Not 94 - 101	Usable (see Table VII)
5 (Sec.6)	Not 101 - 108	Usable (see Table VII)
	Randomly sited	Also high-power FM. cosited with TV
7 (Sec.7.9)	Not 90.5 - 94	Not 90.8 - 92.7
		Not 93.0 - 93.6
		Not 93.85 - 93.9
9 (Sec. 7.11)	Not 97.5 - 101	Not 97.8 - 99.7
		Not 100 - 100.6
		Not 100.85 - 100.9
10 (Sec.7.12)	Not 104.0 - 107.5	Not 104.3 - 106.2
		Not 106.5 - 107.1
		Not 107.35 - 107.4

At 0.8 MHz spacing, this provides 0 channels for high power FM randomly sited

plus 2 channels for high-power FM, cosited with TV Ch.7

plus 15 additional channels for low-power FM

If Ch.5 in Newcastle were closed down, then some restrictions on high-power FM operation in the Sydney area would be removed, resulting in

- 4 channels for randomly sited high power FM stations

Plus 5 channels for high-power FM stations cosited with TV Ch.7 or Ch. 10

Plus 8 channels for low-power FM stations

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10. Limitations on FM operation 88-108 MHz in other areas

Proceeding in the same manner as in 8 and 9, the situation in the television areas served by Stages 1, 2, 3 and 4 of development may be summarised as follows -

Table IX

		TV Channels in Use	TV Channels in adjacent areas	Possible number of FM stations with existing TV services operating. High-power (typically 100 KW erp)		Low-power (up to 1 KW erp)	Possible number of FM stations if Ch. 5 TV were closed down without replacement. High-power (typically 100 KW erp)		Low-power (up to 1KW erp)
Stage 1	Sydney	2,7,9,10	1,3,4,5,5A,8	2	+	15	9	+	8
	Melbourne	0,2,7,9	1,3,4,6,8,10	8	+	4	8	+	4(No Change)
Stage 2	Brisbane	0,2,7,9	1,3,4,6,8,10	8	+	4	8	+	4 N.C.
	Adelaide	2,7,9,10	1,4	13	+	4	13	+	4 N.C.
	Perth	2,7,9	3,4,5	2	+	18	8	+	12
	Hobart	2,6	3,4,8,9	11	+	10	11	+	10 N.C.
Stage 3	Townsville	3,7,9,10	4,6,9,10	10	+	7	10	+	7 N.C.
	Rockhampton	3,7	4,6,8	9	+	11	9	+	11 N.C.
	Darling Downs	3,5,10	0,1,2,4,6,7,8,9	0	+	0	4	+	0
	Richmond Tweed	6,8	0,1,2,4,7,9,11	12	+	11	12	+	11 N.C.
	Newcastle	3,5	1,2,4,5A,7,8,9,10	1	+	0	12	+	0
	Orange	1,8	2,3,5,7,9,10	7	+	15	15	+	7
	Illawarra	3,4,5A	1,2,3,5,7,8,9,10	2	+	6	5	+	3
	Canberra	3,7	0,1,2,4,5A,8,10	10	+	10	10	+	10 N.C.
	Shepparton	3,6	0,1,2,4,5,7,8,9,11	3	+	18	12	+	9
	Bendigo	1,8	0,2,3,6,7,9,11	8	+	0	8	+	0 N.C.
	Ballarat	3,6	0,1,2,4,7,8,9	8	+	0	8	+	0 N.C.
	Latrobe Valley	4,10	0,2,3,7,9	7	+	1	7	+	1 N.C.
	Launceston	3,9	0,2,4,6,7,10	10	+	0	10	+	0 N.C.
Stage 4	Cairns	9,10	3,7	18	+	0	18	+	0 N.C.

Table IX (Cont'd)

	TV Channels in Use	TV Channels in adjacent areas	Possible number of FM stations with existing TV services operating. High-power (typically 100 KW erp)		Low-power (up to 1 KW erp)	Possible number of FM stations if Ch. 5 TV were closed down without replacement. High-power (typically 100 KW erp)		Low-power (up to 1 KW erp)
Mackay	4,6	3,7	12	+	2	12	+	2 N.C.
Wide Bay	6,8	0,1,2,3,4,7,9,10	12	+	9	12	+	9 N.C.
Southern Downs	1,4	0,2,3,5,6,7,8,9,10	1	+	14	10	+	5
Grafton-Kempsey	2,11	1,4,6,7,8,9	15	+	7	15	+	7 N.C.
Upper Namoi	7,9	1,2,4,5,6,8,11	6	+	12	15	+	3
Manning River	1,8	2,3,5,7,9,11	8	+	12	17	+	3
Dubbo	5,6	1,7,8,9	2	+	0	11	+	0
Bega/	0,6,8,10	3,4,5A,7	Cooma 5	+	16	5	+	6 N.C.
Cooma			Bega 8	+	11	8	+	11 N.C.
Griffith	7,9	0,1,2,4,8	14	+	0	14	+	0 N.C.
Wagga	0,2	1,3,4,7,8,9	8	+	6	8	+	6 N.C.
Albury-Upper Murray	1,4	0,2,3,5,6,7,9	0	+	11	8	+	3
Swan Hill	2,11	0,1,3,4,5,6,8	3	+	19	10	+	12
Mildura	4,8	2,3,6,11	12	+	5	12	+	5 N.C.
Mt.Gambier	1,8	2,3,4,6,11	10	+	10	10	+	10 N.C.
Spencer Gulf	1,4	2,7,9,10	7	+	0	7	+	0 N.C.
Broken Hill	2,7		20	+	0	20	+	0 N.C.
Bunbury	3,5	2,4,6,7,8,9	3	+	0	13	+	0 N.C.
Mawson	4	2,6,7,8,9	11	+	0	11	+	0 N.C.
Mt.Barker	2,9	3,5,6,8	10	+	10	18	+	2 N.C.

11. Adequacy of possible VHF FM services with existing TV allocations

The numerical data of Table IX may be analysed in a number of ways, depending on views held on the number of FM channels required by each community. In the following engineering study, the 40 areas of Table IX have been classified into:

- Areas with 10 or more FM channels available
- Areas with 6 to 10 FM channels available
- Areas with fewer than 6 FM channels available.

TABLE X

Stage of TV development	10 or more FM	6-10 FM	Fewer than 6 FM
Stage 1	-	Melbourne 8	Sydney 2
Stage 2	Adelaide 13	Brisbane 8	Perth 2
	Hobart 11		
Stage 3	Canberra 10	Rockhampton 9	Darling Downs 0
	Townsville 10	Orange 7	Newcastle 1
	Richmond-Tweed 12	Latrobe Valley 7	Illawarra 2
	Launceston 10	Bendigo 8	Shepparton 3
		Ballarat 8	
Stage 4	Cairns 18	Upper Namoi 6	Southern Downs 1
	Mackay 12	Manning River 8	Dubbo 2
	Wide Bay 12	Bega/Cooma 8/5	Albury-Upper Murray 0
	Grafton-Kempsey 12	Wagga 8	Swan Hill 3
	Griffith 14	Spencer Gulf 7	Bunbury 3
	Mildura 12		
	Mt. Gambier 10		
	Broken Hill 20		
	Mawson 11		
	Mt. Barker 10		

On an approximate population count, taking overlaps into account, this gives the following population with these FM channel availabilities.

	10 or more FM channels	6 - 10 FM	Fewer than 6 FM channels
Capital Cities	1,120,000 (11%)	3,600,000 (32%)	3,700,000 (33%)
Other Areas	850,000 (7%)	813,000 (7%)	1,161,000 (10%)

12. Consequences for FM and TV of closing down Channel 5

12.1 As the number of existing TV stations using Channel 5 is less than the number operating in either Channel 3 or Channel 4, it has been suggested that the removal of Channel 5 TV services would permit the establishment of a VHF FM service. An engineering study has been made of the consequences for both FM and TV service.

As regards FM, a similar table to that in 11, above, may be prepared.

TABLE XI

Stage of TV development	10 or more FM	6 - 10 FM	Fewer than 6 FM
Stage 1	-	Sydney 9 Melbourne 8	-
Stage 2	Adelaide 13 Hobart 11	Brisbane 8 Perth 8	-
Stage 3	Canberra 10 Townsville 10 Richmond-Tweed 12 Newcastle 12 Orange 15 Shepparton 12 Launceston 10	Rockhampton 9 Latrobe Valley 7 Bendigo 8 Ballarat 8	Darling Downs 4 Illawarra 5
Stage 4	Cairns 18 Mackay 12 Wide Bay 12 Southern Downs 10 Upper Namoi 15 Dubbo 11 Grafton-Kempsey 15 Manning River 17 Griffith 14 Swan Hill 10 Mildura 12 Mt. Gambier 10 Broken Hill 20 Bunbury 13 Mawson 11 Mt. Barker 18	Bega/Cooma 8/5 Wagga 8 Albury- Upper Murray 8 Spencer Gulf 7	-

On an approximate population count, taking overlaps into account, this would give the following populations classified under FM channel availabilities.

	10 or more FM	6 - 10 FM	Fewer than 6 FM
Capital Cities	1,220,000 (11%)	7,300,000 (65%)	-
Other Areas	1,753,000 (15%)	731,000 (6%)	340,000 (3%)

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This would provide considerable scope for the development of FM services but the limitations presented would undoubtedly restrict development.

12.2 Increased FM availability indicated by the right-hand columns of Table IX is calculated on the assumption that Ch. 5 TV service is closed down and that no other VHF channels are used to replace these services.

This would involve closing down the following :

	e.r.p.
Toowoomba - Commercial translator from DDQ Darling Downs	100 watts
Newcastle - National station ABHN	100 kW
Dubbo - National Station ABQN	100 kW
Deniliquin - National translator from ABGN Griffith	500 watts
Bunbury - National station ABSW	100 kW

The need to close down the following translators is less apparent, and the problem has not been examined in detail -

	Power
National TV translators Bowen from ABTQ Townsville	100 watts
Lithgow from ABCN Orange	5 watts
Alexandra from ABGV Shepparton	50 watts
Strathgordon from ABT Hobart	5 watts
Kambalda from ABKW Kalgoorlie	5 watts

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	Power
Commercial TV translators Castle Hill from TNQ Townsville	5 watts
Cardstone from TNQ Townsville	1 watt
Cracow from RTQ Rockhampton	1 watt
Bonalbo from RTN Richmond Tweed	1 watt
Gladstone from RTQ Rockhampton	1 watt
Kyogle from RTN Richmond Tweed	1 watt
Murwillumbah from RTN Richmond Tweed	5 watts
Port Lincoln from GTS Spencer Gulf	50 watts

Though it would be possible to transfer most of the above to another VHF channel, in all cases an appreciable penalty in reduction of coverage and increase of co-channel interference would have to be accepted, in addition to the cost of transfer ($400,000 per high-power station). Further, whatever VHF channel is selected would impose its own limitations on the use of FM in the area. Thus the only solution to maintaining the existing standard of TV coverage while providing the improved FM facilities indicated in Table IX would be to transfer the existing Channel 5 TV stations to the UHF band.

12.3 Effect on TV coverage in Toowoomba, Darling Downs

Present TV channels 3 (National high-power)

10 (Commercial high-power)

5 (Commercial Toowoomba translator)

Channels in use in adjacent areas 0, 1, 2, 4, 6, 7, 8, 9.

The difficult mountain area centred on Toowoomba is served with the (Queensland) National TV service from the South (Ch. 1), the East (Ch. 2) and the NW (Ch. 3), each of which serves a substantial number of people. It is because of this threefold service that there is no requirement for a national translator in Toowoomba itself.

The Brisbane viewing area extends to the eastern parts of Toowoomba, with considerable audiences for Chs. 0, 7 and 9.

Ch. 11 is not usable as a replacement for Ch. 5 because of oscillator radiation from TV receivers tuned to Ch. 7, leaving Ch. 4 as the only possibility; this would operate co-channelwith the same programme transmitted from SDQ Southern Downs (Warwick). If used, this would destroy reception by mutual interference in a broad band of country between Toowoomba and Warwick - some of which however would be filled-in by a long-distance reception of the same programme from DDQ Darling Downs (Mt. Mowbillan).

12.4 Effect on TV and FM coverage in Newcastle (and Sydney area)

Present TV channels - 3 (Commercial) 5 (National)

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Channels in use in adjacent areas 1, 2, 4, 5A, 7, 8, 9, 10

Channels 6 and 11 cannot be used because of TV receiver oscillator radiation into Ch. 10 and from Ch. 7 receivers respectively. This leaves Ch. 0 as the only possibility. However the use of Ch. 0 would impose other restrictions on FM service than those resulting in Table IX, reducing the available number of FM channels to -

in Sydney 7

in Newcastle 8

A solution more favourable for FM service, with no additional restrictions, might be to use Ch. 1 in Newcastle in place of Ch. 5, at the expense of closing down the Ch. 1 National transmitter at Manning River (Taree). Since the frequency of Coffs Harbour commercial TV station NRN has been changed from Ch. 10 to 11, it would be now possible to put Manning River on Ch. 6. This would result in somewhat poorer TV coverage and increased ghosting in the mountainous areas along the North Coast. In addition there would be adjacent channel interference between National TV services to Ch. 1 and Ch. 2 in the overlap area Newcastle/Sydney (Gosford).

In either case a new transmitting tower would be required to support the lower-frequency aerial.

12.5 Effect on TV coverage in Dubbo Area (Central Western Slopes, N.S.W.)

Present TV Channels - 5 (National), 6 (Commercial)

Channels in use in adjacent areas - 1, 7, 8, 9

Channels below 100 MHz (0, 1, 2, 3, 4) are not usable in the area because of local radio astronomy installations.

Channels 7, 8, 9 are in use in adjacent areas, being Chs. 10 and 11. Ch. 10 cannot be used because of oscillator radiation from TV receivers tuned to Ch. 6.

Ch. 11 is thus the only possibility. It will be subject to interference in the overlap area between Dubbo and Upper Namoi (Narrabri) due to oscillator radiation from TV receivers tuned to Ch. 7 ABUN.

12.6 Effect on TV coverage in Deniliquin

(removal of Ch. 5 necessary to permit FM service in Shepparton and Albury/Upper Murray areas).

At Deniliquin a Ch. 5 National translator is under construction to relay the N.S.W. service (including schools programmes) from ABGN Griffith.

Ch. 0 has been allocated for a probable Deniliquin commercial translator.

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Channels in use in the adjacent areas are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

Ch. 11 has been allocated for a National translator under construction at Jerilderie.

Ch. 10 cannot be used because of oscillator radiation from TV receivers in Deniliquin tuned for fringe reception of Ch. 6 Shepparton.

Ch. 5A cannot be used in areas receiving Ch. 6.

Ch. 4 (in use at AMV Albury/Upper Murray) provides the weakest of the interfering signals, and is therefore the best of the remaining Channels to replace Ch. 5. Coverage of the Deniliquin station will be limited, however, for much of the time by co-channel interference from Albury to a radius of typically, 16 miles instead of 27 miles for Ch. 5.

12.7. Effect on TV coverage in Bunbury, W.A.

Present channels 3 (Commercial) 5 (National)

Channels in use in adjacent areas 2, 6, 7, 8, 9.

As might be expected from its location, there is little difficulty with channels in this case; Channel 1 was allocated earlier as a possible third channel for Bunbury; a new transmitting tower would be required to support the lower-frequency aerial.

12.8 Summary of FM Channel availability in 39 main television areas

	Areas with 10 or more FM channels	Areas with 6 - 10 FM channels	Areas with fewer than 6 FM channels.
With existing TV allocations	16 (18% popn.)	12 (39% popn.)	11 (43% popn.)
With all Ch. 5 TV services removed	25 (26% popn.)	12 (71% popn.)	2 (3% popn.)

Technical Services Division

Report No. 34

Title: The Sharing of Television Channels

Addendum of January 1974

1. Further experimental work has been carried out since August 1973:

   (a) to determine the susceptibility of a wider range of Australian monochrome TV receivers to harmonic or sub-harmonic interference;

   (b) to examine the adjacent-channel selectivity of a recent sample of imported FM receivers.

2. The results of this work have been applied to a recalculation of the number of FM stations which could be established in Sydney and Melbourne, with certain TV channels withdrawn from service.

3. Although some receivers were found less sensitive to harmonic interference than the 1971 sample, this has little effect on the total number of high-power FM stations usable in either area, though it does reduce restrictions on siting, and increases the number of low-power FM stations usable. Table I lists the measured harmonic interference characteristics of the TV receivers tested.

Table I

Harmonic Interference from FM to TV

TV Channel being viewed	Interference from FM stations between High Power FM (90 dbu)	Low Power FM (80 dbu)
Ch. 0	91.2-99 MHz	91.5-95 MHz
Ch. 6	87-89.5	87.5-89
Ch. 7	90.5-93	91-92.5
Ch. 9	97.5-100	98-99.5
Ch.10	104-106.5	104.5-106

Harmonic interference characteristics of Australian TV receivers

Receivers tested			
	No. 1	National Model TP 200	- 1972
	No. 2	Astor F361/A	c. 1965
	No. 3	Philips 11516	c. 1967
	No. 4	HMV V6 - 9D	c. 1966
	No. 5	Pye 23A - 8B	- 1972

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4. Adjacent channel selectivity of portable VHF FM receivers

Five monophonic portable FM receivers of Japanese origin, collected at random, were tested for their separation of two programme-modulated monophonic FM transmissions, separated successively by 800 kHz, 600 kHz, 400 kHz and 200 kHz.

With randomly-sited stations, very large ratios of unwanted to wanted signals can occur. With co-sited stations, such ratios at the receiver input should not usually exceed 6 db, and rarely 12 db.

Laboratory Report No. 19 gives the results of tests with these ratios, the stronger signal being maintained near 80 dbu, to be expected within a few miles of FM transmitters.

Summary of Results

Most receivers had lopsided selectivity curves. Three of the five receivers had insufficient selectivity to reject an interfering signal spaced 400 kHz. All rejected signals spaced 600 kHz, which would therefore appear suitable for spacing co-sited transmitters.

It is concluded that for random siting, where much larger ratios may occur, the U.S. planning figure of 800 kHz minimum separation remains valid.

5. Table II lists the number of available VHF FM channels in Sydney, under differing restrictions of TV service.

6. Table III lists the corresponding number in Melbourne.

Table II

Available VHF FM channels in Sydney *

	High Power FM Random Sited	Additional High Power FM co-sited with TV	Additional Low Power FM
With all existing TV stations	2	0	16
With Ch 5 (Newcastle) closed down	7	2	9
With Ch 4 (Wollongong) and Ch 5 (Newcastle) closed down	11	2	5
With Ch 3 (Newcastle) Ch 4 (Wollongong) and Ch 5 (Newcastle) closed down	15	3	0

Available VHF FM channels in Melbourne *

	High Power FM	Low Power FM
With all existing stations	8	8
With Ch 4 (Latrobe Valley) closed down - No difference	8	8
With Ch 3 (Ballarat) and Ch 3 (Shepparton) closed down	12	4

* Minor amendments and extensions of the information presented in Table IX of Report No. 34 in the light of the further experimental work.