EXECUTIVE SUMMARY OF THE SECOND DTT FREQUENCY PLANNING STUDY

The Office of the Telecommunications Authority (OFTA) has appointed the PA Consulting Group (PA) to conduct a second study on the digital terrestrial television (DTT) frequency plan for Hong Kong and the neighbouring Guangdong areas during August to December 2001. This paper gives a brief summary of the proposed DTT frequency plan for Hong Kong based on the findings and recommendations of PA.

1. BACKGROUND

Digital Terrestrial Television (DTT) is an advanced technology, which employs digital, rather than analogue, techniques for the broadcasting of television services. Programme content flexibility and specific inherent technical advantages put DTT in a significant position to supersede current analogue systems. International standards are in place for DTT, and these are undergoing refinement as the base of understanding and experience with the technology continue to develop.

In August 1999, OFTA appointed PA (hereafter referred to as "the consultant") to conduct a study on frequency planning for introducing DTT into Hong Kong. This resulted in the production of a preliminary DTT frequency plan for Hong Kong and a recommended approach for the migration from analogue to digital services. The results were also published in the Consultation Paper on Digital Terrestrial Broadcasting in Hong Kong issued by the Information Technology and Broadcasting Bureau (ITBB) in December 2000.

Subsequently, issues have arisen during frequency co-ordination between OFTA and the Mainland broadcasting authority, the State Administration of Radio, Film and Television (SARFT), that require the frequency plans to be revised.

In August 2001, OFTA appointed the consultant to perform a second frequency planning study with the objective of developing revised options for introducing DTT into Hong Kong and the surrounding Guangdong region. The study was to account for the latest developments as well as to address the critical interdependencies between the requirements of each territory.

This report documents the findings of the second study and presents recommendations for future DTT frequency planning and the migration process.

2. STUDY METHODOLOGY

The study involved the analysis of the latest analogue frequency plans for Hong Kong, Guangdong and Macau, in order to identify the potential frequencies where DTT channels could be accommodated. Initially, this involved a comprehensive audit of transmitter data so as to include updated information and produce a single harmonised database.

The study made use of a computer based field strength prediction and interference modelling tool, which had been developed by the consultant for the previous study. Significant improvements were applied to the modelling tool to incorporate an increased number of prediction methods and some additional planning features. The tool used digital terrain map data of Hong Kong and the neighbouring regions, in conjunction with the transmitter database information, to perform the field strength prediction and interference analysis. The

optimum prediction model was determined by validating the model results against practical field measurements made by both OFTA and SARFT.

The outputs from this initial part of the study were the channels, power levels and antenna radiation patterns required at each transmitting station in order to deliver DTT coverage.

Having determined which channels were available for DTT, options were developed for the allocation of DTT channels between Hong Kong and Guangdong. These options identified specific issues and changes required to existing analogue stations in order to enable implementation.

Finally, a migration strategy was devised for phasing the introduction of digital services whilst maintaining continuity of service with the existing analogue transmissions.

Other issues surrounding the introduction of DTT were also considered. These included the methodology for future frequency planning and coordination between the authorities and the implications for mobile reception and high definition television (HDTV) services.

3. FREQUENCY PLANNING MODEL

The previous consultancy study investigated the issues surrounding the various DTT standards available. Based on those findings and in accordance with the proposals in the consultation paper issued by ITBB in December 2000, this study has used the frequency planning parameters of the DVB-T 8 MHz transmission standard as baseline reference in making the analysis and planning. It is understood that the Hong Kong DTT standard remains an issue to be decided. However, the frequency planning results of this study would be applicable to the implementation of any DTT transmission standard which is compatible with the current planning model.

Major technical assumptions are summarised as follows.

- Minimum signal strength required for reception – After taking assumptions on channel bandwidth, data rate, minimum C/N ratio, receiver filtering and noise figure, a target minimum median field strength requirement of 47dBμV/m (covering 50% of locations) has been taken for the purposes of this study. Since the planning was done to ensure that 95% of locations within an intended coverage can achieve this target, the actual minimum field strength used in the planning model is 57 dBμV/m.

- Modulation Options – The study concludes that DVB-T 8k mode must be used to make SFN operation feasible. A guard interval of no less than 1/8 must be used to avoid unacceptable interference. To ensure a low risk, practically implementable solution, this study applies planning parameters based on a 1/4 guard interval.

- Protection ratios – Protection ratios are defined for co-channel and adjacent channel (upper adjacent N+1 and lower adjacent N-1) interference. For DVB-T, no protection ratios are defined in the ITU standards for the image channel, and so this is not considered in the study. A summary of protection ratio parameters used in this study is presented in Tables 1 and 2 in accordance with the Recommendation ITU-R BT.1368. The application of these protection ratios in the current planning approach has included margins to account for location variability of both desired and undesired signals (see also paragraph 6 of this summary).

- Field Strength Prediction Model – A number of widely recognised propagation models for field strength prediction were studied and their prediction results were compared with measurement results in order to choose the most appropriate model for frequency

planning purposes. The conclusion of this analysis was that the General Diffraction method described in Recommendation ITU-R P.526 was most accurate and robust against a number of scenarios of varying frequency and path length. Therefore the ITU-R P.526 General Diffraction method was used for all analysis predictions.

Interferer	n-2 channel	n-1 channel	n (co-channel)	n+1 channel	n+2 channel	Image channel
DVB-T	not specified	-30 dB	20 dB	-30 dB	not specified	not specified
PAL B	not specified	-35 dB	3 dB	-38 dB	not specified	not specified
PAL I	not specified	-34 dB	3 dB	-38 dB	not specified	not specified

Table 1 Protection Ratios for wanted DTT signal (DVB-T 8MHz, 64-QAM, 2/3 code rate)

Interferer	n-2 channel	n-1 channel	n (co-channel)	n+1 channel	n+2 channel	Image channel
DVB-T	not specified	-5 dB	40 dB	-5 dB	not specified	-15 dB

Table 2 Protection Ratios for wanted analogue signal (625-line PAL)

4. FREQUENCY PLAN CONCLUSIONS

4.1 General

As a result of the study, frequency plans have been developed which can accommodate a wide range of policy options regarding new programme channels, new broadcasters and advanced services.

The main factors that determine the feasibility of DTT on a channel are:

- Interference incoming from the existing analogue television services – a key issue for determining the suitability of potential channels.
- DTT not causing interference to the existing analogue services in Hong Kong and Guangdong – particularly significant if DTT power levels are set relatively high in order to serve a large area.
- Delivery of minimum field strength required for DTT reception (typically a factor of 10 to 100 times less than that required for analogue) – not the main issue since the required field strengths are generally determined by the ambient interference levels on the channel.

Based on considerations of identifying the maximum number of DTT channels under the existing frequency spectrum resource for coverage of Hong Kong and Guangdong, the key conclusions of the study are:

- 4 SFN or near-SFN multiplexes can be found for Hong Kong and Guangdong respectively.
- It is possible to achieve 1 MFN multiplex in both territories while protecting the assigned analogue stations/channels, making a total of 5 multiplexes each.

For all SFN options, a number of small Hong Kong transposers must be switched off or re-tuned and changes must be made to existing channel allocations in Guangdong. In addition, the use of channels 35 and 37 may affect the radio-frequency (RF) output of some video cassette recorders (VCRs) in Hong Kong and corresponding changes may be required.

4.2 Proposed DTT Frequency Plan

Table 3 summarises the frequency plan findings, including the effective radiated power (ERP) required at the principal television stations in Hong Kong for implementing DTT. Polarisation of DTT channels is taken to be the same as the existing analogue channels at the stations in order to avoid the need for re-orientation of aerials. The existing analogue antenna patterns for the stations are also assumed to be maintained for DTT implementation, except for the case of Castle Peak station to which some changes are made mainly to minimise outgoing interference to the neighbouring regions and some potential interference to analogue service in Hong Kong. Figure 1 shows the proposed Castle Peak antenna pattern.

Further study is required to work out the detailed frequency plan including the most suitable frequencies for the smaller television stations. This might be carried out by the DTT multiplex operators and/or the regulator.

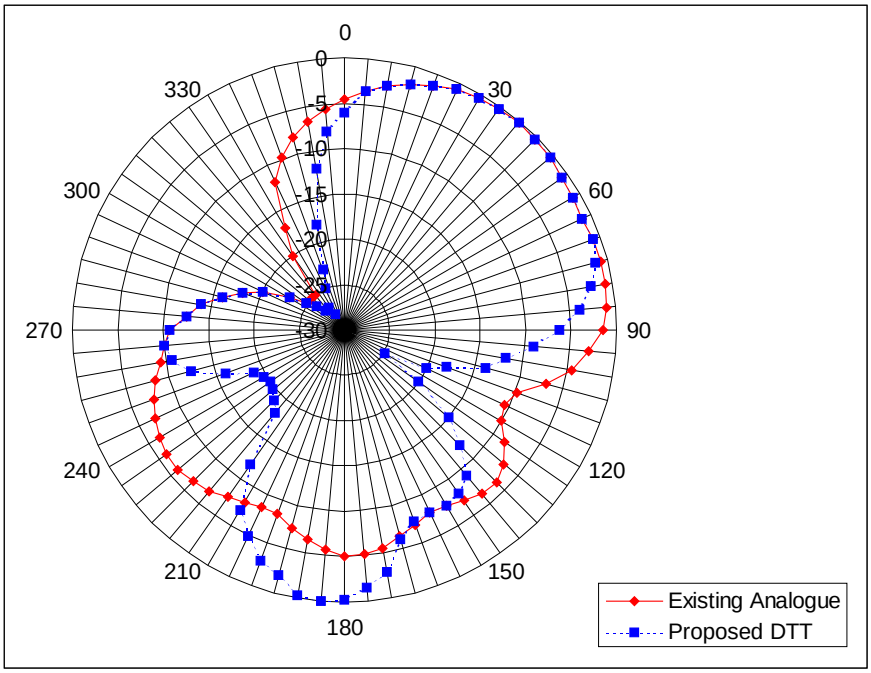

Figure 1 Proposed antenna pattern for Castle Peak DTT station

Channel	Temple Hill	Castle Peak	Kowloon Peak	Golden Hill	Cloudy Hill	Lamma Island	Other Stations (Note 2)
21							
22	316W – 1kW			31W – 100W		47W – 150W	
23							
24	316W – 1kW			31W – 100 W		47W – 150W	
25							
26							
27							
28						150W	
29							
30			31W – 316W		1 kW	47W – 150W	
31							
32			316W				
33		10W – 100W			31W – 1kW		
34							
35	100W – 1kW	31W – 316W	10W – 316W	10W – 100W	31W – 1kW	47W – 150W	-10 dB
36				100W	1kW		
37	100W – 1kW	31W – 316 W	10W – 316W	10W – 100W	31W – 1kW	47W – 150W	-10 dB
38							
39		10W – 100W			31W – 1kW		
40				100W	1kW		
41							
42							
43		10W – 100W					
44							
45							
46							
47	316W – 1kW	1kW	31W – 316W	31W – 100W	1kW	47W – 150W	-10 dB
48							
49							
50							
51							
52							
53							
54							
55							
56							
57							
58				100W			
59							
60							
61							
62	316W – 1kW	100W – 1 kW	31W – 316W	10W – 100W	1kW	47W – 150W	-10 dB

Available DTT channels in Hong Kong

Additional DTT channels which may be available subject to further study.

Note 1: *The above figures show the effective radiated power (ERP) acceptable for DTT transmission on the concerned channel to achieve the same coverage as analogue service on the relevant station without causing interference in Hong Kong and the neighbouring areas. The actual power values may be determined during detailed planning and implementation.*

Note 2: *The available DTT channels for other smaller stations are subject to further study in the future. The power for these smaller DTT stations are assumed to be 10dB less compared with the corresponding analogue stations*

Table 3 Frequency Channels for DTT Stations and the Required ERP

Figure 2 shows the proposed frequency plans for the principal DTT stations of Hong Kong.

Hong Kong	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
Temple Hill		E													A		B										C															D
Castle Peak															A		B						E				C															D
Kowloon Peak										E					A		B										C															D
Golden Hill															A		B			E							C															D
Cloudy Hill										E					A		B										C															D
Lamma Island										E					A		B										C															D

Key to Hong Kong Plan:

SFN : A = HK Mux A B = HK Mux B C = HK Mux C D = HK Mux D

MFN : E = HK Mux E = Also have potential

Figure 2 Proposed DTT Frequency Plan for the main stations

It is found that the six principal television stations in Hong Kong (having an ERP of 1kW or more for the analogue channels) provide the majority of the required DTT coverage. The combined coverage of the six stations, covering the principal populated areas is shown in Figure 3.

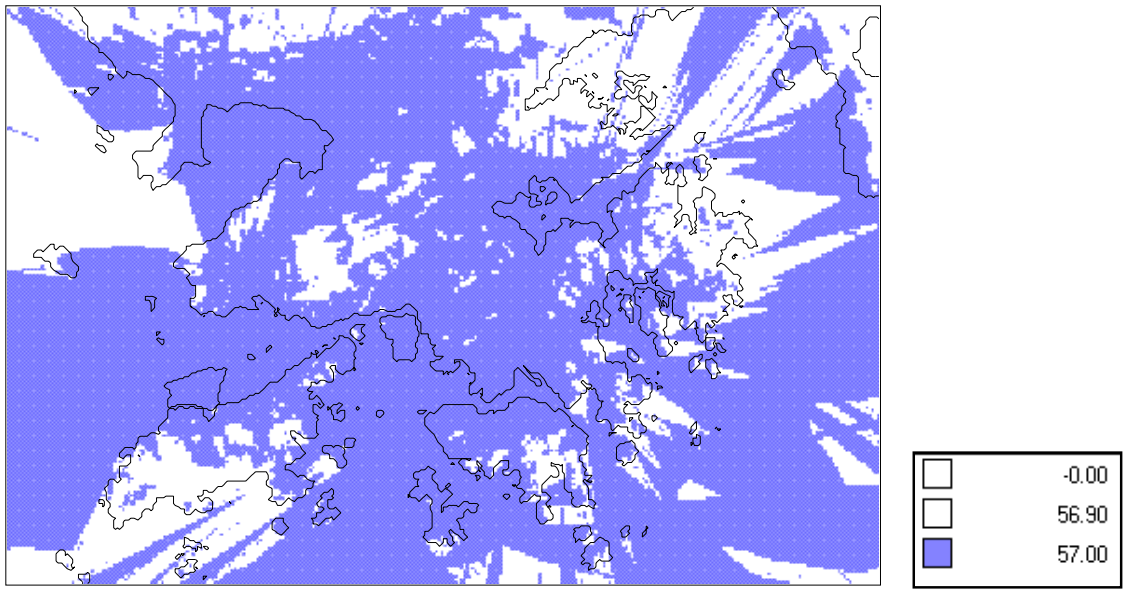

Figure 3 DTT coverage (57dBμV/m contour) achieved using the 6 major Hong Kong stations using the proposed ERP levels

4.3 Fill-in Stations

Some smaller stations are required to fill in the coverage gaps caused by the complex terrain of Hong Kong. To deliver full coverage, it has been firmly identified that a minimum of 23 stations (including the 6 principal stations) are required. In addition, a further six minor sites may be needed, subject to detailed local circumstances, to overcome the problem of shadowing by high-rise buildings in their serving areas. The list of fill-in stations identified by the current study is given in Table 4. Additional fill-in stations may be required and it may be worked out in future when the major stations are in service.

Fill-in Stations Required	Additional Fill-in Stations which may be required
1. Brick Hill 2. Chai Wan 3. Chiu Keng Wan Shan 4. Hill 141, Tai Lam Chung 5. Hill 275 6. Hill 297, Yuen Long 7. Hong Lok Yuen 8. Pottinger Peak 9. Robin Nest 10. Shek Kong 11. Sheung Yeung Shan 12. Stanley 13. Tai O 14. Tai Po Tsai 15. Ying Pun 16. Hill 374 17. Cheung Chau	18. Beacon Hill 19. Mount Nichoson 20. Piper Hill 21. Tsing Yi 22. Tseung Kwan O Village 23. Ma Wan

Table 4 Fill-in Stations Required for DTT

5. MIGRATION PLANNING

Transition from the 4 existing analogue television programmes in Hong Kong to the eventual switch-off of analogue services is complex, and due consideration is required of the trade-off between the speed of introducing DTT and the expense or inconvenience of converting viewers.

The proposed frequency plan enables 3 SFNs (channels 35, 37 and 62) to be introduced in Hong Kong at launch without performing frequency re-tunings of the existing analogue stations, subject to appropriate action being taken regarding the VCR issue to ensure that the reception of DTT channels 35 and 37 will not be affected by the RF output of VCRs. At the same time, a number of Hong Kong transposers must be re-tuned or switched off to provide more multiplexes (SFN channel 47 and one MFN multiplex). A list of analogue transposers in Hong Kong which may need to be re-tuned or switched-off for DTT implementation is given in Table 5.

Channels	Analogue Transposers
30	Tseung Kwan O Village, Tui Min Hoi Sai Kung
41	Sun Yuen Long Centre, Ma Wan
43	Yuen Long Town Centre, Lam Tei
47	Sham Tseng
50	Robin's Nest, Hill 141 Tai Lam Chung, Yuen Long Hill 297, Hill 275
52	Robin's Nest, Hill 141 Tai Lam Chung, Yuen Long Hill 297
60	Ma Wan

Table 5 Analogue Transposers which may be re-tuned / switched-off

6. CO-ORDINATION METHODOLOGY

An in-depth investigation into the treatment of planning parameters and frequency coordination approach was also undertaken during the study.

It was revealed that the methods used for the planning of analogue networks were not directly applicable to the DTT case, mainly due to the fact of the abrupt failure performance of DTT signals. In defining DTT coverage, it is necessary to ensure that the minimum required signal level and associated protection is delivered at a high percentage of locations. This is achieved by the inclusion of 'margins' relating to the variability with location of both desired and undesired signals.

Having ascertained the appropriate minimum field strength targets and margin values, a statistical approach has been proposed for the combination of margins in order to deliver specified levels of availability. This is in accordance with the recommendations contained within internationally recognised literature (eg. ETSI standards and the European Chester Agreement).

The required margins are directly related to the target percentage of covered locations, which is a policy decision. For example, a margin of 18dB is required to achieve 95% location coverage, while a reduced margin of 6dB achieves coverage at 70% of locations.

During frequency coordination, the suitability of proposed frequency assignments may then be determined by applying the predicted field strengths of desired and undesired signals in conjunction with combined margins at the specified 'test points' associated with the coverage of the transmitter under review.

7. ADVANCED SERVICES

7.1 HDTV – High Definition Television

HDTV provides higher picture quality compared with standard definition with an increased data rate required per programme channel. Using the reference planning parameters adopted for the main analysis, each DTT channel can provide 4 to 6 SDTV (Standard Definition Television) programmes (depending on programme content and quality requirements), or only 1 HDTV programme to fixed receiving antennas.

It should be pointed out that the feasibility of HDTV is not linked to any specific frequency plan option, but is applicable to any of the proposed DTT multiplex channels.

Allowing for the need for simulcast of the 4 existing services, at least 2 multiplexes would be required to allow introduction of any HDTV services. However, due to the limited number of channels available for DTT initially, the consultant considers this to be inefficient use of the scarce frequency resource. Therefore, it is recommended that HDTV should not be mandated at the launch or during the early phases of DTT roll-out. Implementation of HDTV should be left as a commercial decision for a multiplex licencee.

7.2 Mobile Reception

Mobile reception is considered to be a desirable feature for the future development of DTT in Hong Kong. As for HDTV, the feasibility of mobile reception is not linked to the specific frequency plan options.

From technical point of view, due to multipath fading caused by motion which results in large fluctuations of the received signal level, and the inferior performance of the mobile receiving antenna when compared with a fixed installation, much higher signal strength is needed for satisfactory reception at a mobile station than at a fixed station.

Various technical solutions are feasible to mitigate this and are currently under research within the industry. One solution that would have a significant impact on the network implementation and cost would be the installation of additional transmitter sites, in particular to serve urban areas. In any case, this would not have an impact on frequency planning if the preferred SFN approach is used to deliver the mobile service.

Provision of mobile reception is driven less by frequency planning than by policy objectives and it will be a number of years before cost effective solutions to the challenges of mobile reception are available. Therefore the consultant recommends that OFTA does not mandate implementation of mobile services, but rather leaves this as a commercial decision for the multiplex licencees.

8. NEXT STEPS

This study is part of an overall programme being conducted by OFTA for the introduction of DTT to Hong Kong. The following presents a summary of the recommendations and next steps which should be taken by OFTA in coordination with the Mainland authorities.

8.1 Frequency Plan Options

OFTA should review the findings from this study and consider taking further actions regarding the following:

- Confirm the availability of channels for re-tuning of all those analogue transposers that must be modified.
- The broadcasters should be consulted to determine the practicality of the proposed antenna patterns for DTT (eg. Castle Peak station). Equipment suppliers should be approached to determine availability of equipment for the recommended ERP and antenna patterns.
- Trade-off analysis must be performed to develop an optimum design for distributing the digital signals to the transposers.

- Work is needed to define the issues surrounding other mobile and fixed (non-television) services operating in frequency spectrum adjacent to DTT in Hong Kong and Guangdong.

8.2 Transition Strategy

The transition strategy should be reviewed in conjunction with other work linked to the introduction of DTT. In particular, policy objectives should be refined based on the findings of the study in areas such as:

- Introduction of new services (mobile reception, HDTV)
- New operators and allocation of programmes to multiplexes
- Restrictions on phasing out analogue services (eg. % population covered by digital before switch-off can occur).

An assessment should be made on the number of viewers who will be affected by the switch-off of those small transposers operating on the channels proposed for DTT. Cost trade-offs should then be performed including aspects such as re-tuning of these transposers (or viewers) to other stations or channels, funding and installing DTT set top boxes, cost of information campaigns and revenue from new services or operators.

OFTA should conduct some research into the VCR question in order to assess the potential difficulty of freeing up channels 35 and 37 for SFN multiplexes.

The exact ordering of the proposed transition plan can be optimised according to policy objectives.

9. CONCLUSIONS

Planning for DTT within an existing analogue environment is a complex process. The congested nature of the existing frequency spectrum and the numerous interdependent factors present significant challenges which can be overcome by means of detailed analysis using advanced computer processing techniques and liaison between the interested parties.

The study has developed frequency plan options and implementation strategies which take into account the various parameters and scenarios required by both SARFT and OFTA.

Finally, an approach for accurate coverage prediction and frequency coordination appropriate to DTT technology has been established. These methods can be applied to future detailed technical planning as necessary to facilitate implementation.

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