Spectrum Policy Review

Final Report

Ovum

Indepen

Aegis

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Executive summary

Scope

The Commerce, Industry and Technology Bureau (CITB) commissioned this Spectrum Policy Review by Ovum in partnership with Aegis and Indepen to examine current spectrum policy and management in Hong Kong with a view to:

- providing greater flexibility and transparency in spectrum access
- promoting the timely introduction of new technologies and services in frequency bands that are currently used and in new bands and thereby maximise the economic benefits to the community from use of the spectrum
- strengthening Hong Kong's strategic position by facilitating the introduction of key new wireless services while at the same time ensuring the availability of sufficient spectrum for essential public services.
- continuing to ensure that Hong Kong's regional and international spectrum obligations are fulfilled.

The tasks we were asked to undertake are as follows

1. Analysis of the future shape of radiocommunications
2. Assessment of the future supply and demand for spectrum
3. Assessment of whether spectrum trading should be introduced and, if so, the changes needed to implement such a policy
4. Assessment of the feasibility of introducing spectrum liberalisation in Hong Kong in the next ten years having regard to the proximity of Mainland China
5. Evaluation of requirements for spectrum by essential public services and the suitability of trading and liberalisation and other market mechanisms for these services.

In responding to these requirements the study team has:

- obtained the views of a large number of spectrum users through a programme of interviews
- discussed current use of the spectrum and spectrum management practices with OFTA
- analysed future technology and market developments and their implications for spectrum demand and supply and spectrum policy.
- reviewed international experience in adopting new approaches to spectrum management.
- proposed a number of elements for a revised spectrum strategy
- outlined an implementation plan relating to spectrum release and the introduction of policy and management changes.

Context

We start from the position that it is important to get spectrum planning and management right in order to support wider economic and social goals for Hong Kong. Spectrum is a critical input for future innovation and growth in the communications sector and there is now overwhelming evidence to show that communications, as a part of the ICT sector, is one of the key drivers of productivity and hence long term economic growth.

The nature and pace of future technology and market development is very uncertain and it is this situation that command and control mechanisms cope with least well – because the regulator does not have full information required to make well founded decisions, incorporating issues such as market risk. In addition, an increasing proportion of the spectrum is being allocated to commercial use and so is potentially amenable to market forces.

These issues are affecting all countries with advanced communications markets. A common set of policy instruments for addressing them is emerging in Europe and North America, and to a lesser degree in some countries in Asia. These policy instruments involve greater transparency in decision making and moves from the command and control model to a more market based model of spectrum management.

Spectrum management in Hong Kong is largely based on a command and control approach in which the regulator makes most decisions concerning the allocation and assignment of spectrum. Auctions have started to be used and the regulator has sought to use a “market led” approach in determining technology choices. However, there is scope to extend the use of market based approaches to spectrum management where beneficial.

Findings

As a result of the work undertaken during the review it has been found that there is a need for a more consistent and explicit set of policy goals and principles for making transparent and predictable policy decisions. In addition more information should be provided to industry on spectrum policy intentions and spectrum use so that users can make informed investment decisions.

Currently there are competing demands for spectrum in bands allocated to trunk radio, fixed links, public mobile and broadcasting services. In addition, the impact of future technologies is already being seen with a requirement to provide suitable spectrum for Broadband Wireless Access, HDTV and mobile TV. This requirement conflicts with existing spectrum users.

In the more distant future applications relating to broadband mobility will place greater demands on 500 MHz to 5 GHz. More sophisticated technologies, such as cognitive radio, will require a more flexible spectrum management framework including an appropriate definition of spectrum rights.

Spectrum policy in Hong Kong should involve an increased use of market based approaches, including the application of secondary trading and liberalisation in

selected bands and the application of AIP[1] in congested bands where other market approaches may not be feasible.

The prospect of continuing increases in demand for spectrum from government users for fixed and mobile broadband applications suggests that there will be a need in future for mechanisms to ration demand for spectrum from the public sector. AIP is likely to be a more practical alternative than trading (given the continued requirement to supply government services) but its effectiveness depends on budgetary arrangements for government departments. Administrative review should also be used to improve efficiency of spectrum use in the public sector.

In the case of use of spectrum by broadcasters, efficiency considerations mainly concern the future allocation of the UHF spectrum and here interactions with broadcasting policy need to be taken into account and ultimately a decision based on qualitative factors will be made. Policy trade-offs in this area could be made more transparent by assessing the potential value of services forgone as a result of spectrum use by broadcasting.

Recommendations

Hong Kong's future spectrum strategy should comprise:

- A set of policy objectives and supporting principles
- A spectrum strategy including a spectrum release plan
- A set of specific regulatory tools for managing the spectrum, including administrative and market-based tools

In support of this strategy we make the following recommendations. The Recommendations are numbered by the Chapter in which they appear. An indicative timetable for implementing these recommendations is given in Chapter 7.

Recommendation 4.1: The objectives for spectrum management in Hong Kong should be as follows

- To facilitate the most economically and socially efficient[2] use of radio spectrum with a view to attaining maximum benefit for the community
- To achieve technically efficient use of radio spectrum to facilitate the introduction of advanced and innovative communications services and strengthen Hong Kong's position as a telecommunications and broadcasting hub
- To fulfil Hong Kong's regional and international obligations relating to the use of spectrum
- To support Hong Kong's strategic position as a world city and the gateway between Mainland China and the world by facilitating the provision of key services in Hong Kong which are deployed or will be deployed, globally or in Mainland China

[1] Administered Incentive Pricing

[2] By this we mean the promotion of economic and social welfare.

- To ensure that necessary spectrum is reserved for essential public services

Recommendation 4.2: The Government should publish its intention to adopt a market-based approach to spectrum management where there are competing demands unless there are good public policy reasons to do otherwise. Policy priorities that the government wishes the regulator to take into account should be given in policy decisions by the Executive Council.

Recommendation 4.3: In general Hong Kong should adopt international allocations for licence exempt services. If, exceptionally, national allocations for licence exempt use are considered, then the following factors should be taken into account when making such decisions

- The likelihood of the band being congested.
- Options for light licensing regimes (e.g. registration) instead of licence exempt use if congestion is thought likely to occur.
- Users' service quality requirements together with the likelihood of congestion.
- The nature of possible technical restrictions on licence exempt use that could address any future congestion issues.
- Relevant public policy objectives.

Recommendation 4.4: In the longer term, and in association with the introduction of liberalisation and trading, consideration should be given to how best to define incumbent spectrum users' rights in relation to use of the band they occupy by underlay and overlay applications. There is no agreed method for doing this so international developments should be monitored by the regulator.

Recommendation 4.5: In order to achieve an appropriate balance between the allocation of spectrum to government and non-government use, we recommend that

- Government requirements for additional spectrum should be appraised against a set of objective criteria and decisions (including reasons) published subject to any limitations caused by public interest issues
- The possibility of sharing between government and non-government users should be explored in cases where non-government users would like access to spectrum allocated to government use

See also Recommendation 6.1 regarding periodic reviews.

Recommendation 4.6: The regulator should publish a spectrum strategy document. This could include a statement of policy principles, discussion of how the principles will be applied in practice, and a forward look at important spectrum allocation and release decisions. The spectrum release plan should be developed based on this strategy.

Recommendation 4.7: The regulator should publish a spectrum release plan consistent with its spectrum strategy. The spectrum release plan represents the regulator's intentions in respect of spectrum. It is a not legally binding commitment, rather it should change in response to market and technology developments.

The plan should have the following elements

- bands to be released for licensed and licence exempt uses and reasons
- the timing of spectrum release and any dependencies with other events (e.g. refarming, ITU decisions, Mainland China decisions)
- method of release – auction, beauty contest etc.
- an indication of whether spectrum will be tradeable/liberalised or restricted to specific uses and the reasons for this
- an indication of the regulator's initial views on packaging of spectrum
- any restrictions on the allocated use of the spectrum that may arise from policy decisions or international regulation
- a discussion of any matters relevant to the period beyond the plan.

Recommendation 4.8: We recommend that the spectrum release plan covers a period of three years. The plan should be reviewed and consulted on with stakeholders at least every three years.

Recommendation 4.9: The regulator should consider the potential benefits of making a number of fixed bands above 23 GHz, for example, available for a wider range of users to apply for on a first come first served basis at a nominated reserve price. The regulator would publish the available spectrum on its website and if an organisation applies for a particular frequency or block of frequencies then the regulator would ask for any competing bids. The approach would be analogous to that used for land in Hong Kong.

Recommendation 4.10: Refarming decisions should be made by the regulator on the basis of an appraisal of the potential costs and benefits of different refarming options, including a "do nothing" option.

Recommendation 4.11: In order to future proof the spectrum management regime in Hong Kong we recommend that the government considers the creation of generic radio frequency licences separate from service/network licences as a medium term goal. Transitional arrangements that would be feasible under existing legislation should be implemented in the short term.

Recommendation 4.12: There should be an explicit policy on minimum notice periods for frequency variation and/or withdrawal. We recommend the following policy

- For spectrum use associated with long duration service licences (10 years and more), decisions concerning frequency variation or withdrawal should be made at least 3 years before licence expiry. This means consultation on this issue will need to start 4 years in advance of licence expiry.
- Annual licences should be converted to a five year duration and licensees should normally be given at least 2 years notice of frequency variation or withdrawal.

Recommendation 4.13: The regulator should publish the conditions under which frequencies (and in future spectrum licences) might be varied or withdrawn before the end of their term. These conditions should be minimal and should include

- Reasons of public interest
- Compliance with government policy, as articulated in a direction from the Secretary
- Compliance with international and regional obligations or treaties

- Interference to other legitimate uses of spectrum

We have suggested that there would be benefits (in terms of promoting trading) from the regulator publishing the conditions under which frequencies (and in future spectrum licences) might be varied or withdrawn when their term expires. However, we recognise that the government may wish to retain the discretion to reallocate/reassign spectrum on licence expiry. This policy choice is a matter for the Hong Kong government to decide.

Recommendation 4.14: The Government should consider whether the spectrum licensing framework should be extended to users who are currently not licensed, including government users and receive only services, in order to enable formal spectrum rights to be established under a spectrum licence. In respect of government users it might be considered appropriate to establish spectrum rights using administrative means other than licensing.

Recommendation 5.1: Auctions should continue to be the default assignment mechanism in circumstances where there are competing demands for spectrum and should be designed according to the circumstances prevailing at the time. Administrative assignment or beauty contests should only be used if there are good cost or policy reasons for such an approach.

Recommendation 5.2: Principles for the application of AIP (or SUFs) should be published. These should include

- AIP is not applied in bands that are auctioned, except in the case where an auctioned licence is renewed
- AIP is only applied where there are competing uses/users for a band (i.e. where bands are congested)
- AIP should be applied (where practical) to all licensees (primary or secondary) whose spectrum use denies access to other potential users in congested bands where spectrum has not been auctioned.
- AIP should be set to reflect the opportunity cost of the spectrum where this may be calculated using
    - the least cost alternative method and/or
    - relevant current market benchmarks, for example, current auction payments for similar spectrum either in Hong Kong or elsewhere. (Lump sum auction payments would need to be converted to annual fees using a suitable industry discount rate.)

Recommendation 5.3: AIP should be applied to congested UHF PMR bands and fixed link bands, such as those below 16 GHz, so as to promote more efficient spectrum use.

Recommendation 5.4: If AIP is implemented there should be a 3-5 year transition to the new higher level of fees. The level of prices should be reviewed every five years.

Recommendation 5.5: Spectrum trading should be introduced in Hong Kong. Initially, this could be done with respect to spectrum auctioned under the spectrum release plan and then extended to other bands once implementation issues have been addressed. Licensees should be able to transfer, aggregate, subdivide and lease access to their spectrum rights subject of course to meeting any

requirements in their carrier licences. As suggested in Recommendation 4.11, in the longer term service/network and spectrum licences should be separated.

Recommendation 5.6: Additional competition safeguards should be put in place if spectrum trading is introduced. It is recommended that parties to a trade be required to seek advance clearance from the regulator and that the regulator is required to give a decision within a pre-specified time period. This may require a change to existing legislation. The regulator could give guidance on the types of trades for which clearance is likely to be a formality (e.g. where market shares/spectrum holdings do not change materially).

Recommendation 5.7: The release of new spectrum should be packaged on a technology neutral basis in the short term if there are no overriding policy reasons for specifying the technology to be used. The licensee should have the right to change its spectrum use subject to operating within the technical boundaries of their licence. In the longer term we suggest a move to technology and service neutral licences be considered where practical and if there are no overriding policy reasons or international / technical constraints on the service that may be provided.

Recommendation 6.1: There should be periodic reviews of spectrum use by government. Periodic reviews of government spectrum use should

- assess the efficiency of this spectrum use
- assess demands for future use
- make proposals for improving efficiency now and in future
- draw conclusions on future spectrum requirements for government users

The results of such reviews should be published, subject to any public interest concerns, and should be an input to future spectrum strategies and release plans. See also Recommendation 4.5.

Recommendation 6.2: The regulator should continue to reserve spectrum for government users, but this policy should be reviewed once market mechanisms have been applied more extensively to private sector use of spectrum in say 5 years time.

Recommendation 6.3: Assuming government users have sufficient budgetary freedoms to benefit from efficient spectrum use, then AIP should be applied to the use of spectrum by government users in bands where there are potentially competing demands for spectrum – either from government or commercial users. At present this means applying AIP to congested UHF PMR and fixed links bands, for example bands below 16 GHz.

Recommendation 6.4: It would be desirable for broadcasting policy to draw a clear line between services that are intended to achieve public service broadcasting objectives and services that are purely commercial. The latter should access newly released spectrum (e.g. in Band III, L band and UHF spectrum released after switchover) in the same way as other commercial services (e.g. commercial telecom services), just as commercial broadcasting services pay market rates for access to satellite capacity or capacity on wired networks. Policy trade-offs in this area could also be made more transparent by assessing the potential value of services forgone as a result of spectrum use by broadcasting.

Implementation

We consider that most of the above mentioned recommendations can be implemented within the existing law. The detailed implementation of individual recommendations will be subject to the policy objectives, assessment of priorities, and related transition planning, for ensuring that the best political, economic and social welfare outcomes are achieved for Hong Kong.

Out of the twenty five (25) recommendations above, we envisage that the following recommendations *may* need legislative change for full implementation:

- **Recommendations 4.11.** The existing regulatory regime may allow the separation of the terms and conditions governing spectrum use from the service licence. For example S 7(6) allows the regulator to issue 'other licence' to cover the terms and conditions of spectrum use; S 8(1)(b) allows the regulator to manage the terms and conditions of spectrum use through apparatus licensing. Although it is possible that the existing legislation may permit the allocation of frequencies without reference to the provision of any specific service or to specific apparatus (for example, by reference to all services and all apparatus), the avoidance of any doubt may require legislative change to ensure certainty on the matter.
- **Recommendation 4.14.** The extension of the licensing framework may require legislative change for the avoidance of doubt.
- **Recommendation 5.5.** The same point applies here as in the case of Recommendation 4.11, in relation to the separation of service /network and spectrum licensing.
- **Recommendation 5.6.** As already noted, the changes envisaged for the protection of competition in the trading of spectrum may well require amendments to existing legislation.

Suggested areas for early implementation

The following areas can be considered for early implementation under the current regulatory regime. In most cases early implementation will assure policy clarity and predictability from the outset, and also signal a high standard of transparency:

- **Spectrum strategy:** Define and communicate policy principles of a market-based approach for spectrum management. Strategy in respect of licence exempt and government use of spectrum, emerging issues from new technology developments, licensing issues and future allocation policy should be stated.
- **Spectrum release plan:** Communicate future supply of spectrum resources for commercial use (including frequency bands, marketing mechanism adopted, timing of availability, etc.)
- **Register or record of spectrum use:** Communicate status of existing spectrum use

Spectrum trading and liberalisation: Incorporate appropriate terms and conditions in future spectrum assignments (eg auctions) and licence renewals to facilitate spectrum trading and technology neutral licences. Based on the analysis of spectrum demand given in Chapter 2 and the approach to developing a spectrum release plan given in Chapter 4 we have given an example of a spectrum release plan in the following table.

Figure 1: Illustrative Spectrum Release Plan

Frequency band	Method of release	Comment
Year 1		
825 – 851 MHz	Packaged to provide North American pairing in the lower two bands and GSM pairing in the upper two bands. GSM – divide between existing GSM operators. 800 MHz pairing (CDMA2000 by policy decision, otherwise technology neutral) – auction	Partially encumbered until November 2008
870 – 890 MHz		Partially encumbered until November 2008
925 – 935 MHz		
1780 – 1785 MHz	Paired – divide between existing PCS operators	
1875 – 1880 MHz		
2300 – 2400 MHz	Packaged on a technology and service neutral basis. Auction	Currently partially encumbered.
2500 – 2690 MHz		
Year 2		
825 – 851 MHz left-over		Consult on market interest.
1785 – 1805 MHz		
1900 – 1905 MHz		
2010 – 2020 MHz		
UHF TV spectrum (678 – 686, 798 – 806 MHz)	Technology neutral[3]; Either auction or administrative decision	Timing and services linked to successful implementation of single frequency network (SFN) for digital terrestrial television
1466 – 1480 MHz	Technology neutral[3]; Auction	Timing and demand linked to decisions concerning UHF TV spectrum – consult on market interest.
Band III (216 – 223 MHz)	Technology neutral[3]; Auction	Timing and demand linked to

[3] Service neutrality could also be considered.

		decisions concerning TV spectrum and global developments in digital audio radio – consult on market interest.
Year 3		
9.8 – 10.7 GHz		To be replanned – consult on market interest.
Future Release		
UHF TV spectrum (vacated spectrum after analogue switch-off)	Technology and service neutral; Either auction or administrative decision	Quantity unknown at this stage – policy decisions required to determine whether spectrum is auctioned on a technology and service neutral basis or not.
3.4 – 4.2 GHz 4.4 – 4.99 GHz	Potential refarming required	Review in the light of WRC-07 outcome.

1 Introduction

1.1 Scope

In January 2006 the Communications and Technology Branch of the Commerce, Industry and Technology Bureau (CITB) in Hong Kong commissioned Ovum in partnership with Aegis Systems Ltd and Indepen to undertake a fundamental review of CITB's current spectrum policy and management for both telecommunications and broadcasting purposes.

The tasks we were asked to undertake are as follows

1. Analysis of the future shape of radiocommunications

2. Assessment of the future supply and demand for spectrum

3. Assessment of whether spectrum trading should be introduced and, if so, the changes needed to implement such a policy

4. Assessment of the feasibility of introducing spectrum liberalisation in Hong Kong in the next ten years having regard to the proximity of Mainland China

5. Evaluation of requirements for spectrum by essential public services and the suitability of trading and liberalisation and other market mechanisms for these services.

The current spectrum policy and management was reviewed and we have advised how it can be modified to

- provide greater flexibility and transparency in spectrum access
- promote the timely introduction of new technologies and services in frequency bands that are currently used and in new bands and thereby maximise the economic benefits to the community from use of the spectrum
- strengthen Hong Kong's strategic position by facilitating the introduction of key new wireless services while at the same time ensuring the availability of sufficient spectrum for essential public services
- continue to ensure that Hong Kong's regional and international spectrum obligations are fulfilled.

In satisfying these aims we have considered alternatives to command and control policies, such as market-based approaches and use of licence exempt bands, and how these alternatives can best be implemented. We have also considered how the existing policy framework and administrative procedures can be enhanced to provide a more predictable, transparent and flexible regulatory environment.

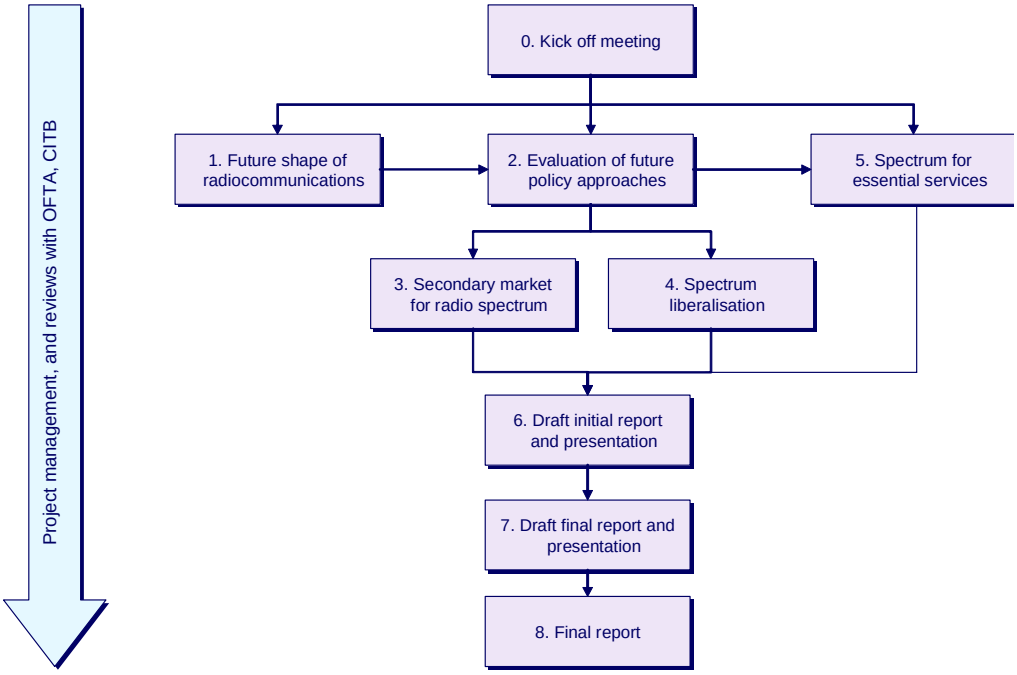
1.2 Approach

Our approach to the study comprises the work steps shown in Figure 1.1.

This report is based on

- information gathered in interviews with 49 spectrum users (a list of organisations interviewed is given in Annex 1 together with the appropriate versions of interview questions for both commercial and government users)
- discussions with and information provided by OFTA
- further research on the Hong Kong situation in terms of demand for final spectrum using services
- a review of international experience in adopting new approaches to spectrum management. This review draws on experience from Australia, Canada, Guatemala, New Zealand, the UK and the US.
- the study team's analysis of possible future technology and market developments and their implications for spectrum demand and supply and spectrum policy.

Figure 1.1 Study Approach



1.3 Report structure

The structure of the report is as follows.

Chapter 2 provides an overview of the current use of spectrum in Hong Kong, the potential future supply of spectrum and future demand taking account of anticipated technology developments.

Chapter 3 describes the current policy context and identifies a number of issues to be addressed by the review.

Chapter 4 proposes changes to administrative arrangements for spectrum management that address the issues identified in Chapter 3. Recommendations aimed at making spectrum management in Hong Kong more predictable and transparent are provided.

Chapter 5 assesses the general case for the application of market based approaches to spectrum management (such as spectrum pricing, auctions, secondary trading and spectrum liberalisation) as a replacement for administrative methods of management.

Chapter 6 looks at spectrum policy in respect of public sector users and broadcasting. In both cases we discuss a number of administrative and market-based options for promoting more efficient spectrum use.

Chapter 7 provides our recommendations for a spectrum release plan based on spectrum demand over the next 5-10 years and indicates the preparatory work required before embarking on this process. An indicative implementation plan is also given for the recommendations made in this report.

Detailed supporting material is provided in Annexes 1-7

2 Future shape of radiocommunications

In this chapter we outline the market conditions affecting future service development scenarios in Hong Kong, and how they will impact the future spectrum requirements. The telecoms and broadcasting technologies and services considered include:

- cellular services, including the IMT-2000 family (WCMDA and HSDPA, TD-SCDMA, CDMA2000) and IMT-Advanced (Super 3G or 4G development)
- broadband wireless services, including ultrawideband and the 802.x family of standards, such as WiFi and WiMAX
- satellite
- fixed links
- private mobile radio services
- broadcast services, including terrestrial broadcast TV and radio
- convergent services: fixed mobile convergence (quadruple-play), telecom and broadcasting convergence, telecom and satellite convergence
- aeronautical, meteorological and maritime services.

Because of the importance of harmonisation and cross-border co-ordination between Hong Kong and Mainland China, we summarise some of the findings on service and spectrum planning developments in Mainland China based on feedback from Chinese industry players interviewed for this report. Information on relevant international situations and trends are contained in Annex 2.

Following the market considerations, we provide an indicative scenario forecasts of spectrum demand with the purpose of identifying the relatively high usage or congested spectrum bands that may require different (more flexible and dynamic) spectrum management strategies or polices. In particular, the scenarios highlight the factors contributing to spectrum demand uncertainty in some bands and we do urge caution with long term demand forecasts, ie beyond five years because of

- uncertainty in service and technology innovation developments,
- change of customer behaviours for new services, and
- availability of data and forecasting parameters which are beyond the level of credibility.

In the final section of the chapter we review the future spectrum supply and conclude with a discussion of longer term management issues.

2.1 Market background

Hong Kong is positioned to serve as the telecommunications hub of the region. Hong Kong is one of the most open markets in the world with a large number of leading international carriers, vendors and equipment manufacturers setting up their regional offices in Hong Kong. The demands of a service-based economy combined with effective regulation have created a sizeable telecommunications market worth HK$49.3 billion (or USD6.4 billion), and the annual capital expenditure in the same period was HK$7.7 billion (or USD1 billion). Hong Kong's

demanding consumers encourage product and service innovation, and the market is often used as a test-bed for new products and innovative service applications.

The telecommunications sector is fully liberalised. There are no restrictions on foreign ownership and the number of operators is determined by the market. The availability of non-exclusive licences for various telecommunications facilitates market entry and further promotes investment in both wired and wireless areas. The Commerce, Industry and Technology Bureau (CITB) formulates supporting policies, and the Office of the Telecommunications Authority (OFTA) regulates and facilitates the development of the sector.

The Closer Economic Partnership Arrangement (2004) free trade agreement between Hong Kong and Mainland China ensures that Hong Kong companies will benefit from the opening-up of the Mainland market beyond China's commitments to the World Trade Organisation (WTO). The Mainland has allowed Hong Kong service suppliers to establish joint venture enterprises in the Mainland to provide the following five types of value-added telecommunications services

- Internet data centre services
- store and forward services
- call centre services
- Internet access services
- content services.

It is important for Hong Kong to foster and maintain a high level of economic and social interaction with Mainland China, for example through cross-border harmonisation of spectrum allocation and interference management, as well as support of continuous and non-disruptive telecommunications (eg mobile roaming traffic).

2.2 Telecommunications

The local fixed telecom services market was first opened to competition in 1995, and was fully liberalised on 1 January 2003. There is no pre-set limit on the number of licences issued. There are no specific requirements on network rollout or investment - they are determined by the market.

In February 2006, there were ten licensed local fixed telecom network service operators and one wireless-based local fixed telecommunications operator. In February 2006 there were about 3.8 million exchange lines (7 million population, 2.3 million households). This is among the highest penetration rate in the world. IP telephony services are available in Hong Kong with a comprehensive regulatory framework for Service-Based Operator (SBO) licences established for application on 6 January 2006.

With established fibre optic networks, provision of broadband service using ADSL, FTTB/FTTH and LMDS and other technologies is very high. In February 2006, there were 186 Internet services providers (ISPs) and 1.66 million registered customers to broadband access with speeds up to 100 Mbps. This equates to a 66.3% household broadband penetration rate, or 24% of total population penetration, which was second only to South Korea.

The external telecommunications services market is highly competitive in Hong Kong resulting in sustained reductions in international call rates. As of February 2006 there were 234 external telecommunications services operators, 6 satellite-based and 20 cable-based external fixed telecommunications services providers. International Direct Dialling (IDD) service is available to 233 countries and regions, and most cities and towns in Mainland China. In the fiscal year ended March 2005, the volumes of outgoing and incoming international calls were 5.07 billion minutes and 2.15 billion minutes respectively.

Cellular services

All of the main 2G and 3G spectrum allocations for mobile cellular services are currently assigned to six mobile network operators. Figure 2.1 summaries all the mobile network operators and their deployed mobile network standards.

There was also a TDMA 800 licence, the spectrum for which has now been vacated. There have been discussions in the industry about the future use of the available spectrum in the 800 MHz band, with a view to enabling the introduction of CDMA2000 services and facilitation of cross-border roaming traffic in Hong Kong.

Figure 2.1: Mobile network operators[4]

Mobile Network Operators	Mobile Network Standards
3 (Hutchison Telephone Co. Ltd.– formerly Orange)	CDMA 800, GSM 900, GSM 1800 WCDMA 2100 (run as three separate networks)
Hong Kong CSL[5]	GSM 900, GSM 1800 WCDMA 2100 (run as an integrated network)
New World PCS Ltd[6].	GSM 1800
China Resources Peoples Telephone Co. Ltd. (CR PEOPLES)	GSM 1800
SmarTone-Vodafone	GSM 900, GSM 1800 WCDMA 2100 (run as an integrated network)
SUNDAY	GSM 1800 WCDMA 2100 (run as two separate networks)

Source: OFTA

The mobile subscriber penetration rate of 122.6% is amongst the highest in the world. Camera phones are popular and terminal replacement is rapid compared to other countries. About 21.7% of mobile subscribers use 2.5G or 3G phones.

[4] The six operators named here run nine networks under fourteen licences to serve a population of 7 million. The term “networks” is dependent on the individual operator’s discretion in keeping its GSM and 3G networks separate eg Hutchison, Sunday or integrated eg SmarTone-Vodafone, HKCSL

[5] Following China Mobile's acquisition of CR PEOPLES and the acquisition of SUNDAY by PCCW, the merger between New World Mobility and Hong Kong CSL was completed in April 2006.

Service rate plans offer large bundles of minutes with effective prices comparable to fixed services. This has resulted in high usage of monthly mobile minutes compared with other countries, ie 387 minutes in HK, 135 minutes in the EU (UK, Italy), 168 minutes in Australia, 282 minutes in Singapore, although it is less than the 630 minutes in the US.

However it is the ongoing and future developments for Super 3G or 4G that will primarily impact current spectrum policy, allocation and management such as:

- services to support voice, data and video (or multimedia) over IP with concurrence of multimedia applications/services operating in a multiple network environments (ie fixed, mobile, Internet, personal networks, etc.);
- data speeds between 100 Mbps (downlink in a 20MHz channel) and 1 Gbps;
- convergence of multiple technologies (ie HSDPA/HSUPA, EV-DO Rev A/Rev B, WiMAX /WiBro (IEEE802.16e, IEEE802.20), WiFi, UWB and DMB);
- increasing use of innovative radiocommunications technologies (eg OFDMA, MIMO/smart antennas, etc.) that divide data into sub frequency bands in non-contiguous bands, and each of these can be processed independently and allow the antenna beam to be focussed to reduce interference;
- differences of local regulations and spectrum allocation plans for incubating and promoting national telecom industry that will make interoperability difficult (eg Korea, Japan, Mainland China)

We take the view that it will take three to five years to realise and implement the current 3G/3.5G development initiatives, and hence some meaningful early form of standardisation of Super 3G or 4G developments will not be possible before 2012.

Figure 2.2 Key mobile statistics for Hong Kong

Mobile network operators (Feb 2006)	6
Number of mobile subscribers (Feb 2006)	8.64 million
Number of 2.5G and 3G mobile subscribers (Feb 2006)	1.92 million
Number of MVNO operators (June 2005)	7
Mobile price premium (average fixed to mobile price ratio)	1.05
Mobile minutes of usage per month	387 minutes

Source: Ovum, OFTA

Fixed links

Fixed links (sometimes referred to as radio relay or point to point links) operate mainly in the bands above 4 GHz that are unsuitable for mobile applications, though there are still some fixed links operating in Hong Kong in the 1.5GHz and 2GHz bands. The lower frequency bands are more suitable for longer distance links due to their better propagation characteristics, while the higher bands are more suitable for providing higher capacity links though over a shorter range.

In Hong Kong, the main use is for backhaul from remote locations (e.g. radar sites) and to access hill top locations. Links are used by a wide range of organisations including mobile operators, utilities, government departments and the emergency services to provide backhaul to their mobile and data transmission networks and broadcasters to feed signals to broadcast transmitters.

In Hong Kong the use of fixed links within the high building density areas of Hong Kong is impacted by new buildings disrupting the line of sight and disrupting communications. Fibre is often preferred by industry except for those cases where the terrain is difficult such as connecting to hilltop sites and the islands.

The current fixed link bands in the 4-7GHz range used for longer distance communications links between islands are heavily congested. Where fixed links are used for backhaul of traffic, there has been a global trend to migrate this across to fibre links (or telecom facilities offered by telecom services operators) to meet the required increasing capacity.

Internationally there are several operators already using or planning to use WiMAX for backhaul purposes. Wireless vendors such as Redline and Airspan provide point-to-multipoint and point-to-point WiMAX equipment. This opens the possibility of providing backhaul capacity in alternative spectrum bands to those traditionally used for fixed links.

At present demand for spectrum for fixed links is controlled by OFTA's policy of only assigning spectrum if there is no leased line alternative. If this policy is continued then growth will be less than if a more liberal approach is taken allowing use of fixed links when demanded (i.e. where it is economic for industry to do so).

During the industry interviews, there was feedback from some of the Government users that they would in future have demand for fixed links for relaying video information from remote locations. Some of this would be to permanent locations, some would be to nomadic but not moving locations, and some to moving locations. While users would like to provide this service through their own managed networks and spectrum allocations, it might be feasible for this to be done through a commercial network with a lower overall spectrum requirement.

Private Mobile Radio

Several frequency bands are available for PMR in Hong Kong, in the VHF and UHF range. There is no congestion in the VHF bands, but the main 440 – 470 MHz UHF band suffers some congestion mainly as a result of Government use in the band and also due to the continuing deployment of legacy 25 kHz systems (most PMR systems now operate on 12.5 kHz channels in order to support greater capacity in the available spectrum).

TETRA is being deployed in Hong Kong by the HK Police using spectrum in the 410 – 430 MHz band, and by KCRC and some other utilities at 800 MHz. There are still several public trunked radio operators using analogue technology in the 800 MHz band.

2.3 Broadcasting

Television

Transmission of the free off-air TV services is at UHF with six principal sites with powers of 1kW or more and around 40 relay sites. All transmitters carry all 4 channels. The free off-air TV services are provided by two broadcasters, namely, Television Broadcasts Limited (TVB) and Asia Television Limited (ATV). Broadcasts are to TV standard I-PAL (as in the UK). Mainland China uses the similar, but incompatible, D-PAL standard. In addition to the free off-air TV services, there are three domestic pay TV services (ie. Hong Kong Cable TV, TVB Pay Vision and PCCW Media), and many satellite TV channels are available through the open sky policy. Hong Kong Cable TV, the cable TV network operator, also makes use of microwave multipoint distribution systems (MMDS) and satellite distribution systems. The TV programmes of Radio Television Hong Kong (RTHK) are also carried by the four free off-air TV channels operated by ATV and TVB, and cable TV.

As elsewhere, plans are in place for a transition to digital TV broadcasting. Technical testing of various standards has been carried out and the government announced the framework to launch Digital Terrestrial TV (DTT).

OFTA has identified five multiplexes for migration to digital TV.[6] Four are single frequency multiplexes, one is a multi-frequency multiplex. The multi-frequency multiplex will be used for the simulcast of the 4 existing off-air TV channels, and each existing broadcaster will be assigned one single frequency multiplex for HDTV and new services. The remaining two single frequency multiplexes will be retained pending review after the successful implementation of single frequency networks (SFNs) in Hong Kong.

On 9 July 2004 CITB announced the implementation framework for DTT broadcasting in Hong Kong. According to the latest updates by CITB on 29 March 2006, the implementation of DTT will be divided into three phases:

- Phase 1 for Realisation of DTT (2004-2008): TVB and ATV shall start broadcasting their existing programmes in both analogue and digital format by 2007, and they will extend the coverage of digital networks to at least 75% of Hong Kong by 2008.
- Phase 2 for Switchover to DTT (2009-2011).
- Phases 3 for Analogue Switch-off from 2012.

On the adoption of a DTT standard, the government has adopted a market-led approach and it is for the market to decide on the standard. ATV and TVB are required to submit proposals for the use of a standard for Government's consideration before end 2006. If China does not have a national DTT standard before end 2006, the two terrestrial TV broadcasters will likely use DVB-T.

In Mainland China, SARFT (State Administration of Radio, Film and Television) announced the progress of digital TV standardisation in the CCBN of 20 March 2006. It was stated that two of the five proposed national DTT standards by MII in June 2002 (ie DMB-T by Tsinghua University, and ADTB-T by Jiaotung University)

[6] A multiplex carries a number of programme channels, typically 4-8 for standard definition TV.

have been selected for final assessment. The two national standards may be 'amalgamated/integrated' based on the core technology of Tsinghua University. There have not been any formal designation of the new national technology, and Tsinghua University has temporarily designated the core technology as DMB-TH. It will require a software upgrade from DMB-T to DMB-TH.[7] The market anticipates that the DTT standard will be finalised in the second half of 2006. In addition to the Mainland China national standard, there are other DTT standards such as DVB-T and T-DMB being actively tested in Mainland China.

Radio broadcasting

Hong Kong radio broadcasting provides thirteen domestic radio services (six on AM, seven on FM). Seven of these services are broadcast by RTHK, and another six by two commercial operators.

Trials of digital radio using the DAB standard have been carried out in Hong Kong at L-band in the past, and current test transmissions, initiated by RTHK are being made in Band III. One of the problems in planning any eventual service relates to the use of the same frequency band for high-power TV transmitters in Mainland China, with consequent mutual interference constraints. Trials of DRM were also carried out in Hong Kong in 2004, using MF frequencies.

2.4 Satellite services

Primary services provided by satellites can be broadly classified into broadcasting, broadband connectivity and telecommunications (fixed and mobile). Of these, TV broadcasting is the most extensive application globally with extensive capacity being used to support this service in terms of video channels for programme distribution etc. There are about 1,800 Satellite Master Antenna Television (SMATV) systems serving about 762,000 households.

Broadband services have long been promoted as a viable satellite service but have never become extensively used in densely populated parts of the world. There is however potential for this service in those parts of the world where population density is low and infrastructure needs to be provided or where economic development is rapid and network roll-out also needs to be rapid.

The main market for satellite services in Hong Kong is for the distribution of video services supporting information providers and broadcasters where these businesses provide services in Hong Kong but perhaps more importantly revenue generating services to the whole of the region. A significant aspect associated with all radio propagation in Hong Kong and the region is the susceptibility to rain degradation. While this is significant for terrestrial services, although higher frequencies are still useable for short links, this has an important implication for satellite links. It means that, unlike many other parts of the world, the lower frequencies (i.e. C-band) are of great importance to satellite operations in the region. It is arguable that higher frequencies can be used to support IP based services carrying applications that do not require real-time connections but for

[7] http://www.ccbn.cn/media/reports/ReadNews.asp?NewsID=2399&BigClassID=1&SmallClassID=4&SpecialID=23

real-time applications associated with broadcast activities it is clear that C-band has a very important part to play. Noting that Hong Kong operators use the territory as a hub to serve other countries there is interest in providing satellite based services, including broadband access, to Mainland China and India for example, using Ku-band and potentially Ka-band.

2.5 Aeronautical, maritime and meteorological

Frequencies are reserved internationally for these services and their use is co-ordinated by the respective international bodies. This means there is relatively little flexibility in the use of these frequencies.

Organisations using these frequencies also deploy applications based on other radio services, e.g. fixed links. These requirements are addressed in other sections.

2.6 Convergent Services

Convergence refers to the increasing deployment of multiple digital media such as broadcasting, telecommunications and information technology to deliver integrated multimedia content and services. These may include textual, audio (speech or music) and/or video material. Radio spectrum has considerable potential for the mobile delivery of convergent services and content, and standards are emerging that straddle the traditionally distinct mobile and broadcast sectors. For example, a range of frequency bands and technologies could be used to deliver mobile video, audio and data including

- DMB technology using VHF Band III and L-band spectrum
- DVB-H and MediaFLO technology using UHF and L-Band spectrum

Convergence, the much faster pace of technology development and shorter product lifecycles have made the traditional command and control (C&C) practice more challenging to implement while still responding to the market's needs. There could be several services and technologies competing for spectrum in a given band and under a C&C system and the regulator will need to make difficult decisions about 'who' should be allocated by 'how much bandwidth' by 'when' for 'how long' under 'what conditions or obligations' in a very uncertain market environment.

Fixed mobile convergence (FMC)[8] between fixed telecommunications and mobile can range from simple fixed voice and mobile bundle, triple-play (ie, voice, data, mobile), quadruple-play (ie voice, data, mobile, TV). TV can either be transported over fixed broadband (eg IPTV) or wireless broadband (eg TDtv or IPWireless). The immediate challenge here is more spectrum demand for the fixed

[8] FMC refers to all possible service and technology developments combining fixed and mobile such as: simple bundles of fixed and mobile services (eg bundles of telephone rental, broadband and mobile rate plan at discounted price); tightly integrated fixed mobile services (eg single number, single mailbox, single bill); single integrated device supporting seamless handover of fixed and mobile calls; integration of fixed and mobile networks using IMS IP-based NGN.

or integrated service operators (eg spectrum for fixed wireless access, spectrum for broadband wireless)

Telecom, broadcasting and satellite convergence services

Mobile service operators partnering with content providers and handset vendors to provide video or TV services, whilst the TV broadcasters partner with fixed or integrated service providers (including ISP) to provide IPTV or similar services. There are relationships developing between fixed, integrated or mobile service providers and ISP or software vendors (eg Microsoft, Google) to offer TV services. Fixed or mobile service operators will also partner with satellite service providers to launch digital broadcasting services, avoiding the lead time to build broadcasting infrastructure.

2.7 Service and spectrum planning developments in Mainland China

The findings of our research together with interviews with industry stakeholders (including CITB, OFTA, operators, equipment vendors and telecom research institutes and relevant websites) in Hong Kong and Mainland China identified the following issues:

- It will be beneficial for Hong Kong to maintain and reinforce harmonisation with the spectrum planning and management practices in Mainland China. The objective of this harmonisation is to facilitate the increasing cross-border business and social activities including roaming. In August 2005, there were 32.3 million CDMA subscribers in Mainland China, representing 12.4% of worldwide CDMA subscribers, facing a potential problem in international mobile roaming in Hong Kong
- The 3G situation will become a focus again when 3G licences are awarded in Mainland China. The Ministry of Information Industry (MII) has openly promised that 3G would be operative in the 2008 Beijing Olympic Games. One issue that needs to be considered is how should the Hong Kong government position its 3G telecom policy when it will also take part in organising the 2008 Beijing Olympic Games in Hong Kong if 3G will only support WCDMA? There will be demand for international mobile roaming in Hong Kong for three 3G standards (ie WCDMA, CDMA2000 and TD-SCDMA).

The interviewed Chinese operators and research institutes were open to a trend of increasing market liberalisation in spectrum management, but some expressed their concerns on the adoption of pure market mechanisms because spectrum is an important national scarce resource, and there are different stakeholder groups.

A summary of pertinent spectrum allocations or plans is given in Figure 2.3.

Figure 2.3: Spectrum allocation / plan in Mainland China

Service	Frequency Plan Information
Current 2G/2.5G	• GSM: 885-915 MHz / 930-960 MHz /1710-1755 MHz / 1805-1850 MHz • CDMA: 825-835 MHz / 870-880 MHz
Current PHS/DECT	1900 – 1915 (PHS) / 1905-1920 MHz (DECT)

FDD mobile access	1890-1900 MHz / 1970-1980 MHz (China Telecom's CDMA WLL)
Future 3G allocation	The following frequencies will be used for 3G mobile service [9]: **For Main Operation** : FDD : 1920 – 1980 MHz / 2110 – 2170 MHz TDD : 1880 – 1920 MHz, 2010 – 2025 MHz **For Expansion** : FDD : 1755-1785 MHz / 1850–1880 MHz TDD : 2300-2400 MHz
WiMax	**Fixed WiMAX**: 3.5 GHz (for fixed wireless access only) [10] China Netcom (CNC) has recently filed an application to MII to apply for the provisioning of WiMAX service at 3.5 GHz at the Beijing 2008 Olympic Games **Mobile WiMAX**: various trials are underway Chinese operators and concerned stakeholders have strong reservations about the future development of WiMAX, at least in the next 2-3 years. Issues include national standards, business model, and development of industry value chain
UWB	Under study (Chinese operators have strong reservations about this because of the potential interference issues)
RFID	917-922 MHz (provisional allocation) [11]
Digital TV (eg DMB Trials)	Eg Band III allocation (207-215 MHz) in Guangdong [12]

Source: Ovum, OFTA

[9] See the following publicly available documents:

- A contribution by China's Ministry of Information Industry (MII) to the 3rd Meeting of the APT Conference Preparatory Group for WRC-2007 : http://www.aptsec.org/meetings/2006/APG07-3/Documents/(13)China-Apg-Item1.4.doc
- A notice of MII on frequency planning for 3G : http://www.srrc.org.cn/SysParts/DepartDoc/infoView.aspx?InfoID=Info63227844732319 88962003145432

[10] See a contribution by China MII to the 2nd Meeting of the APT Wireless Forum http://www.aptsec.org/meetings/2005/AWF/docs/(42)MIICHina.doc

[11] See the Annex of a Draft Recommendation by APT on RFID (http://www.aptsec.org/meetings/2006/AWF-IM2/(38Rev.2)Proposed%20Draft%20RFID%20Recommendation.doc)

[12] See an overview of DMB development in Guangdong at http://www.dmb.com.cn/1-fzlc/index.html

2.8 Spectrum demand forecasting

Mobile voice and data[13]

The mobile market is currently in the early stages of transition to 3G. Current network traffic is still heavily dominated by voice traffic. Hong Kong users have been relatively heavy users of voice primarily due to the very cheap and flat rate pricing plans for voice. Conversely they have been relatively low users of data services such as SMS compared to other markets, primarily due again to the very cheap voice prices and also to the late introduction of inter-operator SMS. Globally, there is still considerable uncertainty regarding even the short term traffic volumes for data services.

One of the largest potential demand drivers, that also has a very high level of uncertainty, is for video services delivered through mobile devices. Video services require a large amount of radio network capacity relative to voice or data services such as SMS, MMS and Internet connectivity. Most operators globally are still providing these services on a trial basis for zero or very low retail prices. The market demand for these services with sustainable pricing has not yet been proven.

Spectral efficiency for mobile services will improve over the forecast period. Operators already have plans for HSDPA and HSUPA over the short term. There are also other foreseeable (but less certain) technology options going forward that will impact on mobile voice and data demand such as:

- re-farming the current 2G spectrum to 3G
- introduction of new mobile voice and data technologies (in new or existing spectrum bands) (eg IEEE 802.16e, iBurst, 802.20)
- introduction of beyond 3G systems (such as Super 3G) possibly towards the end of the long term of the forecasts around the 2015 period.

Broadband wireless access technologies such as IEEE 802.16e provide services that will become closer competitive substitutes for cellular mobile with the development of technology and service convergence. Voice focussed cellular mobile technologies are expanding to provide mobile broadband access, while the technology roadmaps for broadband wireless technologies are planning to provide voice services through VoIP enabled handsets as an extension of data service.

Wireless broadband technologies which are mobility enabled will be a substitute for the traditional cellular mobile technologies. If spectrum is allocated for broadband wireless access then the demand remaining to be serviced through the cellular mobile networks will correspondingly be reduced.

The mobile subscriber market in Hong Kong is already close to saturation, with customers often holding more than one active service. However, the practical definition of 'saturation' is being re-defined by changes in the pattern of market demand and the applications for which customers use their services. The demand model has only factored in a small increase in the market penetration, reflecting a view that saturation thresholds will not rise markedly within the forecast period. Further fragmentation of customers across multiple active services would drive the

[13] The demand forecast in this section has been based on the current demand for services provided through what is regarded as cellular mobile technologies.

number of services higher, but would decrease the per service voice usage with the overall voice usage per actual customer little changed.

Mobile voice pricing in Hong Kong is already very competitive and with the range of flat rate pricing plans available, the per user usage rates are not likely to increase dramatically.

The assumptions driving the steady and high growth scenarios are based on a combination of historical values and an estimate of the impact of the introduction of new services.

Steady growth scenario

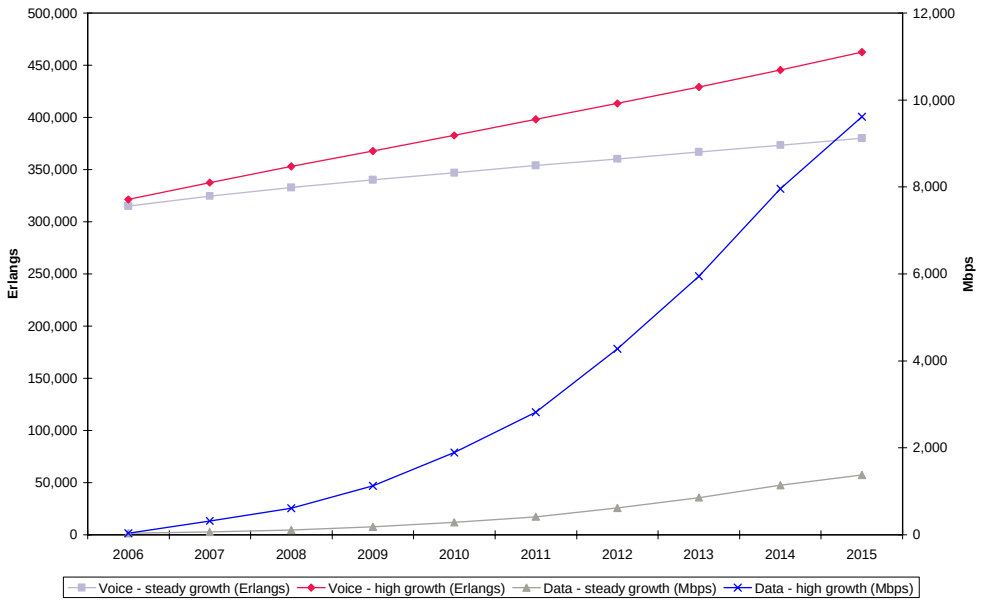
- Voice minutes per user grows at 1% per annum
- Gradual deployment of new data services and moderate usage by end users.

High growth scenario

- Voice minutes per user grows at 3% per annum
- More rapid deployment of new data services and high usage by end users.

Figure 2.4 shows the voice demand (in Erlangs) and data demand (in Mbps) for mobile enabled voice and data services.

Figure 2.4: Mobile voice and data demand



Source: Ovum

Mobile network operators have two main options for providing extra capacity in their networks to meet growing demand:

- install extra capacity in existing base stations – this is limited by the spectrum available to the operator
- increase the number of base stations.

Through access to more spectrum, the mobile operators will be able to meet the growing demand in both scenarios with a lower infrastructure cost. The need for

new spectrum is not an absolute requirement, but rather an economic trade off against the alternative of increased infrastructure investment.

From a network perspective, there is market requirement to provide a network that allows roaming for the subscribers roaming into Hong Kong from their home CDMA network. To provide this will require an allocation of sufficient spectrum. While not available yet, there are plans by the Korean handset manufacturers and operators to provide their market with dual mode CDMA2000-WCDMA handsets for their own market. This could provide a possible market solution for the CDMA roamers. Even if the dual mode handsets only form a niche part of the market, potential roamers will be able to choose to purchase or lease the handsets or alternatively to use a separate GSM/WCDMA handset while in Hong Kong.

Broadband wireless access

Within the Hong Kong market fixed wireless access is likely to be a niche offering. Hong Kong has good availability of high bandwidth services to end customers, a wireless service only providing fixed capability will be limited in the value it provides to customers. There is some opportunity currently for the provision of fixed services in the New Territories.

The real opportunity for broadband wireless access is the mobility aspect. Demand met through what is categorised as broadband wireless access technologies will substitute for demand met through what is categorised as cellular mobile technologies.

Provision of spectrum suitable for broadband wireless access technologies will allow the potential entry of one or more new mobile service providers that are able to provide services in competition to the current mobile operators. Initially these will be data only, but there are plans by the equipment vendors to provide VoIP enabled broadband wireless handsets that would allow voice services to be provided as well.

Operators in some countries are exploring the possibility of using WiMAX for backhaul capacity from base station sites. This can be done on either a point-to-point basis (similar to fixed links, but utilising a block of licensed spectrum and self-managing the interference between different links) or on a point-to-multipoint basis. As discussed previously, with the strong level of fibre network availability in Hong Kong, the potential use of WiMAX for backhaul purposes will mostly be limited to niche opportunities.

The WiMAX Forum is initially focussing on profiles in three spectrum bands:

- 2.3 – 2.7 GHz licensed band
- 3.3 – 3.8 GHz licensed band
- 5.725 – 5.85 GHz licence exempt band.

Ad-hoc network equipment such as that utilised in home and office environments would be expected to use the licence exempt band. This is the most important band from an international harmonisation viewpoint since some of this equipment (such as laptops) will be globally mobile and available in the Hong Kong market.

Fixed Links

Historic figures for the number of fixed links and the spectrum used by them in Hong Kong are in Figure 2.5 below.

Figure 2.5: Number of Fixed links, Hong Kong

	Government			Non-Government		
	2004	2005	Now	2004	2005	Now
30-300MHz	51	60	60	*147*	*147*	147
300MHz – 3GHz	188	241	247	140	140	140
3-10GHz	158	198	212	237	243	243
>10GHz	169	173	191	635	721	753
Total	566	672	710	*1159*	*1251*	1283

Source: OFTA

Note: Italicised figures adjusted

Figure 2.6: Spectrum Use in MHz

	Government			**Non-Government**		
	2004	**2005**	**now**	**2004**	**2005**	**now**
30-300MHz	*2.43*	*2.47*	*2.47*	*3.3*	*3.3*	*3.3*
300MHz – 3GHz	*65*	*65*	*83*	*187*	*187*	*187*
3-10GHz	*611*	*715*	*757*	*758*	*847*	*847*
>10GHz	*722*	*778*	*834*	*2183*	*2190*	*2204*
Total	*1400.4*	*1560.5*	*1676.5*	*3131.3*	*3227.3*	*3241.3*

Note: Italicised figures adjusted

Source: OFTA

The growth rate can be seen to be modest in the lower frequency bands and somewhat greater in the higher frequency bands with higher growth rates applying to government use. It is understood from OFTA that frequencies between 6 and 16 GHz are particularly congested with new assignments being made only where frequencies can be reused.

European and UK growth rates are more consistent from year to year and proceed at a faster rate[14]. However, a comparison of the European and UK figures with the situation in Hong Kong needs to take account of the different circumstances pertaining to the different locations. The most important factors that have to be taken into account are that:

- the use of frequency bands above 13 GHz are constrained by the effects of significant rainfall which occurs in Hong Kong
- the building and terrain topology does not make it easy to implement fixed links but there are a number (50+) of hilltop sites within the territory that are very attractive for the implementation of many fixed links applications.
- there is considerable use of fibre and therefore the main requirements for fixed links are determined by the need for alternative routing and also for those links where it is difficult to deploy fibre (e.g. over water)

In the light of the first of these, OFTA's fee policy is designed to encourage the use of higher frequencies[15] and this appears to have some impact as there are over 900 links in frequency bands greater than 10 GHz (although only some 180 of these operate at frequencies greater than 20 GHz) compared to some 450 links in the frequency range 3 – 10 GHz, approximately 380 links in the range 300 MHz – 3 GHz, and approximately 200 links below 300 MHz (source: OFTA statistics, 22nd May 2006).

OFTA policy regarding the use of hilltop sites is to prioritise their use to government departments and military / defence units, and to require justification in terms of there being no alternative means for TV and sound broadcasters, operators offering public services, public utilities and non-profit making organisations.

It is clear that because of the first two factors there is a large degree of suppression in demand for fixed links. On the one hand the technical constraint at higher frequencies prevents the widespread use of the higher frequency bands where equipment is smaller and well suited to supporting cellular networks, and on the other hand general access to important sites is also restricted. Applying growth rates observed in other parts of the world where these constraints do not exist cannot therefore be readily done. However, even when these constraints are suppressing demand, the fixed link bands between 6.4 GHz and 15.35 GHz are already congested. It can therefore be concluded that, whether the growth in fixed links remains slow and steady under the current regime or whether current policies

[14] ECC Report 3 – Fixed Services in Europe – Current use and future trends post-2002. February 2002.

Final Report for the Independent Audit of Spectrum Holdings – Spectrum Demand for Non-Government Services 2005 – 2025. Analysys and Mason 1st September 2005.

[15] In addition the fees are based on bandwidth consumed and therefore encourage bandwidth saving through the use of more efficient modulation schemes for example.

are relaxed thereby leading to more significant growth, fixed link frequency bands will remain congested and potentially get a great deal worse.

Options for increasing the supply and/or flexibility in the availability of fixed link bandwidth:

- Continue with the current regime – strengthen the frequency dependent AIP
- Introduce trading
- Allow non-government use in government designated bands – for example, the 4400 – 4940 MHz band shown in the Figure 2.7 below which has a 60% occupancy.

Figure 2.7: Options for Fixed Link Bandwidth

Band (MHz)	Total assigned bandwidth (MHz)	Total available bandwidth (MHz)	Occupancy (%)
4400 – 4940	320	540	~60
4940 – 4990	50	50	100
Total	370	590	~63

Source OFTA

Private Mobile Radio

The usage statistics for the sub-bands that make up the VHF PMR band are shown in the table below. It can be seen that usage has largely been static over the recent years and it is not expected that this pattern will change. In any event, utilisation of this band is not particularly heavy so any unexpected increase in demand will be easily absorbed by the existing allocation. For this band it can be noted that demand has not been administratively suppressed.

Figure 2.8: VHF PMR Channels Used (Unassigned) Occupancy

Band (MHz)	2000	2001	2002	2003
66 – 83.2	288 (244) 54%	292 (240) 55%	297 (235) 56%	298 (234) 56%
138 – 156	245 (202) 55%	264 (183) 59%	277 (170) 62%	278 (169) 62%
165 – 172	91 (189) 33%	93 (187) 33%	92 (188) 33%	92 (188) 33%
226 – 235	8 (71) 10%*	11 (207) 5%	14 (204) 7%	14 (204) 7%

Source: OFTA

* Band only partially allocated at the time

Insofar as the **UHF PMR band 440 – 470 MHz** is concerned the total number of assigned private channels for the last three years (Source: OFTA) has been:

- 2005 = 150 channels
- 2004 = 139 channels
- 2003 = 148 channels

It can be seen that the use of private channels over the last few years in this band has also been relatively static. However, this has been because of high occupancy in the various sub-bands. Disregarding government use in the band 440 – 458 MHz and use by an important service in the 466 – 469 MHz band, the current occupancy of channels is 91%. The UHF PMR band can therefore be considered to be heavily congested unless channels designated for government use can be released for private use.

Lack of available channels has in effect suppressed demand. In terms of potential future growth, uninhibited by current constraints, it might be expected that there would be a step change in demand if additional channels were to be made available. How big this step change would be is difficult to quantify without undertaking local primary research with respect to potential users.

Accommodating additional users could be achieved through:

1. Additional spectrum, for example from government bands – see the table below where the current occupancy of the 406 – 430 MHz band is only 57%
2. Changed technology (12.5 kHz spacing rather than 25 kHz spacing)
3. The use of shared rather than individual networks

Figure 2.9: UHF spectrum (Government use)

Band (MHz)	Government assigned (MHz)	Non-Government assigned (MHz)	Total available (MHz)	Occupancy (%)
335.4 – 400	48	0.25	64.6	~75%
406 – 430	13.21	0.45	24	~57%
Total	61.21	0.7	88.6	~70%

Source: OFTA

The 800 MHz bands (806 – 826 MHz and 851 – 871 MHz bands) are heavily used with 24 licensees. About 15% of the available bandwidth is available for new assignments.

Broadcasting / Multi-media Services

Television

Based on our interviews with market players it seems likely there will be demand for UHF spectrum to transmit additional digital TV services in Hong Kong, including standard and high definition services and pay TV as well as free to air TV. If single frequency networks (SFNs) prove feasible then demand may be able to be met from both the currently available spectrum and the spectrum that will be released at switchover. If SFNs are not technically feasible then it is possible there could be unmet demand for spectrum from TV services.

Radio

There is already excess demand for FM radio spectrum in Hong Kong and no way of meeting it. Frequencies are available in Band III for DAB services but so far DAB has only been adopted on a widespread basis in the UK (where over 2.7m sets have been sold and household penetration is around 11%) and even there no operator is making a profit. There is increasing competition being provided by other platforms such as digital TV, the Internet, mobile video services (which could include radio) at UHF or L band and alternative digital standards such as DRM. As the UK regulator Ofcom noted in its recent review of the radio sector

"*DAB digital radio has an opportunity to become a mass market medium … However, other platforms may offer other things which consumers find attractive, including more choice of stations.*" [16]

In summary, the FM band is congested but for the near future it seems unlikely the medium wave band and Band III will become congested, though the situation may change in the longer term.

Multi-media services

Mobile multi-media services – often referred to as mobile TV - could also potentially use spectrum at Band III, the UHF TV band and L-band. Mobile TV services have been launched in Korea (using L Band), the US (using UHF spectrum and L band) and services will soon start in Finland and Italy (using UHF spectrum). Trials are being conducted in many countries across all three bands. While the extent of demand for services is at present unclear there is considerable industry optimism and we identified interest in launching such services in Hong Kong.

In Band III, mobile TV services could operate at lower cost than at UHF, but there would be less capacity available, terminal antennas would be less efficient and transmission antennas would be larger and so unsuitable for small low power sites. L band is more expensive in terms of infrastructure cost than UHF, and so UHF spectrum is generally preferred by potential service providers. Handsets are being made for both L band and the UHF band. The availability of UHF spectrum in Hong Kong for mobile TV will depend on the success of SFNs for delivering TV services and on government policy decisions.

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[16] Para 6.108, Radio-Preparing for the Future Phase 2: Implementing the Framework, Ofcom, 19 October 2005

Ancillary broadcasting services

Ancillary services make use of some of the "white space" in the UHF TV band and the availability of this spectrum could be reduced significantly with the advent of digital TV. Demand for spectrum from ancillary services will not decline, however, and indeed could increase if the number of programme channels increases and/or as viewers' expectations of live feeds also increase.

In summary, we conclude that there could be excess demand for UHF spectrum in future as a result of demand from TV and mobile TV services. In addition we note that the band has also been identified as a possible future frequency range for 3G/4G services. The situation at L band is less certain and depends on the extent to which demand for spectrum for mobile TV services can be accommodated at UHF.

2.9 Future spectrum supply

The provision of spectrum for future applications will come from:

- spectrum that is vacant or in the process of being cleared
- release of spectrum or an increase in capacity due to technological improvements
- refarming to release spectrum

Overall spectrum usage in Hong Kong is summarised in the allocation table (30 MHz – 30 GHz) of Annex 3. The following sub-sections identify for each major application the key frequency bands in use and the frequency bands that could potentially be made available in order to satisfy demand. Bands identified as congested reflect either the regulator having difficulty or limited scope for making new assignments in response to demand, or bands where it is clear from stakeholders that there would be demand now and in the near future if the spectrum were to be available.

It should be noted that there will be guard band requirements between services and coordination constraints with respect to the Mainland which will reduce the amount of clear spectrum identified in the following sub-sections. The exact nature of such constraints will become clear when the detailed work on spectrum packaging is undertaken prior to release of the spectrum.

Cellular

Band	Sub-band	Comment
825 – 851 MHz (*)		Vacant after November 2008 when 831.59 – 834.09 MHz relinquished
870 – 915 MHz	870 – 890 MHz **(*)**	Vacant after November 2008 when 876.59 – 879.09 MHz relinquished
	890 – 915 MHz	Fully assigned to GSM (Mobile Tx)

925 – 960 MHz	925 – 935 MHz **(*)**	Clear spectrum
	935 – 960 MHz	Fully assigned to GSM (Base Tx)
1710 – 1880 MHz	1710 – 1780.1 MHz	Fully assigned to PCS
	1780.1 – 1785 MHz **(*)**	Available
	1785 – 1805 MHz **(*)**	Centre gap for Tx / Rx separation
	1805 – 1875.1 MHz	Fully assigned to PCS
	1875.1 – 1880 MHz **(*)**	Available
1905 – 1980 MHz	1904.9 – 1919.9 MHz	Fully assigned to 3G (unpaired)
	1920.3 – 1979.7 MHz	Fully assigned to 3G (Mobile Tx)
2010 – 2170 MHz	2010 – 2019.7 MHz **(*)**	Available (3G unpaired)
	2019.7 – 2024.7 MHz	Fully assigned to 3G (unpaired)
	2024.7 – 2110.3 MHz **(*)**	Centre gap
	2110.3 – 2169.7 MHz	Fully assigned to 3G (Base Tx)
2300 – 2400 MHz (*)		Largely (92 MHz) vacant by November 2006). Removal of government use would make it fully vacant.
2500 – 2690 MHz (*)		Vacant by November 2006. 3G expansion band / BWA candidate.

It can be seen from the above table that a number of bands are available for future use – indicated thus **(*)**. The available bands fall into a number of categories as follows:

Mixed pairing (North American 800 MHz and GSM 900 MHz):

825 – 851 MHz (partially encumbered until November 2008)

870 – 890 MHz (partially encumbered until November 2008)

925 – 935 MHz

These three bands offer a mixture of pairings; a North American pairing in the lower part of the lower two bands and a GSM pairing in the upper part of the upper two bands. If both pairings are to be accommodated there will be a need for a significant guard band in the middle band to separate the uplink of one from the downlink of the other.

Proposals have already been made to accommodate both pairings – extending GSM downwards in the top two bands and accommodating a North American pairing towards the bottom of the bottom two bands. This approach leaves a significant amount of spectrum available at the top of

the lowest band – potentially around 15 MHz, or possibly more. This available bandwidth extends downwards from 851 MHz and the exact amount depends on the breakpoint between the different pairings in the 870 – 890 MHz band and any guard band requirements. Although this remaining spectrum is identified as IMT-2000 spectrum it is also a Broadcasting allocation and could therefore be used for SAB/OB/ENG.

As an alternative the lowest band could be used for broadcasting related applications but this would then leave the bottom of the middle band vacant and probably only useful for low power applications.

Paired:

The sub-bands 1780 – 1785 MHz and 1875 – 1880 MHz are obvious extensions to existing PCS assignments.

Unpaired:

1785 – 1805 MHz, being the PCS centre gap, means that it is unsuitable for mobile applications in any way integrated with existing mobile services but might be used for applications such as wireless microphones and other low power applications or potentially FWA.

2010 – 2020 MHz is designated as 3G unpaired spectrum and is available for assignment.

2025 – 2110 MHz, being the 3G centre gap, renders it unsuitable for related mobile applications but it could be considered for FWA or ENG. It can be noted that this band is sometimes paired with 2200 – 2290 MHz but this is already being used for ENG.

Flexible:

2300 – 2400 MHz - although not specifically designated as an IMT-2000 allocation, some administrations including Mainland China, are considering its use for 3G

2500 – 2690 MHz – there is strong interest in the band from both the 3G and the BWA communities.

Broadcast

The sound broadcasting band of 88 – 108 MHz and the TV broadcasting band of 470 – 806 MHz are both intensively used largely because of the difficult topology of Hong Kong.

Two 8 MHz channels in the 470 – 806 MHz band earmarked for the implementation of DTT are pending for allocation after the successful implementation of SFNs.

Analogue TV switch-off could release up to 16 TV channels for use by other services, however there is uncertainty about the availability of this spectrum as it depends on the success or otherwise of SFNs, the impact of High Definition Television and the necessary coordination with Mainland China.

Other spectrum that is available for digital multimedia services includes part of Band III (174 – 230 MHz) and L-band (1452 – 1492 MHz) where 8 blocks have already been made available in the middle of the band.

The potential use of these three pieces of spectrum by digital multimedia services needs to be considered as a whole but this cannot be done until the uncertainty associated with the TV spectrum is resolved.

Other services associated with broadcasting, e.g. Outside Broadcasting (OB), Electronic News Gathering (ENG) and wireless microphones have allocations throughout the spectrum: OB between 7 and 15 GHz, ENG between 2 and 3 GHz, and wireless microphones / other studio services below 790 MHz. The spectrum associated with OB and wireless microphones has been relatively stable but, as is common elsewhere, ENG operations around 2 GHz are continuously under pressure due to the interest of other applications in their allocations.

Fixed

Band	Sub-band	Comment
Point-to-point links		
VHF (30 – 300 MHz)		Small amount of growth in government usage. Non-government usage is static.
UHF (300 MHz – 3 GHz)		
4400 – 4990 MHz	4400 – 4940 MHz	Government / security – 60% occupancy
	4940 – 4990 MHz	Police – 100% occupancy
6425 – 8500 MHz	6400 – 7100 MHz	All these channel plans congested
	7420 – 7750 MHz	
	8275 – 8500 MHz	
12.75 – 13.25 GHz		
14.4 – 15.35 GHz		
21.2 – 23.6 GHz		Not significantly used
38 GHz		Not significantly used
Point-to-multipoint (including wireless access)		
2.4 GHz	2400 – 2483.5 GHz	Licence-exempt RLANs and other wireless access
5 GHz	5150 – 5350 MHz	
	5470 – 5725 MHz	
	5725 – 5850 MHz	
5850 – 5950 MHz		P-MP distribution systems
10.15 – 10.3 GHz 10.5 – 10.68 GHz		FWA
18.14 – 18.74475 GHz		MMDS

24.8465 – 24.997 MHz 25.8545 – 26.005 MHz		LMDS
2300 – 2400 MHz		92 MHz vacant by November 2006. All available if government use can be removed. (BWA candidate but also could be considered for 3G)
2500 – 2690 MHz		Vacant by November 2006 (BWA candidate but also designated as 3G expansion band)
3400 – 3600 MHz		Currently occupied by satellite downlinks (sharing not possible)

As noted above, growth in the various VHF and UHF bands has been low and mainly associated with government rather than non-government use.

In the bands above 3 GHz there has been more significant growth and once again this has been associated more with government usage rather than non-government usage. The pattern of growth reflects the congestion in many of the bands and the policy adopted in assigning links which favours government users and requires a lack of alternative transmission means to be demonstrated.

For point-to-point links there is limited opportunity to make further spectrum available except in higher frequency bands although the balance of government to non-government use might be reviewed.

The approach needs to increase the capacity available in existing frequency bands. It is noted that the existing fee structure relates to bandwidth and frequency used so this should encourage use of the relatively empty higher frequency bands and more efficient equipment. Even under this regime congestion is still occurring and there is suppressed demand.

For BWA a number of new bands have been identified but there are competing demands on this spectrum from other new uses in the case of two of the bands (2.3 & 2.5 GHz) and from existing users in the case of the third band (3.5 GHz).

Private / Trunk Mobile

Band	Sub-band	Comment
66 – 235 MHz (12.5 kHz VHF PMR)	66 – 83.2 MHz	56% occupancy
	138 – 156 MHz	62% occupancy
	165 – 172 MHz	33% occupancy
	226 – 235 MHz	7% occupancy

335.4 – 400 MHz		Government – 75% occupancy
406 – 430 MHz		Government incl Police TETRA – 57% occupancy
440 – 470 MHz (25 kHz UHF PMR)		Mixed use – 94% occupancy
806 – 826 MHz (some TETRA but mostly analogue)	806 – 818 MHz (Note 1)	Conventional / trunked MRS and mobile data*
	818 – 819.1 MHz	Cross border trunked radio
	819.1 – 823.1 MHz	*Low power devices (licence-exempt)*
	823.7 – 824 MHz	Conventional / trunked MRS and mobile data*
	824 – 826 MHz	1 MHz guard band
851 – 871 MHz (some TETRA but mostly analogue)	851 – 863 MHz	Conventional / trunked MRS and mobile data*
	863 – 864.1 MHz	Cross border trunked radio
	864.1 – 868.1 MHz	*CT2 and RFID (licence-exempt)*
	868.7 – 869 MHz	Conventional / trunked MRS and mobile data*
	869 – 871 MHz	1 MHz guard band

Note 1: 806–807 MHz to be vacated as a guard band with respect to DTT.

For the main application in the 800 MHz bands (as indicated by *) it can be noted that there are 24 licensees and about 15% of the bandwidth are still available for new assignments.

While spectrum is still readily available in the VHF PMR bands there is evidence that congestion exists in the UHF PMR bands and the trunked bands above 800 MHz. In the absence of any changes it is clear that future demand will be suppressed. It is not necessarily the case that more spectrum is required if trends elsewhere are mirrored, in particular, a move to 12.5 kHz channels and digital equipment as well as the use of joint rather than individual networks could be sufficient to meet likely growth in demand.

In the unlikely event that more spectrum is required it might be appropriate to review the balance of government / non-government spectrum (e.g. in the 406 – 430 MHz band).

Satellite

Mobile satellite terminals are permitted to operate on a licence-exempt basis in the following bands:

1518 – 1559 MHz (Rx)

1610 – 1660.5 MHz (Tx)

1613.8 – 1626.5 MHz (Rx)

1668 – 1675 MHz (Tx)

1980 – 2010 MHz (Tx)

2170 – 2200 MHz (Rx)

2483.5 – 2500 MHz (Rx)

It is not hard to understand why these allocations have been made in relation to the development of Mobile Satellite Services. However, the extent of use of those bands associated with the NGSO systems such as Iridium, Globalstar and ICO (the latter not having an operational system) is questionable.

Fixed satellite use is concentrated in C-band: 3400 – 4200 MHz (downlink) and 5850 – 6425 MHz (uplink). There is little use of Ku-band and no use of Ka-band mainly for propagation reasons, although some operators have expressed an interest in the use of these frequencies. Higher frequency bands are available if needed. There is potential competition from fixed links for these higher frequencies but demand from both services is likely to be suppressed as they both suffer the same local propagation problems at higher frequencies.

The lower part of the C-band downlink has been identified as an FWA candidate. It can be shown that sharing in a dense urban environment is not possible so decisions would have to be made as to which service should be designated as the primary user of the band. It can be noted that focus on this band has been growing internationally and it is anticipated that the situation will be raised at the next World Radio Conference (WRC-07) in the context of systems beyond IMT-2000.

Aeronautical, Maritime & Meteorological

Bandwidth for these services is generally secured on an international basis through the coordinating role of their respective international organisations. It can therefore be assumed that spectrum supply is generally adequate although it is noted that congestion already occurs with respect to assignments in the 131 – 132 MHz band which is used by airline companies for air/ground communications. It is understood from OFTA that assignments in the band are currently based on 50 kHz channel spacing, although elsewhere it has been at 25 kHz channel spacing. 8.33 kHz channel spacing is now used (not exclusively) elsewhere in the world (e.g. Europe) and equipment is widely available. Use of narrower bandwidths will require upgrading of aircraft and ground equipment. While aircraft flying at over 24,000 ft will have narrowband equipment through international agreement (under ICAO), it would seem appropriate to encourage the use of narrowband equipment on the ground through pricing.

It can be noted that there is a requirement for the protection from interference for radiometers associated with meteorological measurements. Generally receive-only terminals are not afforded explicit protection but this is likely to be requested by one user and consideration should be given to offering such protection.

Other bands

The Hong Kong Frequency Allocation Table identifies some parts of the 9.8 – 10.7 GHz band as "to be planned". Fixed and radiolocation services use some parts of the band but 500 MHz of bandwidth is available for use.

Looking beyond IMT-2000 (i.e. at 4G systems) it can be noted that the frequency range extending from above the 3G expansion band at 2.5 – 2.69 GHz up to 5 GHz is being considered, but excluding aeronautical, meteorological and radar bands. Bands falling under scrutiny therefore include 3.4 – 4.2 GHz and 4.4 – 4.99 GHz, the former currently used as a satellite downlink band and the latter by government mainly for fixed links.

2.10 Longer term issues

Sharing

Increasing use of the spectrum inevitably leads to a requirement for systems to share, whether the systems are of the same type or whether different services are involved. Depending on the circumstances (i.e. the characteristics of the systems) sharing at one extreme is easy, requiring minimal co-ordination between services, and at the other extremely difficult if not impossible. When sharing is relatively easy it is straightforward for the regulator to put co-ordination procedures into place. However, with more intense use of the spectrum, which can be expected over the coming years, it is more likely that sharing situations will fall into the difficult if not impossible category.

There is currently active debate going on in Hong Kong regarding the possible introduction of Broadband Wireless Access (BWA) in the band 3.4 – 3.6 GHz which is used for satellite downlinks and is often referred to as "Extended C-band". It can be shown that sharing between these services falls into the difficult if not impossible category. However, the international BWA community has identified this frequency band as one of the possibilities for BWA implementation and the regulator is therefore required to make a decision as to whether BWA operations can be permitted. In circumstances such as this, and for similar circumstances that will increasingly arise in the future, the regulator needs to have a clear and transparent mechanism for deciding what allocations should be made.

In the more distant future (10-15 years hence) it is anticipated that cognitive radio will improve the degree to which sharing is possible. This technology will enable a radio device to sense and adapt its behaviour according to the environment in which it operates. The cognitive functions are performed by applying a process where a sequence of 'observe', 'orient', 'decide' and 'act' is implemented. The implementation of cognitive concepts is likely to be through a software defined radio (SDR) architecture. Such an architecture will provide the ability to reconfigure radio operating parameters which therefore makes it attractive for addressing the adaptability component of cognitive radio technology.

Cognitive radio already exists in a rudimentary form. In the case of Radio Local Area Networks (RLANs) designed to operate in the newly opened 5 GHz bands[17] there is a requirement to implement Dynamic Frequency Selection (DFS). Indeed, without this requirement the 5 GHz bands would not have been opened to RLANs. Historically large parts of the 5 GHz bands have been used by radars (often military and therefore having security implications). In order to satisfy the incumbent users of radar, RLANs are required to detect whether a radar is operating nearby and if so move to another channel (and carry out the test again until a vacant channel is found). From a spectrum management point of view this requirement is relatively easy to specify on paper. However, it has already been seen that some regulators are nervous about the effectiveness of the technique and are awaiting the results of tests to demonstrate whether devices will prevent interference from occurring or not.

Another example of the application of cognitive radio in a basic form comes from the FCC proposal[18] to allow the operation of licence-exempt devices in the TV broadcast bands (VHF and UHF).

One of the rules proposed by the FCC states that:

> *Devices operating under the provisions of this section shall be equipped with a means to automatically and periodically transmit a unique identification signal. Devices must not be equipped with any controls accessible to any party, other than a professional installer, that allow selection of the transmit channel or output power. Devices must include features to ensure that only the software that was approved with a device can be loaded into a device, and the software may not allow the user to operate the device with parameters outside those that were approved. "Software" in this context includes the software that selects a device's operating frequency, software used in determining a device's geographic location or identifying TV channels that are vacant, and to the information in the database accessed by a device. Devices must incorporate a means to detect whether tampering with the hardware or software has occurred and must not operate if tampering is detected. The application for certification must describe how the device complies with these requirements.*

This rule highlights one of the major concerns associated with cognitive radio. While it is recognised that the bona fide application of cognitive radio will undoubtedly improve the possibilities for spectrum sharing, it is also recognised that the technology could be open to misuse, either accidental or deliberate, thereby potentially causing interference rather than avoiding it. Procedures will need to be put in place to control this problem. It is however a world wide issue and solutions to the problem will emerge.

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[17] It is noted that these bands have already been made available in Hong Kong under the Telecommunications (Telecommunications Apparatus) (Exemption from licensing). CAP106Z.

[18] Notice of Proposed Rule Making (NPRM) FCC 04-113 in the Matter of Unlicensed Operation in the TV Broadcast Bands (Adopted: 13 May 2004, Released: 25 May 2004).

Standards

When addressing standards it is important to distinguish between standards that specify every aspect of network operation from the physical layer right up to the application level and standards which restrict themselves to the physical layer (often called interface requirements). The purpose of these two types of standard is different. The complete standards, if open rather than proprietary, generally provide interoperability and are particularly important for mobile/nomadic roaming and for the creation of a regional or global market. The physical interface standards are perhaps of more interest to regulators involved in spectrum management. While in the past spectrum managers have sometimes relied on specifying complete standards for particular spectrum usage it is more common now to aim for at least a degree of technology neutrality by simply defining the RF characteristics (the physical layer). In the longer term specifying the radio interface in a completely neutral way can allow for application as well as technology neutrality. This is one of the objectives of completely liberalised spectrum use as discussed later.

Another important aspect, and one that arises where technology neutrality is not the main focus, is that it is not always clear how to accommodate international standards where these have a significant external influence. However, there is the potential that standards will emerge elsewhere and will, through established use elsewhere, become associated with particular frequency bands. If these frequency bands are already in use locally by other services, the regulator then has to determine an appropriate course of action. In a completely liberalised environment it can be argued that the market will make the spectrum available through trading and change of use and the standards used will be decided by the market. However, in the case where complete liberalisation is not achieved it is necessary for the regulator to have a clear refarming policy based on a stated set of cost-benefit principles.

Licence exempt spectrum

Licence exempt spectrum is available for a wide range of applications, from private and public wireless data networks to short range devices for applications such as RF Identification (RFID) tags, road tolling and medical devices.

The success and continuing development of Wi-Fi has brought the question of how much spectrum should be made available on a licence-exempt basis to the fore.

It is clear that current licence-exempt technologies are very good at sharing spectrum and the sharing will likely become more sophisticated as technology evolves (e.g. cognitive radio). However, with no control on the number of devices using a given frequency band it is probable that congestion will occur. Although there is evidence in some countries of congestion occurring in the 2.4 GHz band (hotspots in densely populated urban areas) little immediate concern is being expressed by regulators as users are expected to migrate to the newly opened 5 GHz bands should the quality of service become unacceptable.

The satisfactory situation regarding the migration path from 2.4 GHz to 5 GHz has been arrived at largely due to the representations of manufacturers with only a little planning from regulators whose main activity has been to determine whether interference is likely to occur rather than how much spectrum is required. In the future a more rational approach to determining how much licence-exempt

spectrum should be made available will be required. Undoubtedly pressure will continue to be exerted by manufacturers and interest groups and this pressure is likely to be global in nature. However, in establishing an appropriate balance between licensed and licence-exempt spectrum, the regulator should have a view as to what capacity is really required based on a measure of occupancy, what the economic benefits of licensed v. licence-exempt spectrum are, and what the Quality of Service (QoS) implications are.

It is not easy to arrive at a balanced view on this issue as the three factors noted above are inter-related and furthermore, there is limited knowledge regarding user QoS expectations when considered in association with adaptive technology.

Another key growth area for licence exempt spectrum in the future could be intelligent transport systems, such as anti-collision radars operating in the 24 GHz band and at frequencies above 50 GHz, and applications such as automatic toll collection in bands around 5 GHz.

Underlay and overlay

Underlay and overlay are terms used to describe opportunistic uses of the spectrum generally on a licence-exempt basis.

Underlay operations are based on very low power density levels at or near the noise floor so in theory no interference is caused to existing (licensed) users of the spectrum. The prime example of this is Ultra-Wide Band (UWB) although some would argue that there is the potential for interference to existing users of the spectrum.

It is noted that Hong Kong has released the band 3.1 to 10.6 GHz for technical trials of UWB technology. The permitted power level is -33 dBm/MHz, 10 dB higher that the US limit. Furthermore, whereas indoor trials are permitted to use the whole 3.1 to 10.6 GHz band, outdoor trials are constrained to 4.2 – 10.6 GHz. It is assumed that this distinction is to protect satellite receive terminals that are prevalent in the band 3.4 – 4.2 GHz, especially given the power level is 10 dB higher that the FCC limit which has not necessitated such a distinction. In Europe, where C-band satellite operations are not widespread (Mobile Satellite Service feeder links being an exception) the concern is initially directed towards indoor operations in the range up to 4.2 GHz and possibly for future systems up to 4.8 GHz or 5 GHz. In this lower part of the UWB spectrum it is proposed that UWB devices should have a Detect And Avoid (DAA) mechanism to prevent them operating at full power near a Broadband Fixed Wireless Access (BFWA) antenna placed on a desk top for example.

In the case of overlay operations the power levels used are at a more conventional level and therefore have the ability to interfere with existing users of the spectrum. In order to avoid causing interference to existing users spectrum is used on an opportunistic basis when it is not being used by others in time and/or geography. Knowledge of other spectrum users is essential and cognitive radio (discussed earlier under sharing) has a key role to play here.

Both underlay and overlay rights have the potential to cause interference and it is therefore important that rules and procedures are put in place to manage their introduction. Traditional spectrum management effectively specifies users rights in terms of what they are able to transmit and not in terms of their receive rights (except the ability to complain about harmful interference, an ill-defined measure).

Spectrum users have an expectation as to the levels of interference that they might reasonably expect from other spectrum users. If spectrum management is to become more liberalised it will be important that underlay and overlay rights are considered as part of that process.

2.11 Conclusions

It is clear that there is spectrum congestion in Hong Kong both from a technical point of view and in terms of unsatisfied demand for allocations associated with fixed links, mobile and broadcasting. Future demand for spectrum, particularly by new applications emerging around the world will undoubtedly lead to an increasing number of situations where the potential for congestion has to be resolved.

Traditional approaches to spectrum management require the spectrum regulator to predict the market and to make provisions accordingly. This is easier when there is no congestion. In the case where there is competition for spectrum the regulator is in a difficult position in terms of managing the market. This leads to the overall conclusion that more effective approaches to spectrum management are required. There is a growing opinion that greater flexibility in spectrum usage can be obtained by allowing the market to decide how it is best used thereby obtaining greater economic efficiency. In order to do this the spectrum has to be packaged and opened to market trading and liberalisation. These market mechanisms are discussed in greater detail later in this report.

An overall regime that applies market mechanisms for managing the spectrum also has to accommodate some of the issues identified in the sections above, in particular how to encompass underlay and overlay rights, how to decide on the provision of licence-exempt spectrum, and how to manage harmonisation where this is required.

3 Current Spectrum Policy

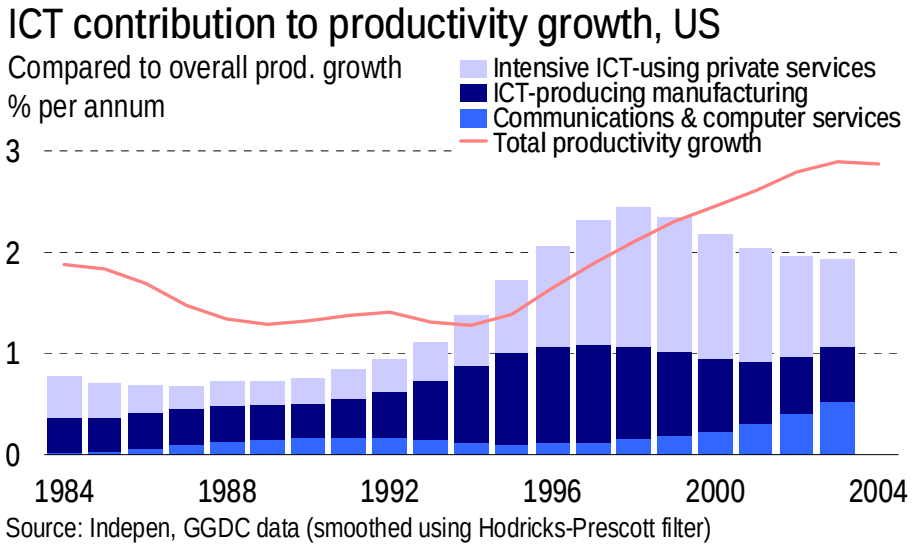
3.1 Introduction

This chapter describes the policy context for this study and international developments in spectrum policy. Our comments are based on a review of relevant legal and policy documents and interviews with 49 spectrum users, OFTA and CITB.

We start from the position that it is important to get spectrum planning and management right in order to support wider economic and social goals for Hong Kong. Spectrum is a critical input for future innovation and growth in the communications sector and there is now overwhelming evidence to show that communications, as a part of the ICT sector, is one of the key drivers of productivity and hence long term economic growth (see Figure 3.1).

What this means is that if spectrum is not managed in a way that supports the development of the communications sector then there is a risk of falling behind economically. Spectrum management can no longer be treated as an obscure technical area, rather it is a critical part of any national communications strategy and so needs to be at the heart of policy making.

Figure 3.1 ICT contribution to productivity growth in the US



3.2 Policy framework

Current position

The legislative framework for spectrum management is set out in the Telecommunications Ordinance (TO) and the associated regulations and guidelines. Responsibility for management of all spectrum lies with the Telecommunications Authority (TA). Under Section 6A of the TO, the Secretary for Commerce,

Industry and Technology (the Secretary) may give written policy directions to the TA pursuant to which the TA is to carry out its functions and exercise its powers.

Under the TO (section 32G) the TA is required to "promote the efficient allocation and use of the radio spectrum as a public resource of Hong Kong". The TO does not give any other specific objectives for the development of spectrum policy. Although the relevant legislation provides little guidance, the broadcasting and telecom regulators have articulated their policy positions and the overall government position is set out in the mission statement of the CITB, and the government's digital strategy. [19] Whilst under the TO the Secretary may issue written policy directions to the TA under Section 6A of the TO, so far no directions concerning spectrum policy issues have been issued.[20]

Policy objectives in respect of telecommunications are as follows. The TA's vision statement indicates that its role is to enable Hong Kong to have an advanced telecommunications infrastructure and the best telecommunications services to meet the Challenges of the Information Age. The vision states that the "regulatory regime is pro-liberalisation, pro-competition and pro-consumer, providing a regulatory framework which ensures that the widest range of quality telecommunications services is available to consumers at reasonable prices".[21]

In parallel with this, the Broadcasting Authority (BA) seeks to create an attractive, dynamic and highly competitive broadcasting hub in Hong Kong.[22] In respect of OFTA's spectrum management activities the following objectives of the BA are particularly relevant[23]

- Widen programming choice to cater for the diversified tastes and interests of the community
- Encourage investment, innovation and technology transfer in the broadcasting sector
- Ensure fair and effective competition in the provision of broadcasting services
- Promote Hong Kong as a regional broadcasting and communications hub

Spectrum management policies and decisions should support these overarching objectives.

The TA's overall approach in making specific spectrum allocation and assignment decisions is intended to be market led and technology neutral[24], albeit within a traditional command and control legislative framework. There is an inherent tension here as a market-led approach requires greater flexibility and transparency

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[19] Digital 21 Strategy, CITB, March 2004

[20] Provisions for Ministers to give Directions to regulators exist and are used in other countries including Denmark, New Zealand and the UK.

[21] OFTA Annual Report 2004/05, www.ofta.gov.hk/en/trade-fund-report/0405/html/full.htm. See also the objectives listed on OFTA's website.

[22] www.hkba.hk/en/annula/vision.html

[23] www.hkba.hk/en/policy/overview.html

[24] See for example recent consultations on 2G licence renewal and licensing BWA services

(together with suitable controls to deal with market failure) than a regime based on command and control mechanisms. This study is intended to address this issue and propose a suitable way forward.

Issues

Under the TO the regulator has a single objective, namely to promote the optimum use of the radio spectrum, but this needs elaboration if it is to be useful in guiding specific policy decisions.

While the TA's consultations do articulate a range of policy objectives, the absence of a consistent statement of relevant considerations and the absence of a stated spectrum strategy may create unnecessary misunderstanding or confusion.

This increases the uncertainty faced by businesses investing in wireless services and so potentially reduces investment in the sector. Comments to this effect were made in the industry interviews. Although no concrete examples of delayed or abandoned investments were given in the stakeholder interviews, we note that regulatory uncertainty can lead less directly to reduced investment via a down rating of shares in companies that undertake investment. Emphasising the importance of regulation in determining sector investment, Credit Suisse First Boston have noted that "*US telecoms regulation is relatively more supportive to the network operators, following the ending of broad support for unbundling in the US and having more support for consolidation. In Europe, the EU is much more protective of the consumer. Furthermore, US telco regulatory policy has becoming more supportive of investment in the last three years, and an important part of the recent turn around in the US sector*." [25]

These issues will become more acute as telecoms and broadcasting converge and if the telecommunications and the broadcasting regulators are merged. In Chapter 4 we discuss the policy framework that is required for spectrum management in future.

3.3 Allocation and assignment of radio frequencies

Current position

Allocations

The TA manages all spectrum use in Hong Kong. Information on spectrum allocations in Hong Kong is made publicly available in the Hong Kong Table of Frequency Allocations (HKTFA). This contains information on the Region 3 allocation, the Hong Kong allocation and the mix of uses in the band and, in some cases, the frequencies allocated to each use.

Policy initiatives that will be undertaken by the CTB and OFTA for the period July 2005-June 2007 are published and these include spectrum related activities: specifically analogue to digital terrestrial TV migration, the framework for the

[25] Credit Suisse, Europe Telecommunications Services, Q2 2006 Update, 6 April 2006, p.17.

deployment of BWA and the commissioning of this study.[26] In addition, OFTA publishes an annual statement of the major tasks and projects it intends to undertake in the year ahead and these include numerous spectrum related activities.[27]

OFTA does not produce a statement of its plans for future release of spectrum. However, it often brings position papers on allocation and other issues to the Radio Spectrum Advisory Committee (RSAC) for discussion in advance of formal consultation. The papers submitted to the RSAC are published as are the agendas and meeting minutes. This gives a degree of transparency concerning OFTA's plans, however, industry participants would like to see more information on existing spectrum use, currently available spectrum and future spectrum releases in the public domain so that they can better plan their wireless investments and make better informed decisions concerning which spectrum they should bid/apply for.[28] For example, OFTA may release a number of frequency bands at 2GHz that could be used to provide potentially competing mobile broadband services.

The allocation and re-allocation of the use of spectrum is decided by the TA in consultation with industry, other interested parties and the RSAC. There is no requirement to undertake impact (or cost benefit) analysis for allocation decisions though we understand this is sometimes done informally by OFTA.

The majority of allocations to licence exempt use are designated in an order issued under the TO.[29] As a general rule the bands conform to internationally harmonised bands for licence exempt services in Region 3. In addition, under the government's policy to promote Hong Kong as a regional broadcasting hub TVRO systems are generally licence exempt.

Assignment

As is common with many other spectrum management administrations OFTA does not make detailed assignment information publicly available. However, some industry participants thought there could be value in making such information publicly available so that they would be better informed about what might be available when they apply for frequencies.

Administrative arrangements for making assignments differ for government users and non-government users. Government users are not licensed but are issued a letter from the TA setting out the transmissions they are permitted to undertake and they are required to pay charges to cover the TA's administrative costs on the same basis as non-government users. The defence forces self manage their frequencies allocated by the TA under a memorandum of understanding with the TA.

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[26] http://www.citb.gov.hk/about/policy.htm

[27] http://www.ofta.gov.hk/en/aboutOFTA/majortasks_05-06.pdf

[28] We obtained this feedback in industry interviews. In addition 13 industry participants have made their views clear in their joint letter to the regulator dated 21 November 2005.

[29] Telecommunications (Telecommunications Apparatus) (Exemption from Licensing) Order, CAP 106 sub. Leg.Z. There is another order for exempting radio receivers – Telecommunications (Radio Receivers)(Exemption From Licensing) Order sub leg. P.

Non-government users of spectrum are licensed and pay charges to cover OFTA's administrative costs. The licensing arrangements for use of the spectrum differ somewhat between operators providing a public communications service (fixed or mobile) and other users. The former are issued a carrier licence[30] or a public radiocommunications service (PRS) licence / public non-exclusive telecommunications service (PNETS) licence and the frequencies they may use are itemised in a schedule to their licence. Other users are issued with a licence relevant to a specific application (e.g. broadcast relay station licence, aircraft station licence, private radio paging system licence, demonstration licence, experimental station licences and so forth). Guidelines on how to apply for a licence and the criteria applied to award them are issued under section 6D(2)(a) of the TO.[31]

In bands where there is no excess demand, frequencies are generally assigned on a first come first served basis after applicants have demonstrated their "need" for frequencies. OFTA's rationale is that spectrum is a limited resource and should be assigned on a needs basis. For example, in the case of applications for a licence to provide a microwave link, the applicant is required to show there is no wired alternative that could be used.

In bands where there are competing demands for spectrum, OFTA originally assigned licences using a beauty contest but since 2001 its policy has been to assign licences by auction. In the case of broadcasting and government use, frequencies are reserved for these purposes. The period of validity of carrier licences is prescribed by the Secretary under the Telecommunications (Carrier Licences) Regulation (Cap.106V). Fixed carrier licences and mobile carrier licences are valid for 15 years. For licences other than exclusive licences and carrier licences, the TA may determine the period for which the licences are valid.[32] Under section 32H(3) of the TO, the TA may vary or withdraw frequencies which have been assigned to a licensee by giving reasonable notice to the licensee concerned of the intended variation or withdrawal.

Licence fees

As mentioned above all licensees pay licence fees that are intended to recover OFTA's costs of managing the spectrum (and to earn an 8.5% return on capital under the trading fund arrangements[33]). These fees are payable on the issue or renewal of licences and the structure of fees varies by licence type. Fixed link fees depend on the bandwidth and frequency used, with lower fees per MHz applying in the less congested, higher frequency bands. In the case of mobile services fees depend on the bandwidth used and the number of transmitting and receiving

[30] Or its antecedents the FTNS and PRS licences.

[31] See www.ofta.gov.hk/en/legislation/guideline_6d_2a/main.html

[32] Section 7(6) of the TO.

[33] This rate of return is applied to annual net fixed assets, excluding interest earnings.

stations/outlets/receiving units but do not vary with frequency band.[34] In other cases a single fixed fee is generally paid.

In addition, the TA may designate bands for the application of a spectrum utilisation fee (SUF), and the Secretary for Commerce, Industry and Technology may by regulation prescribe the level of SUF or the method for determining the SUF, for example by auction or tender.[35] At present frequency bands designated as subject to the payment of an SUF comprise bands used for 2G and 3G mobile services.[36] The level of SUF or the method for determining the SUF is prescribed in regulations made by the Secretary[37]. There are no general guidelines in the TO setting down the factors to be considered by the TA in deciding to impose an SUF or by the Secretary in making a regulation on the appropriate method for determining an SUF.

So far OFTA has held one auction – namely that for 3G licences which took the form of a royalty auction in which bidders paid the maximum of a fixed reserve price or a percentage of network turnover.[38] In the event, the number of bidders equalled the number of licences offered and the reserve price and royalty level applied.

The SUF for 2G licences, which was set for 2G licences renewed in 2005, has the same general form as that for 3G licences – namely a fixed minimum sum and a royalty (5%) where the licensee pays the larger of the two (after an initial five years in which the fixed fee only is paid). The level of payments is at present lower for 2G as compared with 3G licences. In setting the 2G SUF the government took account of the fact that 3G equipment was not yet available on 2G spectrum at the time the 2G licences were renewed. In order to maintain a level playing field in the mobile market, a transitional period of 5 years should be given to 2G operators. The government took the view that towards the end of the 5-year transition period, the gap between the capabilities of 2G and 3G networks would narrow gradually and ultimately converge, and so the SUF structure for 3G spectrum auctioned in 2001 could then be applied to both 2G and 3G operators. More recently, in the case of BWA licences at 3.5 GHz OFTA proposed that a simultaneous multi-round auction should be conducted with all payments made as an upfront lump sum.

Issues

The following matters are not well defined within the current allocation and assignment processes:

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[34] Schedule 3 of the Telecommunications (Carrier Licences) Regulation (Cap 106V) and "Period of Validity and Licence Fees determined by the Telecommunications Authority, Issue 8, January 2006".

[35] See Section 32I of the TO and the associated regulations.

[36] Telecommunications (designation of frequency bands subject to payment of spectrum utilisation fee) order, CAP 106 sub.leg.Y

[37] Telecommunications (Method for Determining Spectrum Utilization Fees)(Third Generation Mobile Services) Regulation (Cap.106X) and Telecommunications (Level of Spectrum Utilization Fees) (Second Generation Mobile Services) Regulation (Cap.106AA).

[38] The auction was preceded by a pre-qualification stage.

- What spectrum is potentially available for release to the market
- How the TA will make allocation and re-allocation decisions
- When the TA will decide to release additional spectrum into the market
- What factors will determine how spectrum released will be packaged
- How much notice the TA will give in the case of variation or withdrawal of frequencies
- Which bands an SUF will be applied to, other than those auctioned, and how it will be determined

Uncertainty around these issues is not untypical of a command and control management regime. A spectrum strategy and associated policies that address the issues listed above are required.

A specific issue that has arisen in the context of applying the current SUF for 3G and 2G licensees concerns its formulation as a royalty payment, where the royalty is expressed as a percentage of network turnover. As network turnover rather than "gross turnover" is the basis for calculation of SUF, the "revenue streams" that are included in the calculation of SUF may therefore be different for different operators as each operator would have its own business model. The situation becomes more complicated when licensed telecommunications services are provided to the licensee's other businesses. In this case, these services must be charged at transfer prices that cover at least the cost of providing the goods and service.[39] This means both OFTA and licensees have to expend considerable administrative effort in determining the level of SUF payments.

Finally, we note that the current licensing framework in which use of spectrum is tied to the provision of particular services is not well suited to an environment where licences are tradeable and where spectrum use is liberalised.

3.4 Interference management

Interference is managed through technical parameters given in licences and associated guidelines, legal instruments (for licence-exempt spectrum), enforcement activities and international co-ordination of frequency use with other countries including Mainland China.

Technical controls

Technical parameters are typically specified in the schedule to the relevant licence. For example, schedule 1 of the PMR apparatus licence includes details of the assigned frequencies, frequency tolerance, radiated power, ITU emission code and antenna characteristics. EIRP and modulation requirements are similarly specified in the class licence for public WLAN systems. For licence exempt systems, the technical criteria are specified in schedule 2 of the Telecommunications (Telecommunications Apparatus)(Exemption from Licensing)(Amendment) Order 2005, on a band-by-band basis.

This approach is consistent with that used by other regulators around the world and should provide adequate protection from interference under the existing

[39] Section 2 of Cap.106X and Cap.106AA both provide a definition of "network turnover".

allocation regime, however the parameters specified tend to be specific to the type of system licensed. A more generic approach, perhaps involving the definition of spectrum masks rather than specific emission characteristics, may be appropriate if a more liberalised regime is adopted.

Enforcement

Enforcement activities are undertaken by OFTA in order to ensure compliance with the TO and/or licence or licence exemption conditions and to avoid interference to licensed users. Interference cases requiring enforcement action are relatively rare but there have been instances of deliberate interference to PMR systems which have required action to be taken.

A person who knowingly and without lawful excuse uses an apparatus in a manner that causes harmful interference with any lawful telecommunications service or apparatus, commits an offence under section 32J and shall be liable for a fine at level 5 and to imprisonment for 6 months. The equipment involved may also be subject to forfeiture under section 36 of the TO. In addition to section 32J, licensees are also obliged under licence conditions to take reasonable measures not to cause any harmful interference (see, for example, General Condition 9 of Fixed Carrier Licence). Where a licensee fails to comply with the TO or a licence condition, the TA may impose a financial penalty of up to $200,000 for the first occasion, $500,000 for the second occasion and $1,000,000 for any subsequent occasion, to the licensee under section 36C. The TA may also issue directions under section 36B requiring the licensee to take necessary action to comply with the provisions of the TO and the licence conditions.

In industry interviews it was noted that some interference issues arose from signal spillover from Mainland China and we understand that this is addressed through border monitoring and discussions with the neighbouring authorities.

Where interference cannot be resolved, the TA may consider varying the frequencies assigned to the licensee, but co-ordination and enforcement actions are usually successful in resolving such situations.

Frequency co-ordination with Mainland China

Frequency co-ordination takes place under a bilateral agreement with Mainland China which specifies the frequency parameters that will be exchanged and frequencies that will be co-ordinated to avoid interference. In general for services having a wide coverage mutual interference might occur (e.g. broadcasting services). The frequencies concerned are shared between Hong Kong and the neighbouring Chinese province of Guangdong on roughly an equal basis.

In future Hong Kong is seeking to align its frequency plan with that in Mainland China to improve service coverage in border regions and for technical efficiency and longer term economic reasons. However, because Hong Kong has been ahead in the use and deployment of frequencies, allocation decisions have been taken on a case by case basis depending on the relative costs and benefits to Hong Kong. It is sometimes the case that the development of Chinese standards and frequency allocations for new services lags developments elsewhere in Asia, Europe or the US and in these circumstances there may be benefits from Hong Kong aligning its spectrum use with international use in countries other than Mainland China.

Issues

We have not identified any major issues in this area but note that the frequency use decisions adopted by Mainland China must be taken as a constraint on spectrum policy in Hong Kong.

3.5 International developments in spectrum policy

The economic importance of wireless communications has increased rapidly in the last ten years. Technology change, rapid growth in demand for wireless (particularly mobile) communications and possibility of wireless communications providing competition to wired platforms are leading governments to consider changing their approach to spectrum management policies. Governments are seeking policies that better promote rapid development of the communications sector, the secure provision of public safety and defence services and more generally promote overall economic growth through the widespread adoption of information and communications technology (ICT).

There have been a number of surveys of international developments in spectrum management[40] which we draw on in this report (but do not seek to replicate) together with our own experience. Important recent initiatives in spectrum management taken by other countries are as follows:

- In the US, the Federal Communications Commission's (FCC) Spectrum Policy Taskforce developed recommendations for improving the way the radio spectrum is managed.[41] This report advocated increased reliance on market oriented reforms together with increased use of a spectrum commons model i.e. more licence exempt and shared use of spectrum. Since the report (in 2002) the FCC has initiated rule makings to further liberalise spectrum use and to introduce secondary spectrum markets (through spectrum leasing)[42] and has continued its programme of spectrum auctions. A Notice of Proposed Rulemaking has been issued permitting licence exempt activity in the VHF and UHF bands for intelligent low power transmitters that "hear before they talk" and fill the "white space" in this spectrum. In 2004, the President's spectrum policy initiative developed recommendations aimed at modernising the management of government use of spectrum and this has been followed by legislation and rule makings to facilitate the auction of certain bands currently allocated to government use. The auction proceeds are used to pay for

[40] "Study on conditions and options in introducing secondary trading of radio spectrum in Europe", Analysys et al, for the European Commission, 2004 "Towards more flexible spectrum regulation", WIK, Federal Network Agency, Germany, 2005; Consultation on a Renewed Spectrum Policy Framework for Canada and Continued Advancements in Spectrum Management, Industry Canada, May 2005.;"Radiocommunication Inquiry Report", Productivity Commission, Australia, 2002. "Review of Radio Spectrum Policy in New Zealand, Ministry of Economic Development, 2005; Spectrum Policy Task Force, Report, ET Docket No 02-135, November 2002, FCC and http://wireless.fcc.gov/licensing/secondarymarkets/

[41] Spectrum Policy Task Force, Report, ET Docket No 02-135, November 2002, FCC

[42] http://wireless.fcc.gov/licensing/secondarymarkets/

government users' moving costs.[43] Finally, the US government has recently indicated (in its 2007 budget plan) that it plans to allow the FCC to set "user fees" on spectrum that has not been auctioned so as to promote efficient spectrum use taking account of public interest and spectrum management principles.[44]

- In the European Union (EU), the European Commission has made moves towards the development of a policy to promote more flexible use of spectrum and greater use of market approaches to spectrum management. The Commission has emphasised the need for "a gradual but systematic liberalisation of radio spectrum use" with a view to introducing spectrum trading and more flexible spectrum use in the period up to 2010.[45] The strategy[46] is aimed at ensuring a common approach to managing spectrum resources at the EU level to allow innovators to place new technologies on the EU single market quickly and with legal certainty. It has been estimated that secondary trading together with liberalisation could yield net consumer benefits of €9bn per annum in the EU.
- It is important to note that the European Commission's policy does not currently have the force of law in Member States and individual Member States are undertaking their own initiatives. For example, the Czech Republic, Denmark, France, Netherlands and Sweden have considered allowing trading and liberalisation of spectrum use, while other countries have not. The most detailed work on trading and liberalisation issues and the most progress on implementing these policies has occurred in the UK.
- In the UK, the regulator Ofcom has set out its strategy for increased use of trading and liberalisation of spectrum use,[47] making additional spectrum available for licence exempt use and its plans for spectrum release over the next 2-3 years. Spectrum trading was introduced in 2004 and applications for liberalised spectrum use will be assessed by Ofcom on a case by case basis until a general regime has been developed. Spectrum pricing for spectrum not auctioned has been in place for some time. In addition, the UK government has recently completed a review of ways to strengthen incentives for efficient spectrum use by government users.[48]
- In Canada, the government has initiated a consultation on its objectives and policy guidelines for spectrum management and on opportunities to improve

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[43] Spectrum Policy for the 21st Century – the President's Spectrum Policy Initiative: Reports 1 and 2, June 2004

[44] http://www.whitehouse.gov/omb/budget/fy2007/other.html

[45] European Commission. June 2005. "A forward-looking radio spectrum policy for the European Union: Second Annual Report." COM (2005) 411.

[46] European Commission. 29 September 2005. "Commission proposes advancing single market for radio spectrum use." IP/05/1199.

[47] Spectrum Framework Review, Ofcom, June 2005; Spectrum Implementation Plan – Interim Statement, July 2005, Ofcom

[48] Professor Martin Cave. December 2005. "Independent Audit of Spectrum Holdings" http://www.spectrumaudit.org.uk/final.htm

Canada's spectrum management system.[49] Canada has already implemented technology neutral spectrum access in a number of bands and in the cellular and PCS bands licences are tradeable and divisible. The consultation considers the extension of these arrangements to other users, spectrum leasing, relaxing regulation of licence exempt use and streamlining existing processes (e.g. allowing more operator to operator co-ordination across international borders).

- Japan's $70 billion mobile market has been an oligopoly led by three mobile service players (ie NTT DoCoMo, KDDI and Vodafone KK, now Softbank) for twelve years. This has suppressed the domestic demand of spectrum use for other competitive/substituting wireless applications. This changes in 2006, when the first (Yozan) of four new entrants will launch service (see Figure 3.2 below). All operators are using new wireless technologies, from WiMAX to TDD to HSDPA, and all expect to benefit from the introduction of Mobile Number Portability (MNP) in September 2006. Before these most recent changes, the government has reviewed and rejected the use of auctions and trading, partly because it is believed than a higher density of use can be achieved under a command and control regime and because most licences have a relatively short five year duration which limits the value of market mechanisms. However, since the end of 2005 it has applied spectrum pricing to commercial spectrum use below 6GHz to promote efficient use of spectrum and in particular to refarm spectrum for new services (e.g. new 4G services). Spectrum fees are now related to spectrum used and congestion.[50] Around 30% of the money raised from spectrum pricing is used to partially compensate users for moving to less congested frequency bands or alternative services, to fund research into advanced radio technologies (e.g. cognitive radio) and to extend broadband services to rural areas. In addition, selective liberalisation has been implemented with the adoption of registration rather than licensing of spectrum use for selected services such as high power outdoor wireless LANs and by introducing more competition into the mobile market through the licensing of alternative wireless services (e.g. WiMAX).

[49] Consultation on a Renewed Spectrum Policy Framework for Canada and Continued Advancements in Spectrum Management, Industry Canada, May 2005.

[50] The approach to policy development is described in "Spectrum Policy in Transition", Phillipa Marks and Kiyotaka Yuguchi, Keio Communications Review, No 26, 2004.

Figure 3.2 Summary of technology rollout plans of the Japanese Players

	Core technology	Core technology coverage plan	WLAN	WiMAX
Yozan	Pager/WLAN/WiMAX	Fixed WiMAX evolving to mobile, supporting WLAN hotspots	8,000 APs planned by June 2006	Initially planned for backhaul, with standardised services offered when 2.5Ghz and 3.5Ghz spectrum is available
NTT DoCoMo	WCDMA/HSDPA	To launch HSDPA by Summer 2006	M-Zone service increasingly integrated with cellular offering	No plans announced
KDDI	CDMA 2000	Rev A to be introduced during 2007	n/a	Testing WiBro with Samsung: interested in the 2.5Ghz band to deliver converged services
Vodafone KK	WCDMA/HSDPA	Will launch HSDPA in 2006/2007	n/a	No plans announced
IPMobile	TD-CDMA	Tokyo, Osaka, Nagoya by Oct 2006, nationwide by 2010	n/a	n/a
eMobile	FDD - UMTS/HSDPA		n/a	Planned for 2009 launch, in sub 6Ghz spectrum
BBMobile	FDD- UMTS/HSDPA	15-20k base stations	820 'BB Mobile Point' Aps	Planned as a 'support' network for WCDMA/HSDPA, in 2.5Ghz spectrum

Source: Ovum, company data

- In Australia and New Zealand, systems of tradeable, flexible spectrum rights have been in place since 1993 and 1989 respectively. In both cases detailed reviews of the policies have been undertaken and improvements suggested to deal with problems encountered and extend the scope of the trading to additional frequency bands. In both cases these reviews concluded that continued use market based spectrum management was appropriate.[51]

In all of these countries the administrations are moving away from a traditional "command and control" management approach to one involving a greater involvement by spectrum users (particularly commercial users) and market processes in determining when and how spectrum is allocated and assigned. It is

[51] In Australia: "Radiocommunication Inquiry Report", Productivity Commission, 20002. In New Zealand: "Radiocommunications Act Review: Preliminary Conclusions", Ministry of Commerce, December 1995 and Review of Radio Spectrum Policy in New Zealand, Ministry of Economic Development, 2005 http://www.rsm.govt.nz/spp/review/report/index.html

important to recognise that in all cases changes are incremental with small but increasing amounts of spectrum being subject to market mechanisms. Changes have tended to be focussed on newly auctioned spectrum though in the case of spectrum pricing, this applies more widely to other bands.

There are a number of reasons why these changes are occurring.

Firstly, the economic importance of decisions made is increasing. This means there has been much more attention given to using market mechanisms where these are likely to result in improved economic performance of the communications sector (i.e. increased innovation, investment and competition). Where market solutions are not appropriate (e.g. where there are overriding policy objectives such as those relating to broadcasting or government use) or where markets are unlikely to work as in the case of licence exempt use, other policy instruments have been adopted including cost/benefit analysis to support decisions and more rigorous questioning of the efficiency of existing spectrum use.

Secondly, the complexity of decisions that regulators need to make is increasing. Growing spectrum use often means new allocations and assignments can only be made if existing users are moved. Licence renewal or revocation is more contentious as licences grow in value and competition issues are becoming more difficult to determine as markets converge. In response to these developments regulators have sought to refer more decisions to the market via auctions, secondary trading and liberalisation of spectrum use. For example, spectrum may be auctioned on a technology and service neutral basis with the winning bidders determining their spectrum use subject to restrictions on interference. In other cases where spectrum is to be reallocated to a different use the regulator has required the new potential users (whether obtaining the spectrum through auctions or trading) to fund the relocation of existing users of the bands as an obligation of the auction/trade.

Thirdly, users are demanding greater transparency, certainty and rigour in their rights to use spectrum and in regulators' spectrum related decisions because of the substantial economic value at stake. Regulators have responded by articulating their spectrum policies more clearly (e.g. publishing strategies and policies), publishing more information concerning actual spectrum use and planned spectrum releases and linking decisions more clearly to their specific policy objectives.

Fourthly, there has been rapid growth in the development of technologies for low power uses (e.g. WiFi) and that allow radios to detect transmissions by others and avoid them (Radio LANs at 5.8 GHz).[52] This has led to pressure to allow low power devices into licensed bands (e.g. UWB) and to open up more frequency bands for licence exempt use. It has been argued that one reason for recent innovation in this area has been the absence of regulatory barriers and costs associated with licensing spectrum and some have therefore concluded that regulators should seek to remove licensing controls and speed up licensing processes where possible (e.g. by replacing licensing with a simple registration or notification of use).

[52] These technologies are a precursor to cognitive radio. Full implementation of cognitive radio, allowing dynamic sub-letting of spectrum and the concept of a spot or futures market in spectrum is likely to be a decade or more away, but elements of the technology are already in use, e.g. within some of the 802.16 (WiMax) standards and the increasing use of "listen before transmit" protocols.

3.6 Findings

The key findings from this chapter are as follows.

A more consistent and explicit set of policy goals and principles is needed to provide a framework for making transparent and predictable spectrum policy decisions that will support investment and innovation in the Hong Kong communications sector. At present it is not clear to spectrum users

- What spectrum is potentially available for release to the market?
- How the TA will make allocation and re-allocation decisions?
- When the TA will decide to release additional spectrum into the market?
- What factors will determine how spectrum released will be packaged?
- How much notice the TA will give in the case of variation or withdrawal of frequencies?
- Which bands an SUF will be applied to, other than those auctioned, and how any SUF will be determined?

The growing economic importance of the regulator's decisions in this area and the desirability of reducing regulatory uncertainty (in a context of considerable technology and market uncertainty), means stakeholders need a more predictable basis on which to plan. This can be assisted by the provision of clearer spectrum policies, more information on the regulator's plans and more integrated decision making across telecoms and broadcasting. To achieve this regulator needs adequate resource with economic, public policy and legal expertise in addition to engineering expertise.

These issues are affecting all countries with advanced communications markets. A common set of policy instruments for addressing them is emerging in Europe and North America, and to a lesser degree in some countries in Asia. These instruments have been implemented in varying degrees and have been mainly applied to commercial use of spectrum. They include

- a published set of policy objectives and principles for their application to spectrum management
- publication of a spectrum strategy that includes an overall direction for spectrum policy (including the balance between market and command and control mechanisms) and spectrum release plans consistent with that policy and polices for telecoms, broadcasting and the provision of essential services
- auctions to assign and in some cases allocate spectrum
- consideration of allocating more spectrum to licence exempt use to stimulate innovation and promote efficient spectrum use, and
- secondary trading and liberalisation of spectrum use, where judged appropriate.

There is also an awareness of the need to provide stronger incentives for efficient use of spectrum by public sector organisations while at the same time ensuring there is adequate spectrum available to meet national security, safety of life and other public policy purposes. Policies in this area are less well developed and relatively untried as compared with new polices applied to commercial use of spectrum.

4 Elements of a Revised Spectrum Strategy

The purpose of this study is to provide recommendations for Hong Kong's future spectrum strategy. Such a strategy would comprise

- A set of policy objectives and supporting principles
- A spectrum strategy including a spectrum release plan
- A set of specific regulatory tools for managing the spectrum, including administrative and market-based tools

In this chapter we provide recommendations on policy objectives and principles, the approach to developing a spectrum release plan and administrative tools for spectrum management. Market tools are discussed in Chapter 5 and details of the spectrum release plan are given in Chapter 7.

4.1 Policy objectives and principles

Policy objectives

The objectives of regulation, and the assessment of both market outcomes and implementation of regulation, act to incentivise the regulator's behaviour. Establishing explicit objectives, in statutes or other instruments, may serve a number of purposes including:

i. increasing the *clarity and predictability* of regulation since the publication (by government) of the objectives in a formal statement means that it is not possible for the regulator to change the basis for decisions. This also allows decisions to also be challenged on the grounds that they were not consistent with the objectives

ii. increased scope for regulatory commitment which is necessary to reduce problems in relation to time-inconsistency (the problem that once investors have invested in a sunk asset regulatory expropriation may be attractive *ex post* even though it is harmful when anticipated *ex ante*)

iii. as a focus for the development of an alignment within the regulatory organisation, based on a guiding strategy (for this purpose elaboration of a set of internal principles which apply the statutory objectives in practice may be necessary)

iv. to increase the legitimacy[53] of the regulatory institution and therefore predictability since a clear statement of objectives serves to increase understanding of the purpose of regulation by consumers, businesses and politicians.

[53] In terms of its perceived authority, rather than its legal authority.

For these reasons there is benefit in providing a more explicit statement of OFTA's objectives in respect of spectrum management.

The objectives for this study are to make recommendations that promote the following objectives

- To facilitate the most economically efficient use of radio spectrum with a view to attaining maximum benefit for the community
- To achieve technically efficient use of radio spectrum to facilitate the introduction of advanced and innovative communications services and strengthen Hong Kong's position as a telecommunications hub
- To fulfil Hong Kong's regional and international obligations relating to the use of spectrum
- To support Hong Kong's strategic position as a world city and the gateway between Mainland China and the world by facilitating the provision of key services in Hong Kong which are deployed or will be deployed, globally or in Mainland China
- To ensure that necessary spectrum is reserved for essential public services.

These objectives usefully expand on the TA's objective, under the TO, to "promote the efficient allocation and use of the radio spectrum as a public resource of Hong Kong" by taking into account specific objectives in respect of telecommunications, broadcasting and essential public services. To provide an overarching set of objectives for spectrum management in Hong Kong we suggest the objectives listed above are slightly modified to include reference to Hong Kong as a broadcasting hub (as is mentioned in the BA's objectives) and to explicitly refer to social objectives.

Recommendation 4.1: The objectives for spectrum management in Hong Kong should be as follows

- **To facilitate the most economically and socially efficient[54] use of radio spectrum with a view to attaining maximum benefit for the community**
- **To achieve technically efficient use of radio spectrum to facilitate the introduction of advanced and innovative communications services and strengthen Hong Kong's position as a telecommunications and broadcasting hub**
- **To fulfil Hong Kong's regional and international obligations relating to the use of spectrum**
- **To support Hong Kong's strategic position as a world city and the gateway between Mainland China and the world by facilitating the provision of key services in Hong Kong which are deployed or will be deployed, globally or in Mainland China**
- **To ensure that necessary spectrum is reserved for essential public services**

[54] By this we mean the promotion of economic and social welfare.

In the Hong Kong context these objectives would be promulgated through advice given by the Executive Council and made by the Chief Executive in accordance with Article 54 of the Basic Law. The TA would then have to take due regard to these objectives when exercising his statutory authority.

Below we give an example of the way in which the policy objectives might be applied to make an allocation decision. The example given concerns the analysis of the options for use of the spectrum released from the IS-95 CDMA system (i.e. 826.59-834.09/871.59-879.09 MHz) which may be packaged with some adjacent blocks (for example 834.09 – 837.5 MHz / 879.09 – 882.5 MHz).

Possible options for use of the spectrum include

- TV broadcasting including mobile TV. (This frequency range is used for broadcasting in Europe)
- Mobile services including CDMA 2000, GSM850 and UMTS850
- Ancillary broadcasting applications, such as wireless microphones
- "Do nothing" i.e. withhold possibly for later release.

In respect of TV broadcasting there are likely to be co-ordination issues with Mainland China which would limit the use of the band for this purpose. While the core band is not sufficient to support an 8 MHz TV channel (as is used in Hong Kong) the addition of adjacent channels could address this problem.

The co-ordination issues may be less severe with mobile TV because of the lower signal strengths and because systems (e.g. DVB-H and MediaFLO) can operate in bandwidths ranging from 5-8 MHz. However, the frequency range under consideration is not likely to be suitable for mobile TV because interference inside the terminals is likely to occur if the upper part of the UHF band is used because of its proximity to the GSM/CDMA mobile bands.[55] We therefore do not consider this option further.

In respect of mobile services, CDMA2000 services operate in this band in Mainland China and so users would have the opportunity to roam between the two areas with single band handsets. There would also be spectrum efficiency benefits relative to options in which a different technology operates in Hong Kong versus China. In respect of roaming, while the majority of subscribers in Mainland China[56] and Hong Kong subscribe to GSM networks and so already have roaming capabilities, there are around 30m CDMA subscribers in Mainland China and many Japanese and Korean CDMA subscribers who may not have roaming capabilities in Hong Kong when the migration period granted to the former CDMA licensee expires in November 2008. However, Korean handset manufacturers plan to develop dual mode CDMA2000-WCDMA handsets which should help alleviate the problem. We note that a study for OFTA on this issue found that the consumer benefits of a new CDMA operator would be "rather neutral". [57] This is because the new operator is

[55] Frequencies below 700 MHz are preferred for this reason. Filter design becomes more complex above these frequencies.

[56] At the end of Q1 2006, approximately 91% of subscribers in Mainland China were on GSM networks.

[57] "Study on the Hong Kong mobile market for 2G licence renewal: prospect for a new mobile licence in the 800 MHz spectrum band", Spectrum for OFTA, November 2004

estimated to have little impact on the development of the data market and no advantage in terms of in-bound roaming.

GSM850 services operate primarily in the US, and Motorola supplies a quad-band GSM phone that will operate in this band as well as 900, 1800 and 1900 MHz bands. However, GSM users in China or Hong Kong are unlikely to have such multi-band phones so only limited roaming is likely to be feasible. GSM850 is a 2G technology so its data capabilities will be more limited than CDMA2000, however, this shortcoming can be addressed by UMTS850 services and so we do not consider this option any further.

UMTS (or WCDMA) is able to utilise the 850MHz spectrum, however deployment in this band is currently limited. Cingular (USA) launched an UMTS850 network in December 2005, though the coverage is still limited. Telstra (Australia) has begun UMTS850 deployment in Q1 2006, with a commercial launch expected in 2007. It is also expected that Rogers (Canada) and some Latin American operators will also deploy UMTS850 networks in 2007. UMTS850 has the advantage of better cell range (though this is less applicable in Hong Kong) and in-building penetration compared to 1900MHz or 2100MHz networks.

Vendor support for UMTS850 network infrastructure is good. Ericsson and Lucent already supply UMTS850 equipment, and Nortel, Huawei and Nokia will have equipment available by 2007. The main issue in the short term is the availability of handsets that cover both 850MHz and 2100MHz, which is most commonly used for UMTS outside of the Americas. Handset volumes are currently being driven by Cingular which is using dual-band 850/1900 handsets. There is expected to be little support for dual-band 850/2100 handsets, and operators (such as Telstra who will be running at both 850MHz and 2100MHz) will need to wait until a range of tri-band 850/1900/2100 handsets become available in 2007. There is already good support for tri-band data cards for laptops, and several laptop manufacturers (Dell, Lenovo, Sony and HP) have announced support for integrated HSDPA including 850MHz. On the question of CDMA/UMTS850 handsets, there are currently about four providers of so-called world phones that cover CDMA and GSM/UMTS, however they are very much an expensive niche product. The drivers to extend them to UMTS850 are weak.

Ancillary broadcasting activities such as wireless microphones or ENG would be feasible (i.e. there is equipment available) in the band and we have already noted in Chapter 2 that such services may require additional spectrum in future as they are displaced from existing bands around 2GHz.

Finally, there is the option to withhold the spectrum and reconsider its release in several years time. We are not aware of any potential future use of the band or prospective international regulatory decisions which might justify delaying release of the band. Furthermore we note that the market for mobile use of the band could be taken by other 3G operators over the next few years thereby making the band less valuable for this application. In addition, there is likely to be demand today from ancillary broadcasting.

A qualitative assessment of the different options is given in the table below, relative to the situation of the “do nothing” situation in which the spectrum is not released. The assessment reduces to a trade-off between the economic and technical benefits from use of the spectrum by services other than CDMA2000

versus the limited roaming benefits and "gateway" benefits from harmonisation with Mainland China that allocating the spectrum to CDMA2000 may provide. More detailed analysis that is beyond the scope of this study is required to quantify these benefits where possible and to assess the likelihood of their being realised.

The key point to note is that any conclusions involve a trade off between policy objectives in respect of Hong Kong's position as a gateway to Mainland China and various economic factors. The conclusion depends on the weight given to the former policy objective. This is a matter for the Hong Kong government to decide.

Figure 4.1: Assessment of Options for Use of the 850MHz band relative to a do nothing scenario

Objectives	CDMA 2000	UMTS850	TV	Ancillary broadcasting
Net economic benefits	Some (limited) roaming benefits Uncertain benefits in terms of development of the data market.	Roaming benefits only if users buy new handsets and these become available. No service enhancement benefits.	Additional TV services in Hong Long, but these may be able to be met through switchover	Possible reduced cost of supplying these services as compared with use of other bands (this would need to be substantiated)
Net social benefits	Not applicable	Not applicable	Not applicable	Not applicable
Technical benefits	Greater spectrum efficiency compared with GSM	Greater spectrum efficiency compared with GSM	Poor spectrum efficiency	-
Introduction of new services	Possible benefits in terms of development of the data market – though see negative results from consultancy study	Possible benefits in terms of the development of the data market, though the same services possible as at 2100 MHz	Additional TV services	-
Telecoms, broadcasting hub	Not applicable	Not applicable	Not applicable	Not applicable
International obligations	Not an issue	Not an issue	Not an issue	Not an issue
Gateway benefits from harmonisation with Mainland China	Positive benefit	Not advanced by this option	Not advanced by this option	Not advanced by this allocation
Sufficient spectrum for essential public services	Not applicable	Not applicable	Not applicable	Not applicable

Policy principles

To prove effective, regulatory objectives need to express clearly the way in which policy will be developed including methods and procedures. Methods might include the economic models which are to be applied in coming to a decision, transparency concerning the data and evidence used to reach a decision and procedures that allow public input to decisions and scope for decisions to be contested (through either administrative or judicial procedures).

Other regulators (e.g. UK, Canada) have found it useful to set out how they will interpret their statutory duties when making decisions and we suggest that a similar approach is adopted in HK in order to:

- Increase the transparency of decision-making
- Increase the predictability of decision-making
- Enable users to reasonably anticipate regulatory decisions and to plan their operations and investments on that basis on a rational basis.

The example of the UK regulator's principles is given in the box below.

Box: Regulatory Principles of Ofcom (UK regulator)

In interpreting its statutory objectives Ofcom has published the following set of regulatory principles:[58]

- *Ofcom will regulate with a clearly articulated and publicly reviewed annual plan, with stated policy objectives.*
- *Ofcom will intervene where there is a specific statutory duty to work towards a public policy goal which markets alone cannot achieve.*
- *Ofcom will operate with a bias against intervention, but with a willingness to intervene firmly, promptly and effectively where required.*
- *Ofcom will strive to ensure its interventions will be evidence-based, proportionate, consistent, accountable and transparent in both deliberation and outcome.*
- *Ofcom will always seek the least intrusive regulatory mechanisms to achieve its policy objectives.*
- *Ofcom will research markets constantly and will aim to remain at the forefront of technological understanding.*
- *Ofcom will consult widely with all relevant stakeholders and assess the impact of regulatory action before imposing regulation upon a market.*

OFTA has set out a number of principles which govern its behaviour and decisions including

- Only intervening where market forces cannot achieve the goal of creating a "pro-liberalisation, pro-competition and pro-consumer" regime [59]
- Being a transparent regulator (see www.ofta.gov.hk)
- Being "market led" and "technology neutral".

[58] Ofcom. "Statutory duties and regulatory principles". http://www.ofcom.org.uk/about/sdrp/

[59] OFTA Trading Fund Report 2004/05

We endorse the transparency principle. The other two principles would seem to suggest a market-based approach to spectrum management unless there are good reasons to do otherwise. However, in practice Hong Kong has made only limited use of market mechanisms for spectrum management and the objectives listed in Recommendation 4.1 suggest both market and public policy factors should influence spectrum policy.

The main issue that needs to be decided therefore is whether the regulator should

1) consider first whether a market based approach to spectrum management could achieve the objectives and then make adjustments or interventions to accommodate any constraints implied by the policy objectives listed above, or

2) consider which administrative rules best address public policy objectives and so only adopt a market based approach is adopted in circumstances where public policy factors do not apply

While there may only appear to be a semantic difference here we think that the order in which market-based versus administrative management tools are considered matters in practice. The reason for this is that the challenge of having to think about whether and how a market might deliver desired outcomes imposes a discipline on policy makers to justify their interventions more rigorously than if intervention through administrative rules is the default method of operation. This can also lead to innovative thinking about better ways of delivering policy objectives rather than the relatively blunt instrument of "special" access to spectrum. This is a blunt approach because spectrum use itself is not generally the objective of the policy. Rather spectrum is usually only one of a number of inputs that is being used to achieve a desired output (e.g. policing, broadcast of particular programmes etc) and policy focussed on the desired outputs can often be more effective. We therefore recommend the first approach over the second and that this should be made explicit together with any overriding policy objectives.

Recommendation 4.2: The Government should publish its intention to adopt a market-based approach to spectrum management where there are competing demands unless there are good public policy reasons to do otherwise. Policy priorities that the government wishes the regulator to take into account should be given in policy decisions by the Executive Council.

4.2 Allocation policy

The allocation or reallocation of spectrum may in principle be determined by market processes or administrative decision making. Market processes may be used to make allocation decisions as follows

- Auctions: spectrum may be auctioned on a technology and service neutral basis. The user will be required to operate within a spectrum mask where this is based on a known use of the spectrum (typically the most likely use). For example, auctions in Australia, New Zealand and more recently in the US and the UK have been conducted on a service and technology neutral basis.
- Trading: A user may buy out others and reconfigure the spectrum so it can be used for a new application or service. For example, in the US Nextel bought up spectrum used for private land mobile services and aggregated this to support a public mobile network.

The advantages of using the market to make allocation decisions are that market players have the best information on demand for future applications and this avoids the regulator having to make difficult judgements. The disadvantages are that policy objectives cannot be taken into account and in some cases reconfiguring spectrum may be difficult and costly to achieve through market processes e.g. when there are many small users or if a small number of key users refuse to sell. The choice of approach therefore depends on the characteristics of bands under consideration.

Here we focus on cases where allocation decisions must be made by the regulator, namely when deciding licensed versus licence exempt use and government versus non-government use.

Licensed vs licence exempt spectrum

There has been an active but unresolved policy debate concerning the appropriate balance of spectrum allocations between licensed and licence exempt use. Ting et al (2005) attempt to model the choice with a number of stylised assumptions concerning demand and costs but their results are ambiguous.[60] The literature has been reviewed in Webb and Cave (2003)[61] who seek to provide some decision rules for making allocations to licence exempt versus licensed use. They conclude that

- Spectrum should be designated as licence exempt where congestion is unlikely. This is because licence exempt users face weak incentives to economise on their spectrum use (because they do not face a price) and this is required in congested bands in order to maximise output (by avoiding interference). This of course assumes it is possible to make such judgements.
- There is no evidence to suggest that designating spectrum as licence exempt rather than licensed would remove congestion problems in the 100MHz to 5GHz range
- Regulatory rules (e.g. politeness protocols, controls on transmit power) can greatly reduce the probability of congestion in licence exempt bands.

It has also been suggested that the market could decide whether or not to make bands licence exempt. The mechanism for this would be that a private organisation would buy spectrum at auction and would designate it as open for licence exempt use, thereby creating a "private commons". The question is what kind of organisation would want to do this? Possible candidates include device or component manufacturers (e.g. Intel) but, unless they can find a way of excluding products used by competing companies, there is a free rider problem that could inhibit the creation of private commons.

Decisions about whether to allocate bands to licensed versus licence exempt use need to be taken carefully because once a band is allocated to licence exempt use it can take many years to reverse the decision. Users of licence exempt bands are not known and so the regulator has no mechanism to curtail their use, apart from

[60] "Comparing welfare for spectrum property and spectrum commons governance regimes" ,Ting, Wildman and Bauer, Telecommunications Policy 29, 2005.

[61] Spectrum licensing and spectrum commons – where to draw the line, W Webb and M Cave, Warwick Business School, September 2003

publicly announcing that the use of the band will change at some future date. This has led some regulators to introduce a system of registration for some licence exempt applications, where registration involves the user registering the location of its use on a computerised database. This allows co-ordination between users and the regulator to identify users more readily than under a licence exempt regime.

In terms of international practice in this area the following are of note

- European legislation[62] requires that "Member States shall, where possible, in particular where the risk of harmful interference is negligible, not make the use of radio frequencies subject to the grant of individual rights of use but shall include the conditions for usage of such radio frequencies in the general authorisation." In other words there is a presumption in favour of licence exempt use or a light licensing regime (say requiring only registration of use) rather than designating bands for licensed use.
- The FCC's Spectrum Policy Taskforce has recommended expanded use of the "commons model" (i.e. licence exempt use) particularly in bands where scarcity is relatively low and transaction costs associated with market mechanisms are relatively high.

In practice, numerous licence exempt devices are internationally mobile (e.g. WiFi in laptops, RFIDs) and in these cases Hong Kong may have little choice but to align its designation of licence exempt bands with those decided at a regional or global level if these devices are not to suffer interference.

While the Hong Kong market is unlikely to be large enough on its own to support the development of licence exempt equipment for a national band, there may be situations in which bands used in some other countries (but not harmonised regionally or globally) could in principle be allocated to licence exempt use. There are good reasons, however, to be cautious about making such allocations because of the difficulty of refarming such bands should international allocations change.

While in principle an analysis of the risks, costs and benefits of the options should be undertaken in practice this can usually only be done qualitatively. There has been relatively little quantification of benefits of many licence exempt uses of spectrum by any regulators.

Recommendation 4.3. In general Hong Kong should adopt international allocations for licence exempt services. If, exceptionally, national allocations for licence exempt use are considered, then the following factors should be taken into account when making such decisions

- **The likelihood of the band being congested.**
- **Options for light licensing regimes (e.g. registration) instead of licence exempt use if congestion is thought likely to occur.**
- **Users' service quality requirements together with the likelihood of congestion.**
- **The nature of possible technical restrictions on licence exempt use that could address any future congestion issues.**

[62] Article 5, Authorisation Directive, Directive 2002/02/EC, 7 March 2002

- **Relevant public policy objectives.**

Underlay and overlay

Two specific types of licence exempt use need to be considered – underlay and overlay - as these raise additional issues.

The approach to underlay, taking UWB as the clear example, has been different in different parts of the world. Regulations, mainly in terms of maximum power density levels, were first established in the US after extensive debate across the industry. Since then some countries have established regulations allowing for the experimental deployment of devices on a time limited basis and others have sought to establish a similar but different set of regulations to the US model depending on the local circumstances.

It has been notable in Europe that the usual conflict between the interests of incumbent services and the interests of those parties wishing to introduce a new service or technology has been readily apparent. Initially the proposed regulations for Europe were so stringent that it would not have been practical to develop underlay devices. The current situation is that the initial proposals are being reviewed with a view to allowing the introduction of such devices. One important factor that will undoubtedly be taken into account in the European review is the inevitable global movement of ubiquitous devices such as those being proposed.

Another important factor that needs to be considered with respect to the possible impact of underlay on incumbent services concerns the rights of receivers (which can in effect also be regarded as protection from interference). Current regulatory regimes largely define rights in terms of what a device is allowed to transmit and provide protection from harmful interference. In the context of underlay, the use of the term harmful interference as a definition of protection has highlighted how inadequate this term is. It will be even more so in the context of liberalisation and trading. While there are often implicit interference criteria used in making assignments it is not always the case and it will become increasingly important to define the receive rights of users more explicitly.

The case of overlay is somewhat different to underlay but in the end returns to the same issue in terms of receive rights. In theory it should be possible to define rights solely in terms of what transmitters are allowed to do, for example by imposing a general requirement that no interference is caused to the primary user of that band. However, there is not sufficient confidence in the technology (e.g. current forms of cognitive radio) to allow only such general requirements. It then becomes necessary to define what the technology has to do with reference to the receive rights of the incumbent or primary user. A good example of this is the FCC's proposal to allow the use of unlicensed devices in the TV broadcast bands[63].

Recommendation 4.4. In the longer term, and in association with the introduction of liberalisation and trading, consideration should be given to how best to define incumbent spectrum users' rights in relation to use of the band they occupy by underlay and overlay applications. There is no

[63] FCC Notice of Proposed Rulemaking (NPRM FCC 04-113) – Unlicensed Operation in the TV Broadcast Bands – Released 25 May 2004.

agreed method for doing this so international developments should be monitored by the regulator.

Government vs non-government use

In Hong Kong, as elsewhere in the world, the spectrum needs of government users are met by reserving spectrum for these users so that they can fulfil their operational functions. The reallocation of spectrum between government and non-government uses is achieved administratively, typically with displaced users being offered alternative spectrum. The issue to be considered here is how can allocations between government and non-government use be achieved in a transparent, efficient and equitable manner?

The application of market mechanisms in principle provides a transparent means for users to obtain access to spectrum. A recent review of government use of spectrum in the UK concluded that government users should as a rule obtain access to spectrum in the same way as commercial users, and government should be prepared to pay for this access just as it pays for other inputs such as buildings, labour etc. [64] The review suggested that only in exceptional circumstances should government users be allocated additional spectrum through administrative processes and the following criteria should be used to decide whether an allocation was justified

- Demonstration of safety or security critical requirement or mandatory international obligation
- Demonstration that the need cannot be met though more intensive use of existing bands
- Demonstration that needs cannot be met through the market
- There is no alternative means of providing the service

The issues associated with applying a market approach to the government sector are considered in more detail in Chapter 6.

If market mechanisms are not thought to be suitable then a transparent administrative approach is required. Cost benefit analysis will have its limitations because the benefits from many government uses cannot be quantified, although cost benefit analysis does provide a useful framework for identifying the costs government use may impose on the private sector and for requiring the benefits of government use to be at least described if not quantified.

This suggests there should be a list of objective criteria that can be used to determine government users' "need" for a particular band. The list given above provides a starting point. The criteria should provide a way of checking that, where there are competing demands for the spectrum from government and non-government users, access to the band in question is the minimum necessary to meet the stated government need. For reasons of transparency assessments should be published.

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[64] "Independent Audit of Spectrum Holdings", Professor Martin Cave for Her Majesty's Treasury, December 2005.

In cases where non-government users want access to bands currently allocated to government users, opportunities for sharing spectrum should be explored. It is sometimes the case that government requirements are intermittent making sharing a possibility. An example of a service that can share well with government use is outside broadcasting. Control over the spectrum can be retained by giving the government user pre-emption rights. For example, in many countries, defence forces have pre-emption rights over part of the GSM spectrum.

In some circumstances, continued government use of spectrum occurs because of a lack of funds to buy new equipment for alternative bands. In the US a market oriented approach has been used to address this problem.[65] Certain bands have been designated for potential transfer to non-government use. The costs of moving government users from these to other (less highly desired) bands are estimated. The designated bands are auctioned but are only released to private sector bidders if the revenues raised exceed 110% of the cost of moving the government users – this is the reserve price of the spectrum.

Recommendation 4.5: In order to achieve an appropriate balance between the allocation of spectrum to government and non-government use, we recommend that

- **Government requirements for additional spectrum should be appraised against a set of objective criteria and decisions (including reasons) published subject to any limitations caused by public interest issues**
- **The possibility of sharing between government and non-government users should be explored in cases where non-government users would like access to spectrum allocated to government use**

See also Recommendation 6.1 regarding periodic reviews.

4.3 Spectrum strategy

In order to provide clarity and predictability for spectrum users all elements of the spectrum policy should be brought together with a spectrum release plan in a single statement of the national spectrum strategy. The spectrum strategy should be reviewed periodically (say every 3-5 years) to ensure it is still relevant taking account of technology, market and wider policy developments.

The strategy should be a document published by the regulator and should include the following

- A statement of policy principles reflecting government policy objectives
- A statement of how the principles will be applied in practice, in respect of licensed and licence exempt spectrum, government and non-government use and emerging issues arising from new technology developments
- A forward look at important spectrum allocation and release decisions

If accepted by government the recommendations developed in this report could form the basis for the spectrum strategy.

[65] Under the Commercial Spectrum Enhancement Act, 2004

The strategy will provide the starting point for the development of the spectrum release plan for non-government and government use of spectrum. Ideally the spectrum release plan for government and non-government users would be included in the spectrum strategy, however, we recognise that in practice that the position with respect to government users will not be clear for some time and there may be sensitivities around releasing information in this area. Hence only the spectrum release plan for non-government use of spectrum is likely to be included in the first spectrum strategy document.

Recommendation 4.6: The regulator should publish a spectrum strategy document. This could include a statement of policy principles, discussion of how the principles will be applied in practice, and a forward look at important spectrum allocation and release decisions. The spectrum release plan should be developed based on this strategy.

4.4 Spectrum release plan

The value of information on current and future spectrum use

Information on the allocated use of spectrum, its potential availability for new applications, current assignments and the spectrum that the regulator plans to release to the market can assist manufacturers seeking to develop or test equipment in new bands and users in seeking additional frequencies, planning future service offerings and deciding whether or not to bid in current auctions. As discussed in the previous Chapter industry is concerned that OFTA does not currently supply sufficient information to the market to allow them to make fully informed investment decisions.

Recognising the economic benefits of providing spectrum users with the information they need to make sound business decisions, regulators elsewhere are starting to put their spectrum strategy, spectrum release plans and information on actual spectrum use into the public domain. This trend is reinforced by the adoption of market processes for allocating and assigning spectrum which require publicly available spectrum use information to operate efficiently.

A recent study for the EU[66] found that six of the thirty one European countries surveyed (namely Denmark, Germany, Ireland, Norway, Slovak Republic and the UK) published their spectrum strategy in the form of a specific document covering substantially the following aspects

- Description of present strategy
- Directions the regulator wants to take in terms of future spectrum strategy
- Details for specific frequency bands or services.

These documents are generally reviewed every 2-3 years as market and technology developments can lead to changes in priorities. In some cases the

[66] "Information on the allocation, availability and use of the radio spectrum in the community", Aegis, IDATE and Bird and Bird, February 2005 for the European Commission http://europa.eu.int/information_society/policy/radio_spectrum/docs/info_spectrum/spectrum_info_fin_rep.pdf

strategies provide details of future spectrum release plans and as a rule these look one or two years ahead. For example, in the UK Ofcom has published a list of the bands it intends to release for auction over the next 2 years. Similarly in Australia and the US[67] the regulator has published lists of forthcoming auctions of spectrum in bands where there is anticipated to be strong demand. In addition the US Federal Government Spectrum Task Force has argued that a long term national strategic spectrum plan should be developed for both government and non-government use of spectrum.[68]

We recommend that OFTA publishes a spectrum release plan consistent with its spectrum strategy. The main purpose of the plan is to give commercial users advance notice of the spectrum that will be released for use over a given time period so that they can make informed choices about infrastructure investment, service development and which bands to bid for. While the focus is on bands that will be released for auction, there would be merit in publishing as part of the plan information about bands intended to be released for licence exempt services and applications.

Recommendation 4.7: The regulator should publish a spectrum release plan consistent with its spectrum strategy. The spectrum release plan represents the regulator's intentions in respect of spectrum. It is a not legally binding commitment, rather it should change in response to market and technology developments.

The plan should have the following elements.

- **bands to be released for licensed and licence exempt uses and reasons**
- **the timing of spectrum release and any dependencies with other events (e.g. refarming, ITU decisions, Mainland China decisions)**
- **method of release – auction, beauty contest etc.**
- **an indication of whether spectrum will be tradeable / liberalised or restricted to specific uses and the reasons for this**
- **an indication of the regulator's initial views on packaging of spectrum**
- **any restrictions on the allocated use of the spectrum that may arise from policy decisions or international regulation**
- **a discussion of any matters relevant to the period beyond the plan.**

Considerations in developing a Spectrum Release Plan

Figure 4.2 sets out a possible decision process that could be undertaken internally by the regulator for determining a spectrum release plan. Our reasoning for each consideration in Figure 4.2 is given below.

Consideration 1: Potential demand

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[67] For Australia see "From DC to Daylight – Accounting for Use of the Spectrum in Australia", Australian Communications Authority, June 2004. In the US, Auctions completed, current, scheduled and not scheduled are listed on http://wireless.fcc.gov/auctions/default.htm?job=auctions_all

[68] Recommendation 9, Spectrum Policy for the 21st Century – The President's Spectrum Policy Initiative, Report 1, June 2004.

Clearly there is little to be gained in terms of economic or social benefit in selecting bands for release for which there is no interest from users. The initial criterion for the choice of bands is therefore

- There is demand for the spectrum from users (government or non-government)

The likelihood of demand for the spectrum may be indicated by equipment availability, demand elsewhere (pilots and actual commercial systems), and interest in Hong Kong from users. Timing issues are addressed in Consideration 4. Where there is conflicting opinion from market players as to whether there is demand or not, it is far better to obtain the potential benefit by releasing the spectrum rather than withholding it, especially when the opinion on lack of demand may arise from a defensive position with respect to competition.

The potential benefits from releasing spectrum for which there is demand from users include one or more of the following

- Reduced costs of supply for those operators that would otherwise have to build additional infrastructure to meet in future either existing or increased levels of demand for their services

- Launch of new applications and consequent consumer benefits. The new applications may substitute to some degree for existing applications in which case there could be a transfer of benefit from one set of producers to another.

- An increase in competition if new operators enter the market (as a result of the removal of the entry barrier caused by spectrum scarcity).

    - If the market is not effectively competitive this should lead to an increase in competition and consequent consumer benefits – lower prices, better service quality, etc. But see the note below.

    - If the market is already reasonably competitive, then in theory new entry will only be profitable if the new entrant is able to exploit a proprietary innovation or some other special advantage (e.g. access to cheap capital) to be more efficient than incumbents i.e. again there should be some competitive stimulus and consumer benefit from entry. Entry in this case could lead to the demise of incumbents/consolidation for which there are one-off costs (but this is simply a consequence of the competitive process).[69]

These benefits need to be weighed against any loss of benefit if existing users of the band need to be moved. This issue comes into play at Consideration 3.

We note that it has been argued that the relationship between innovation and competition has an inverted U shape i.e. innovation declines after some point

[69] Problems could arise if there is inefficient (or possibly irrational) entry, as this risks creating a situation in which incumbents are weakened and the new entrant becomes dependent on favourable treatment by the regulator.

where there are many competitors.[70] The reason for this is that the expected returns to innovation also decline if there are numerous competitors who may copy the innovation. The evidence on this point is not conclusive and more recent analysis qualifies the results.[71] In particular, it is found that the response to competitive entry depends on how close the incumbent firms are to the production frontier.

Consideration 2: Policy factors

Next there could be interactions with public policy considerations that will influence decisions about whether spectrum is to be released or not and when such releases may occur. In the case of TV broadcasting the extent to which spectrum released by digital switchover plan will be reserved for specific broadcasters or released to the market will need to be considered. In the case of public mobile communications decisions about whether allocations are to be decided through market processes alone or also by administrative decisions (e.g. as has been proposed for the 800 and 1800 MHz spectrum) will be relevant. Finally, in the case of essential public services spectrum may be reserved for their use.

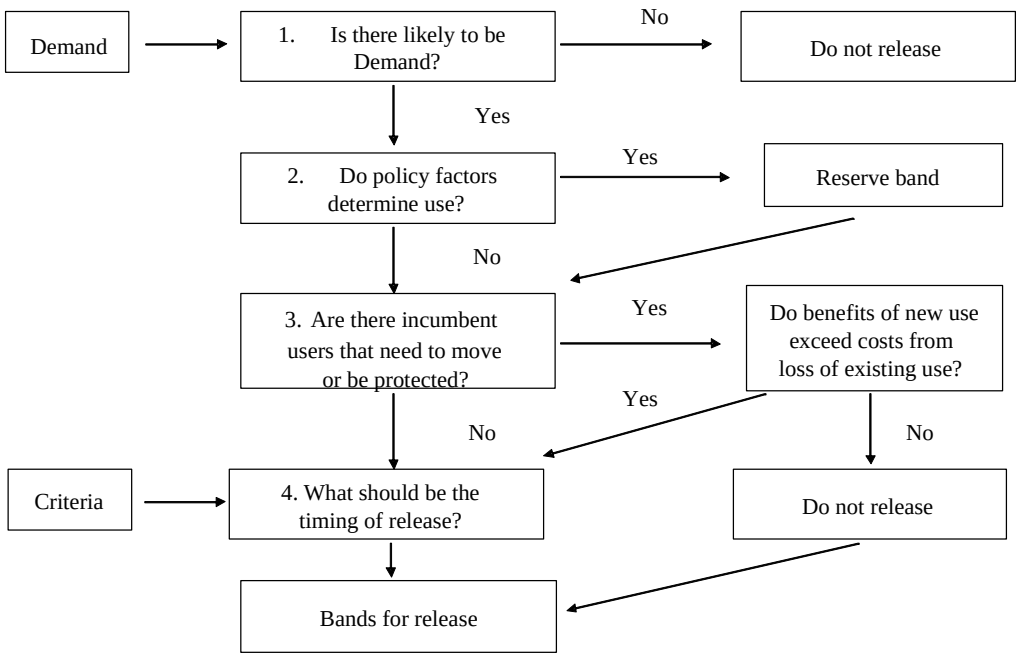
Consideration 3: Incumbent use and refarming decisions

The next consideration that needs to be addressed is whether there are any existing users in the bands identified. If not then there is no problem and one can move to the next consideration. If there are existing users then OFTA will need to weigh up whether these users are to be migrated in advance of a spectrum auction. This will depend on whether potential new users can co-exist with the incumbent use without causing the incumbents harmful interference and without imposing high costs or severe service restrictions on the new users i.e. without making the unusable for commercial services. If this is the case then the band could be auctioned encumbered. Otherwise an assessment of the net benefits of refarming the spectrum needs to undertaken. This is discussed below in Section 4.6.

[70] NECG's report for Hutchison on "Innovation and Competition", June 2004.

[71] "The Effects of Entry on Incumbent Innovation and Productivity", P Aghion, R Blundell, R Griffith, P Howitt and S Prantl, October 2005.

Figure 4.2: Internal decision process in determining the spectrum release plan



Consideration 4: Timing of release

Finally priority given to bands for release needs to be considered. We suggest this is determined by the following criteria

- Policy priorities
- Whether a number of the identified bands are substitutes or complements for particular applications. In these cases consideration should be given to whether the bands should be released simultaneously
- The timing of decisions on spectrum allocations and related standards development elsewhere, particularly in Mainland China
- Whether the band is currently free of existing use or not, and if not, the time required to develop a migration policy and then, if necessary, to migrate any incumbents. This could depend on the term of existing licences.
- The strength of demand for particular bands. If demand is very uncertain or if new information on demand may be revealed by waiting then later rather then earlier release would seem prudent.
- The effort required by OFTA in managing the release both in absolute terms (if the regulator is resource constrained) and relative to the expected economic benefits of doing so (e.g. in deciding the technical constraints on packages offered, packaging of the spectrum, auction format, policy constraints).

Plan duration and review process

The duration of the release plan is determined by the balance between what can reasonably be forecast and the need to offer as much information as is useful to industry.

Recommendation 4.8: We recommend that the spectrum release plan covers a period of three years. The plan should be reviewed and consulted on with stakeholders at least every three years.

Our reasons for a three year duration for the plan are

- This is common international practice where such plans exist
- Anything beyond three years exceeds the immediate business planning cycles of most organisations - spectrum users and government agencies
- Demand forecasts become unreliable beyond this timeframe
- New technologies can gestate within three years

The plan is just that and may change in the three year period as a result of, say, international technology and market developments or changes in local policy priorities. Any major changes should be subject to consultation.

The plan might, where possible, give indications of release issues beyond the three year period to provide maximum guidance to the industry where it might be sensible to do so. The point of the plan is to provide guidance and notice, not to stick religiously to a three year time horizon. Matters beyond the three year time horizon that might be covered are spectrum bands that will be reviewed at the next review (to create an on-going agenda) and spectrum bands that have not been released and for which no plans exist. It can be noted once again that the plan is to provide guidance to industry of the regulator's intentions and that it should therefore be considered by all parties to be a living document and not legally binding.

The plan would be reviewed at least every three years and consulted on with stakeholders through an appropriate mechanism (e.g. the RSAC) before going live. The consultation would ask industry's views on the elements of the plan.

Publication of assignment information

In addition to publishing information about future policies and spectrum releases in specific bands, some regulators also provide users with information concerning the current use of spectrum. In particular, in those countries which have implemented trading (i.e. Australia, Canada, Guatemala, New Zealand, the UK and the US) licence registers are publicly available – either the complete electronic register is available for download or purchase or interrogation of the register is possible. Often operators have concerns about the commercial confidentiality of information on their network deployment and these can be addressed by only releasing information about blocks of spectrum assigned without revealing the detail of frequency assignments at particular base stations. Examples of countries that publish information on frequency assignments in electronic form so organisations can identify where spectrum may be vacant also include Denmark, the Netherlands and Norway. [72] We come back to the issue of publishing assignment information in our discussion of spectrum trading in Chapter 5.

[72] Under European legislation the regulatory authority has relatively little discretion to refuse an application for use of a vacant frequency or band. Authorisation Directive, Directive 2002/20/EC, 7 March 2002.

In Norway the regulator has gone one step further by publishing the use and availability of vacant spectrum in certain (relatively low value) bands from 2GHz-40 GHz.[73] Organisations may apply for vacant spectrum and applications are notified on the website. If within a given time period there are other applicants for the spectrum an auction is held, otherwise the original applicant is licensed. A similar approach is used in Guatemala for the release of spectrum and has been also used in the UK for the release of specific bands (e.g. at 28 GHz). We note that this approach is similar to that currently used in Hong Kong for the release of land (see Annex 4) and might also be considered for some spectrum blocks in the spectrum release plan. In practical terms it would involve

- Announcing that certain frequencies or bands were available and possibly also setting a reserve price. Bands for which equipment is available at a reasonable cost and for which there is evident demand either locally or internationally would be obvious priorities.
- Allowing organisations to register their interest (which would be binding)
- If an organisation registers its interest announce this and ask if any other parties are interested
- If there is more than one interested party hold an auction within a specified timeframe
- Otherwise assign the frequencies to the first applicant.

This approach provides a relatively low cost and transparent way of assigning spectrum in bands where there are no major regulatory or policy issues to be addressed. It allows users to consider the options open to them in an informed way and should reduce the transaction costs of finding suitable spectrum as the user does not need to keep making repeated enquiries to OFTA about what spectrum might be available. For example, it could provide an efficient method of assignment in relatively uncongested bands used to provide private communications (e.g. fixed links, CCTV). Fixed bands above 23 GHz could be candidates for such an approach but the exact breakpoint frequency above which there is little congestion requires further consideration.[74]

Recommendation 4.9: The regulator should consider the potential benefits of making a number of fixed bands above 23 GHz, for example, available for a wider range of users to apply for on a first come first served basis at a nominated reserve price. The regulator would publish the available spectrum on its website and if an organisation applies for a particular frequency or block of frequencies then the regulator would ask for any

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[73] High value bands for broadcasting and public communications services are not included. Information on the available bands can be found at http://www.npt.no/portal/page?_pageid=118,46191&_dad=portal&_schema=PORTAL

[74] Where the assignment is a block of spectrum it would be expected that the assignee would manage individual frequency assignments. Such an approach would be less efficient in the case of individual frequency assignments as OFTA would have to continue to be involved in the technical assignment process unless this responsibility were to be contracted to a band manager.

competing bids. The approach would be analogous to that used for land in Hong Kong.

4.5 Refarming policy

Refarming involves reallocating spectrum from one use to another. Refarming policy needs to address when should spectrum be refarmed and how should this be achieved? Answers to the latter question need to address who pays for refarming and whether displaced users are offered alternative spectrum and/or monetary compensation.

We consider separately the following situations for the incumbent use of the band.

1. Termination of long duration licences to allow for the possibility of refarming
2. Existing licences are annual and so can in principle be terminated with a relatively short notice period
3. Existing use is not licensed (e.g. satellite broadcasts, other receive only applications, some government use)

In all situations, the case for considering refarming is that there is a potentially higher value use of the band. The key criterion that needs to be applied is: Do the benefits from the new use exceed the costs arising from loss of the existing use or moving/protecting existing users?

The costs and benefits of the new and the existing use need to be considered, at least qualitatively, and should take account of government policy objectives and international constraints. This assessment may be informed by actions taken by regulators elsewhere. If the rest of the world is undertaking a particular refarming policy it would seem likely Hong Kong should do the same.

Policy objectives affect the weighting of costs and benefits and international constraints will affect their scale. We note that in undertaking the cost/benefit analysis known costs of migrating users/losing existing services will need to be weighed against uncertain future benefits of the new service. This means that the benefits may need to exceed costs under even relatively pessimistic scenarios.

In the three cases listed above the benefits will be of a similar character, namely the benefits derived by consumers and producers from the new use of spectrum. These will comprise the sum of consumer and producer surplus, plus any dynamic benefits such as those that arise from competition, less costs associated with the refarming process.

The forgone benefits from refarming could be qualitatively different in each case and these are discussed in Figure 4.3 below. Broadly they fall in one of three categories: the costs of protecting existing systems so sharing is feasible, the costs of moving to another band or technology and/or the costs arising from loss of an existing application.

Figure 4. 3: Costs of refarming by nature of incumbent use

	Costs	Comments
1. Long duration licence	Losses of continuation of existing service. This will depend on extent of use and availability and cost of alternatives. If there are close alternatives then the forgone benefit may be small.	If there is a large user base for the existing service then renewal is likely to be the only feasible option politically. A known current benefit from existing use needs to be weighed against an uncertain future benefit attributed to the new user/an alternative user.
2. Existing annual licensees	Here the costs will often be those associated with migrating to an alternative band or service which can offer the same functionality but at a higher cost.	Such licensees will be either fixed links, PMSE, radars, PMR or satellite earth stations. In the case of radars and satellite earth stations the costs of migration are usually high but there may be opportunities to share the spectrum esp. with radars. In the case of fixed links, most countries experiencing high demand for bands below 3GHz have a policy of moving almost all such links to bands above 3GHz (long distance narrowband telemetry links are sometimes exempted) on the grounds that the alternative mobile allocations will always be of higher value, there is plentiful spectrum for fixed links above 3GHz and the costs of equipment in such bands are similar to costs in lower bands. In Hong Kong congestion in fixed bands below 10 GHz and rainfall attenuation need to be taken into account. In the case of land mobile services the situation is less clear cut and so the costs of moving to substitute bands may need to be considered. PMSE use around 2GHz can be more problematic because of the lack of suitable substitute bands. However, much of this use is on a secondary basis and there is a good case for these users having to buy the spectrum they want if they are seeking to occupy bands for which there is competing demand.
3. Existing use not licensed	Two cases need to be distinguished - government use - satellite reception The costs depend on whether the application can share (possibly at a cost) or use alternative bands or not and the costs of moving. If neither of these options is possible then the "value" of the loss of service needs to be considered.	For government use, policy issues will clearly come into play and we expect these will be dealt with internally in government. For satellite reception, co-existence may be possible but interference issues may need to be addressed.

Once the costs and benefits of refarming have been appraised, then decisions about how to refarm need to be made. Current policy is that the moved party incurs the costs of moving. Alternatives might include auction proceeds are used

to pay for some of the incumbents' moving costs or the new users move the incumbents.[75]

Possible reasons for changing current policy might be that an alternative approach, in which there is a financial incentive to move, might speed up the refarming process significantly and there is a clear benefit from doing this. Compensation may also need to be paid if the frequencies being refarmed were assigned relatively recently or disruption costs are large. We note this rarely happens.

Recommendation 4.10: Refarming decisions should be made by the regulator on the basis of an appraisal of the potential costs and benefits of different refarming options, including a "do nothing" option.

4.6 Licensing issues

In this section we discuss the following issues

- Separation of network/service licences and rights of access to spectrum
- Licence duration, modification and revocation
- Possible extensions to the licensing framework

Separation of network/service licences and rights of access to spectrum

Licences granted by the TA are to authorise the establishment and maintenance of the relevant means of communications, possession and use of radiocommunications installations / apparatus, provision of a public telecom service and/or dealing in the radiocommunications apparatus. Some licences (e.g. mobile carrier licences or wide band link and relay station licences) additionally authorise the use of frequencies.

In other countries rights of access to radio frequencies are separated from rights to provide broadcasting or communications services. Examples include, all EU member states, Australia, Canada, New Zealand and Singapore.

There are three main advantages from separating network/service licences and rights of access to spectrum:

- to promote competition by ensuring spectrum access is not used unnecessarily as an entry barrier
- in the context of liberalised spectrum use, decoupling service provision from spectrum access could support new entry by allowing an entity with a service licence to enter the market using a "non-standard" spectrum allocation
- in the context of tradeable/liberalised spectrum, to simplify administrative processes associated with making changes to spectrum rights including the development of secondary rights thereby reducing costs for both the regulator and industry.

[75] This is only practical if incumbents have a time limited tenancy, otherwise they can hold the new users to "ransom".

To put such changes into practice could require a change in legislation (this is considered further in Chapter 7). In the interim, other instruments that would be feasible under the TO should be considered. This might include making licence amendments so that spectrum assigned under the licence of the seller is withdrawn or reduced while spectrum assigned to the buyer is increased. Note this arrangement means that only trades between existing licensees are possible. Trades with newcomers might be possible through whole licence transfers or splitting an existing licence and transferring one of the split licences to the buyer.

Recommendation 4.11: In order to future proof the spectrum management regime in Hong Kong we recommend that the government considers the creation of generic radio frequency licences separate from service/network licences as a medium term goal. Transitional arrangements that would be feasible under existing legislation should be implemented in the short term.

We anticipate that most rights of access to spectrum would continue to have service specific elements e.g. indicating whether services provided using the spectrum are mobile or fixed until a more general liberalised licensing regime is introduced.

Licence duration, modification and revocation

There is an unwritten presumption by licensees in many countries that if they are behaving lawfully then their rights to use radio frequency will be renewed unless there are good reasons not to. This is why users often accept annual licences to provide services where the associated investment in transmission equipment and receivers has an economic life of at least 5-10 years. In the case of licences with durations of 10 years and more, the situation in respect of licence renewal is less clear cut. Hong Kong is no different from other administrations in this respect.

OFTA may vary or withdraw frequencies which have been assigned to a licensee by giving reasonable notice of the intended variation or withdrawal to the licensee concerned. At present there is no explicit policy on what constitutes a reasonable notice period or on the conditions under which frequencies may be varied or withdrawn. Greater transparency in both these aspects of policy would provide users with greater certainty as to their rights of access to spectrum and so should provide a more predictable investment environment. Notice periods elsewhere range from one or two years (e.g. Denmark) to five years or more (e.g. the UK). Period should depend on the service under consideration and the associated costs of moving but periods of 2-5 years would seem reasonable as business planning periods are rarely longer than this. However, if notice is inadequate or unreasonable, having regard to the services of the current licensees, a prima facie case for compensation may arise. The approach to compensation would need to be made explicit in the guideline document on the notice process.

Having notice periods of 2-5 years for annual licences may seem rather odd but this is what happens in Hong Kong at present and in most other countries, in recognition of licensees' equipment investments and the time taken to put in place alternative communications facilities. In recognition of this oddity and to reduce the administrative costs of annual licence renewal some regulators have extended the duration of annual licences to five years (e.g. the UK, Denmark). We think there would be merit in implementing such a policy in Hong Kong.

Finally, the lack of clarity in the status of renewal of licensees' spectrum access rights can raise transaction costs when regulators seek to vary or withdraw frequencies assigned to the licensees and, depending on how the regulator uses its discretion, could in principle deter investment in wireless applications. It would seem helpful to give users greater clarity over whether spectrum assignments are either 1) renewable unless there are good reasons to revoke them or 2) of the stated finite duration unless there are good reasons to extend them. As discussed in Annex 6 trading is likely to be promoted if licences are renewable unless specified conditions apply such as

- Government decision or direction that the spectrum is required by another service
- Refusal to pay a renewal fee
- Compliance with international or other regulations
- Public interest reasons.

However, against this government may wish to have the discretion at the end of the licence term to reallocate/reassign the spectrum. While it is our view that for economic reasons it is desirable that licences are renewable unless there are good reasons to do otherwise, in the end this is a political decision and we note that countries differ in the approach taken.

Recommendation 4.12: There should be an explicit policy on minimum notice periods for frequency variation and/or withdrawal. We recommend the following policy

- **For spectrum use associated with long duration service licences (10 years and more) decisions concerning frequency variation or withdrawal should be made at least 3 years before licence expiry. This means consultation on this issue will need to start 4 years in advance of licence expiry.**
- **Annual licences should be converted to a five year duration and licensees should normally be given at least 2 years notice of frequency variation or withdrawal.**

Recommendation 4.13: The regulator should publish the conditions under which frequencies (and in future spectrum licences) might be varied or withdrawn before the end of their term. These conditions should be minimal and should include

- **Reasons of public interest**
- **Compliance with government policy, as articulated in a direction from the Secretary**
- **Compliance with international and regional obligations or treaties**
- **Interference to other legitimate uses of spectrum**

We have suggested that there would be benefits (in terms of promoting trading) from the regulator publishing the conditions under which frequencies (and in future spectrum licences) might be varied or withdrawn when their term expires. However, we recognise that the government may wish to retain the discretion to reallocate/reassign spectrum on licence expiry. This policy choice is a matter for the Hong Kong government to decide.

Possible extensions to the licensing framework

Not all users of spectrum in Hong Kong are licensed. Government users are not licensed[76] , though their authorised use is clearly specified in a letter from OFTA, and receive only devices such as satellite TV receivers are exempted from licensing[77] In practice and up until now these services receive interference protection but this is not formalised. The question then arises as to whether there would be benefits in placing all these users on the same basis as licensed users so that there is greater clarity about their rights to spectrum access. The recent consultation on BWA at 3.5 GHz provides an illustration of a case where there has been conflict between the "rights" of the companies distributing services by satellite and other potential users of the bands. We also note that the Hong Kong Observatory indicated to us that it would be seeking rights to protection from interference for a receive only device.

One approach for providing greater clarity over rights in these circumstances has been suggested by the UK regulator. This involves creating a right to interference protection called "recognised spectrum access" (RSA). It is proposed that RSA (like licences) could be auctioned, tradeable and subject to administered incentive pricing. RSA is intended for situations in which spectrum users cannot be licensed for legal reasons – say because transmissions come from outside the licensing territory (e.g. satellite services, radio astronomy, passive radiometers) or their legal status (e.g. some government users) means this is not possible.[78] RSA is optional, meaning users need only opt for RSA if the benefits of interference protection and any trading opportunities offered outweigh any associated costs.

The receive part of a transmit/receive terminal operating as part of a system in practice receives protection as knowledge about its location is available and assignments to transmitters can take account of it. Knowledge of the receiver is therefore implicit in knowledge of its associated/co-located transmitter. This is not the case for receive-only terminals but recognised spectrum access would identify them to the regulator such that they can in principle be provided with the same level of protection as the receive part of a transmit/receive terminal. These receive-only terminals can be identified on an individual basis or perhaps more importantly, as licence-exempt operation often implies numbers of devices at unknown locations, on an area basis. From the regulator's point of view, whether it is specific locations or an area, there would be a duty to protect such receive-only terminals from interference from other spectrum users.

So far in the UK only radio astronomy services have opted for RSA (though this has not yet been implemented) and the issue is currently being debated by the satellite industry. The latter are in general opposed to the introduction of RSA because of the likelihood they will be charged for their spectrum access and

[76] Section 5 of the Telecommunications Ordinance

[77] Section 8(4)(c) of the Telecommunications Ordinance

[78] See http://www.ofcom.org.uk/consult/condocs/astronomy/statement/ and for a general discussion in the Ofcom/RA Joint Consultation on Spectrum Trading, November 2003 http://www.ofcom.org.uk/consult/condocs/spec_trad/

because a number of practical problems need to be resolved – namely there is a potential free rider problem as the first user in a band to opt for RSA in effect gives protection to all other users.

Recommendation 4.14: The Government should consider whether the spectrum licensing framework should be extended to users who are currently not licensed, including government users and receive only services, in order to enable formal spectrum rights to be established under a spectrum licence. In respect of government users it might be considered appropriate to establish spectrum rights using administrative means other than licensing.

5 Market Mechanisms

5.1 Introduction

There is a fundamental trade-off between the market versus the government deciding much of the future development of wireless communications. While there are some decisions that cannot be made by the market, an increasing proportion of the spectrum is being allocated to commercial use and so is potentially amenable to market forces.

The argument for and against use of markets rather than administrative processes goes as follows. If government makes decisions about future spectrum use then

- decisions will not be sufficiently responsive to market developments (i.e. will be made too slowly) because of lack of relevant market information and because administrative processes (with requirements for transparency and consultation) are slow. Innovation will therefore be delayed.
- mistakes will be made because of lack of relevant information (which is only held by market participants) and because governments are susceptible to lobbying by special interest groups. These mistakes will have an economic cost and in some cases this could be significant.[79]
- reallocating or reassigning spectrum from low to high value uses will be slow because incumbents will seek to block or delay changes through lobbying and this represents an economic cost to society.
- users will not have appropriate incentives for efficient spectrum use because they do not face the market prices when using spectrum. This will lead to economically inefficient use (in the sense that there is no incentive to transfer spectrum to the highest value use), technically inefficient use of spectrum (in the sense that narrower bandwidths could be used and less interference exported into neighbouring areas and bands) and hoarding (because there is little cost to doing this).

The advantages of administrative decision making on the other hand are

- it enables costly transaction processes to be undertaken more efficiently in some cases (e.g. in refarming spectrum occupied by many small licensees with interdependent spectrum use)
- it may take account of social and other policy objectives that are not taken into account through market mechanisms (e.g. national security and national cultural values in broadcasting).
- problems of monopolisation can be addressed directly. Wireless technologies have the potential to provide strong competition to incumbent wired services.
- markets are myopic, driven by short term profit considerations, and this does not result in the best overall outcomes for society

[79] For example, in the US it is estimated that delays in licensing cellular services cost the economy around $50bn per annum. “Valuing the Effects of New Telecommunications Services”, J Hausman, Brookings Papers: Microeconomics, 1997, http://econ-www.mit.edu/faculty/download_pdf.php?id=470

Clearly there is a balance to be struck between these two positions as the arguments are stronger or weaker depending on the frequency bands and services under consideration.

The arguments for use of market mechanisms are strongest in those bands where spectrum use is largely commercial, social or political objectives align with market incentives and competition issues can be addressed through regulators' competition powers and mechanisms such as spectrum caps. Market mechanisms offer the greatest benefits in bands where there are competing demands for the spectrum (assuming a low or zero price), for it is in these bands that

- more efficient use of spectrum will yield the greatest benefits in terms of releasing spectrum for other higher value users or uses
- command and control mechanisms are slow to respond to market developments because incumbents have vested interests in and lobby hard for the status quo
- propagation characteristics are good and equipment costs are low and so they have the potential to attract the highest value wireless applications.

These comments assume that it is possible to identify bands where there are now or will in future be competing demands for spectrum. In some cases this is straightforward (e.g. in bands allocated globally to public mobile services) in others the situation will be less clear. The nature and pace of future technology and market developments are very uncertain and it is this situation that command and control mechanisms cope with least well – because the regulator does not have the information required to make well founded decisions. This suggests that market mechanisms should be applied more widely than an *ex ante* analysis of current and anticipated congestion would imply.

The market mechanisms given in the box below could be used for spectrum management purposes. There are also variants of these approaches that can be used to refarm spectrum. For example, organisations winning spectrum though an auction may be required to move incumbent users where necessary and governments have established spectrum funds to pay part of incumbents' (or final users') refarming costs in order to free up spectrum for higher value users.

- **Auctions:** Auctions involve assigning licences based on the sums bid. These may be absolute amounts or percentages of revenue (i.e. royalties). Bidders may be required to meet minimum technical, financial or other criteria. To the extent that auctions are well designed they are likely to result in the allocation and assignment of spectrum to the highest value uses/users.
- **Administered incentive prices (AIP):** Prices charged to spectrum licensees are set by the regulator and are intended to reflect the opportunity cost of spectrum use[80] and thereby provide effective incentives for efficient use of spectrum. They are applied to incumbent users of spectrum in circumstances where the spectrum is not auctioned. AIP can be applied to government and non-government users.
- **Secondary trading:** Secondary trading involves allowing licensees to trade their licences. It spans a range of trading arrangements including simple sale, leasing and aggregation and subdivision of rights of access to spectrum. The analogy with trading in land can be useful in thinking about how spectrum trading might work. By making spectrum tradeable users face the opportunity cost of their spectrum use and therefore have incentives to economise on their spectrum use and to reallocate spectrum to higher value uses/users. Through leasing spectrum users in effect become private band managers.
- **Liberalisation of spectrum use:** Liberalisation of spectrum use allows users to change the technology used, network deployment and services offered using a block of spectrum. It is of most value when linked to trading, as significant changes of uses will require trades with neighbours if spectrum is to be used efficiently. Liberalisation allows market participants to reallocate spectrum to higher value uses.

Figure 5.1 shows the spectrum management functions that market based policy instruments could undertake as compared with the traditional common and control approach.

In the remainder of this chapter we describe and evaluate possible market mechanisms and the circumstances in which they should be used.

[80] Opportunity cost is the value of an asset or resource in the next best alternative use that is forgone as a result of its actual use. In a competitive market the prices set should reflect the opportunity cost of the resource in question.

Figure 5.1: Spectrum Management Tools

	Command and control approach	**Market mechanisms**
Assign spectrum to users	First come, first served An assessment of "need" based on technical efficiency Beauty contests	Auctions Trading
Allocate spectrum to particular uses	Administrative decision	Auctions Trading and Liberalised spectrum use
Refarm spectrum	Administrative processes e.g. notice periods for licence revocation	Auctions Trading and liberalisation of use Administered incentive pricing (AIP)
Encourage efficient use of occupied spectrum	Technical requirements Administrative decisions concerning technology and "needs" of users Use it or lose it conditions in licences	Administered incentive pricing (AIP) Trading Liberalisation of spectrum use

5.2 Auctions

Auctions are now the default assignment mechanism in Hong Kong in situations where there are competing demands for spectrum. This is also the case in an increasing number of countries. Auctions are increasingly used because they are transparent, efficient, and can be used in situations where the future use of the spectrum is uncertain and/or there could be many bidders who will be difficult to compare. There is also no evidence so far that auctions raise final prices or have resulted in worse outcomes than beauty contests (e.g. in terms of service roll-out).[81]

There are however some circumstances in which auctions will not be justified and the regulator may choose to either

- assign spectrum directly to users administratively. For example, in circumstances where auctions would be unduly costly relative to administrative

[81] See "Spectrum auctions do not raise the price of wireless services: Theory and evidence, Evan Kwerel, Federal Communications Commission, October 2000. "Spectrum auctions: distortionary input tax or efficient revenue instrument? A Morris, Telecommunications Policy, 29 (2005)

decisions, such as for the remaining small amounts of 900 and 1800 MHz spectrum

- assign licences by beauty contest if there are non-price factors of overriding importance in determining who should be assigned the spectrum.

In interviews with industry, a number of organisations commented on a seeming inconsistency in OFTA's approach to setting the sum bid in auctions – a royalty arrangement was used for the 3G auction and a lump sum bid has been proposed for BWA auctions. While this specific issue is outside the scope of this study we have the following general observations

- The royalty method was used in the case of 3G to share market and technology risks between industry and government, and to alleviate concerns that high auction prices (as had occurred in Europe) would form a potential barrier to entry.
- The royalty method is proving costly (for the regulator and companies) to implement and in hindsight appears less desirable than lump sum bids.
- Consistency does not mean simply repeating past policies, particularly if these policies do not appear optimal (*ex post*). The reserve price / mode of payment for a particular auction should reflect the circumstances prevailing at the time of the auction and therefore need not be the same as any previous auction.
- There are merits, in terms of simplicity, promoting competition and reducing transaction costs in settling on one or two tried and tested default auction formats e.g. simultaneous multi-round auction and a single round sealed bid format. Any move away from these formats would then need to be justified with respect to the characteristics of the licences being auctioned.

Recommendation 5.1: Auctions should continue to be the default assignment mechanism in circumstances where there are competing demands for spectrum and should be designed according to the circumstances prevailing at the time. Administrative assignment or beauty contests should only be used if there are good cost or policy reasons for such an approach.

5.3 Administered Incentive Pricing

Where there is current or anticipated future excess demand for spectrum, the application of spectrum fees that reflect the economic value (or opportunity cost) of the spectrum will promote optimal use of scarce spectrum resources. Ideally prices for spectrum would be set through market processes (e.g. auctions or trading), or by using market benchmarks derived for "similar" spectrum. The New Zealand government, for example, plans to set charges for the renewal of spectrum rights that were initially auctioned with reference to the original auction price and a growth factor and, if necessary, other market benchmarks. In practice this may not be possible because of the absence of market benchmarks, in which case estimates of market prices will need to be calculated by the regulator and this can be done by considering the opportunity cost of the spectrum.

Relatively few attempts have been made to develop methodologies for determining the opportunity cost of spectrum in a rigorous, quantifiable way. So far the UK has done the most work in this area and sets AIP based on the estimates of the *least cost alternative* to use of the spectrum for all potential uses of a particular

frequency band[82]. Fees developed in this way reflect the additional cost (or cost saving) to an average user as a result of being denied access to a small amount of spectrum (or being given access to an additional small amount of spectrum). The additional cost (cost saving) depends on the application and is calculated as the estimated minimum cost of the alternative actions facing the user. These alternatives may include

- investing in more/less network infrastructure to achieve the same quantity and quality of output with less/more spectrum (this would apply for a cellular operator, for example)
- adopting narrower bandwidth equipment (this would apply to fixed links, for example)
- switching to an alternative band (this might apply where some bands are shared with other, more valuable services and others are exclusive, for example satellite earth stations share with fixed links in some bands but not in others)
- switching to an alternative service (e.g. a public service rather than private communications) or technology (e.g. fibre or leased line rather than fixed radio link).

AIP is a price for spectrum and so should be related to the quantity of spectrum used or equivalently the spectrum use denied to others.[83] This means that AIP should apply to all users who deny use of spectrum to others i.e. all users who receive protection from interference either explicitly or implicitly. In this regard we note that secondary as well as primary uses may receive such interference protection.

In the UK, opportunity cost based pricing applies to commercial and Government services (such as police and military bands) where the latter use spectrum that could be used by commercial services. So far AIP does not appear to have any noticeable effect on incentives for efficient spectrum use in the UK and it is argued this is because the price level is too low.[84]

In many other countries, regulators have set fees for spectrum use that exceed simple cost recovery and are intended to be a payment for the use of the spectrum resource and so are related to the amount of spectrum used as well as a range of other factors. While these fees are intended to provide a fair return for the state and incentives for efficient spectrum use, the way in which they are calculated is generally rather ad hoc.

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[82] See "An economic study to review spectrum pricing", prepared for Ofcom by Indepen, Aegis and Warwick Business School, February 2004 (http://www.ofcom.org.uk/research/radiocomms/reports/independent_review/spectrum_pricing.pdf)

[83] The amount of spectrum used generally has three dimensions – spectrum space, geographic space and time. CDMA systems use encoding techniques to enable spectrum space to be shared between multiple users, hence for such systems codes may be considered to be a further dimension, analogous to time in a TDMA system.

[84] For more detail see "An Economic Study to Review Spectrum Pricing", Indepen, Aegis and Warwick Business School for Ofcom, February 2004.

Under the TO OFTA may designate certain frequency bands where the Spectrum Utilisation Fee (SUF) shall be applied according to the level prescribed by regulations made by Secretary for Commerce, Industry and Technology. In effect this provision allows OFTA to implement spectrum pricing (i.e. AIP). The objectives of the SUF and the characteristics of bands to which it may be applied are not specified in the TO or in regulations. However, the principles and approach used to set the SUF for 2G licences are instructive. The principles applied were as follows[85]

- Fair compensation for use of a public resource
- Level playing field between all players (2G and 3G)
- SUF should be proportional to bandwidth
- Technology neutrality

In addition, the TA in its Statement on 2G licences referred to desirability of convergence between 2G and 3G SUF structures over a transition period (para 13) and the desirability of providing incentives for efficient spectrum use (para 14). In practice the SUF for 2G licences was set for an initial 5 year period at a level below the level of prices bid in the 3G auction. The main reason given by the regulator for applying an SUF to 2G licensees was equity, though the consequential financial impact on licensees and consumers was also mentioned.[86] The level chosen was the result of the regulator balancing these factors.

We have suggested that prices for spectrum should reflect the opportunity cost, as will be the case with prices bid in an auction. If this were taken as the basis for setting the SUF for 2G licences then there would be no reason why the fees should be set at the level paid for the 3G licences, as these were auctioned 5 years ago. It is clear that the market value of spectrum for mobile services has declined since 2001 as expectations of the technology and of future market growth have not been realised. This can be seen in the table below which shows the sums paid in auctions of GSM spectrum in Austria since 1998.

Figure 5.2: Comparison of amounts paid in GSM auctions in Austria

Network	Date	Spectrum	Amount	Licence duration	Amount / MHz	Annual Equival	Per capita
One	1998	2x28.8MHz	165.6M €	20 yrs	5.75M €	0.61M €	0.08€
TeleRing	2000	2x14.6MHz	98.0M €	20 yrs	6.71M €	0.72M €	0.09€
One	2001	2x6.4 MHz	21.9M €	20 yrs	3.42M €	0.37M €	0.045 €
T-Mobile	2001	2x3.2 MHz	11.6M €	20 yrs	3.63M €	0.39M €	0.047 €
Mobilkom	2001	2x10.2MHz	36.4M €	20 yrs	3.57M €	0.38M €	0.047 €

[85] "Spectrum Utilisation Fee (SUF) for 2G Spectrum: Licensing of Mobile Services on Expiry of Existing 2G Licences, A Report for OFTA by Spectrum, November 2004.

[86] "Licensing of Mobile Services on Expiry of Existing Licences for Second Generation Mobile Services", Consultation Paper, OFTA, 1 August 2003.

Network	Date	Spectrum	Amount	Licence duration	Amount / MHz	Annual Equival	Per capita
Mobilkom	2002	2x2.6 MHz	5.2M €	20 yrs	2.0M €	0.21M €	0.026 €
T-Mobile	2002	2x4.8 MHz	9.6M €	20 yrs	2.0M €	0.21M €	0.026 €
Mobilkom	2004	2x6.6 MHz	0.56M €	20 yrs	0.08M €	.01M €	0.001 €
One	2004	2x3.2 MHz	0.25M €	20 yrs	0.08M €	.01M €	0.001 €
TeleRing	2004	2x 2.2 MHz	0.157M €	20 yrs	0.07M €	.01M €	0.001 €

Note: T-mobile was formerly MaxMobil and One was formerly Connect Austria

Source: Aegis Systems, Austrian regulator

http://www.rtr.at/web.nsf/englisch/Telekommunikation_Frequenzvergabe_Bisherige+Auktionen

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We consider that it would be helpful to set down some general principles for setting SUFs or AIP, for otherwise there will be no objective basis for determining an appropriate fee level and there will be the on-going risk that decisions will be continually challenged.

Recommendation 5.2: Principles for the application of AIP (or SUFs) should be published. These should include

- **AIP is not applied in bands that are auctioned, except in the case where an auctioned licence is renewed**
- **AIP is only applied where there are competing uses/users for a band (i.e. where bands are congested)**
- **AIP should be applied (where practical) to all licensees (primary or secondary) whose spectrum use denies access to other potential users in congested bands where spectrum has not been auctioned.**
- **AIP should be set to reflect the opportunity cost of the spectrum where this may be calculated using**
    - **the least cost alternative method and/or**
    - **using a relevant current market benchmarks, for example, current auction payments for similar spectrum either in Hong Kong or elsewhere. (Lump sum auction payments would need to be converted to annual fees using a suitable industry discount rate.)**

In Chapter 2 we identified UHF PMR bands and all fixed bands below 16 GHz as congested. Spectrum in these bands has not been auctioned and so they are a potential candidate for AIP. The alternative policy of making the spectrum tradeable could be more problematic to implement because assignments are generally specific to a particular location and so user and so may not be able to be easily traded. Though we note in the case of fixed links many links are to/from

hilltop sites and so could in principle be traded. The other reason for applying AIP in the first instance is that there may be windfall gains from making spectrum tradeable and AIP provides a means of giving the community a fair return for use of the asset while also providing incentives for more efficient spectrum use.

Recommendation 5.3: AIP should be applied to congested UHF PMR bands and fixed link bands, such as those below 16 GHz, so as to promote more efficient spectrum use.

In the case of fixed links and PMR spectrum, AIP would need to be calculated using the least cost alternative approach described above because there are no relevant market benchmarks. For fixed links this would mean calculating the minimum of the cost of alternatives such as changing the modulation scheme and using a leased line. In the case of PMR it would mean calculating the minimum of the cost of migrating to a narrower (12.5 kHz) bandwidth and the cost of migrating to a public system such as cellular.

There will need to be a transition from the existing spectrum fees to AIP. The length of time will depend on the scale of change in fee levels but a period of 3-5 years would seem sufficient to give users time to adjust to the change. AIP levels will need to be reviewed periodically as spectrum values change. The question of the frequency with which AIP should be reviewed also needs to be addressed. Factors affecting the choice are:

- The time taken to undertake a pricing review
- The volatility of demand for spectrum
- The need to give licensees some certainty concerning the charges they will pay.

A pricing review takes up to one year – 3-6 months to do the work and the same again for consultation - and changes could then be implemented in regulations in the following year. This suggests a minimum of two years between reviews.

A pricing review would have to start at least a year in advance of implementing new prices and so this suggests there should be at least 5 years between reviews. This would also give users a reasonable degree of certainty around which to plan.

Recommendation 5.4: If AIP is implemented there should be a 3-5 year transition to the new higher level of fees. The level of prices should be reviewed every five years.

5.4 Secondary Trading

Secondary trading refers to a situation in which spectrum licensees are permitted to sell all or part of their spectrum usage rights and/or to lease access to the spectrum covered by these rights to third parties for a limited time period. Decisions about who is assigned spectrum access rights are made through bi-lateral negotiations between spectrum licensees, rather than by the regulator (as happens at present).

The analogy with trading in land can be useful in thinking about how spectrum trading might work. As with land, there needs to be careful consideration of the definition of the rights that can be traded and their duration, the institutional arrangements for making trades, the rights and responsibilities of the various parties to a trade, publicly available information on who owns what, consideration

of the treatment of windfall gains and safeguards against potential anti-competitive behaviour.

In Hong Kong, spectrum users cannot readily trade their spectrum usage rights. The only way in which a trade may occur is if one company buys another and in the process acquires spectrum usage rights along with all the other company assets. In the case of trades involving parties with carrier licences, merger and acquisition activities are subject to regulation under section 7P of the TO and, if it involves disposal of assets of more than 15%, the TA's approval. The main consideration in giving approval is fair competition. By contrast rights of access to land in Hong Kong are tradeable. Aspects of these rights are summarised in Annex 4. A system of tradeable spectrum rights might have similar features to the system for trading land in Hong Kong. If secondary trading was to be introduced then to be of value it should permit a greater range of transactions than is currently allowed. In particular, aggregation and subdivision of spectrum rights together with the possibility of spectrum leasing would offer users greatest flexibility and so potentially offer the greatest economic benefits.

International Experience

Spectrum trading has been introduced in some frequency bands in Australia, Canada, Guatemala, New Zealand, the UK and the US. Trading is also likely to be permitted on a case by case basis in certain bands a number of countries. For example Austria, Germany, the Netherlands, Norway and Sweden all allow limited forms of trading.[87]

The details of the trading arrangements implemented differ between these countries. Some only allow simple trades whereas others allow licensees to aggregate, divide, transfer and lease spectrum. The extent to which the use of spectrum can change as a result of a trade varies – in some cases use may change so long as interference constraints are met whereas in others use may not be changed.

Some of the key features of the trading regimes in Australia, Canada, Guatemala, New Zealand, the UK and the US are described in Annex 5.[88] What this shows is that in all cases a mixed regime applies, with both tradeable and non-tradeable licences, spectrum and apparatus licences and more or less flexibility in what systems may be deployed. Spectrum licences are generally defined to be licences that allow the use of spectrum within a specified frequency range and area subject to certain technical constraints. Apparatus licences generally specify the operation of a particular type of radiocommunications transmitter (or receiver) at a particular

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[87] See "Study on conditions and options in introducing secondary trading of radio spectrum in the European Community, Analysys, Dotecon and Hogan and Hartson for the European Commission, May 2004.

88 Much more detailed descriptions can be found in "Towards more flexible spectrum regulation", WIK, Federal Network Agency, Germany, 2005; Consultation on a Renewed Spectrum Policy Framework for Canada and Continued Advancements in Spectrum Management, Industry Canada, May 2005.;"Radiocommunication Inquiry Report", Productivity Commission, Australia, 2002. "Review of Radio Spectrum Policy in New Zealand, Ministry of Economic Development, 2005; Spectrum Policy Task Force, Report, ET Docket No 02-135, November 2002, FCC and http://wireless.fcc.gov/licensing/secondarymarkets/

location subject to certain technical constraints. The key difference between apparatus and spectrum licences is that the deployment of transmitters is specified in the former but not the latter and this considerably limits flexibility of spectrum use.

At the end of the Annex we give an example of the licensing framework that has been introduced in Australia, Canada, New Zealand and the US for the frequency band around 3.5 GHz (2.3 GHz in the US, 2.3 and 3.5 GHz in Canada) initially intended for fixed wireless access type systems but auctioned on a technology-neutral basis[89]. There is a significant difference between the Australian approach which specifies a wide range of parameters and allows for registration of terminals in order to reduce the risk of potential interference problems, and the US where the technical framework is minimal and spectrum users are expected to resolve any interference problems that might arise. The approach taken depends on attitudes to controlling interference with Australia taking a more conservative approach than the other countries.

Australia and New Zealand have the longest experience with trading and liberalisation. This experience together with the more limited experience from the other countries reviewed in Annex 5 suggests that

- The costs of implementing a spectrum trading regime do not appear to be large. Small as well as large countries have implemented these arrangements, including new legislation and a new licensing regime. In the UK, a much larger economy than Hong Kong, the set up costs of spectrum trading have been estimated at around £3m and on-going costs in the range £0.3-2m pa., depending on the level of trading activity and whether change of use also occurs. If trading without change of use occurs then costs are at the low end of the range.[90]
- A variety of trading arrangements is possible ranging from flexible property rights through to more limited rights
- Annually the number of trades could be small relative to the number of licences, particularly in circumstances where the regulator is releasing a considerable amount of spectrum to the market.
- Trading is more likely to occur if administrative delays and costs caused by the need for regulatory approvals are low.
- Significant windfall gain problems have not yet arisen.
- Parties need easy, low cost access to publicly available information on who owns what (i.e. a licence register)
- Under a trading regime licensees are expected to take on more responsibility for sorting out interference issues
- When interference disputes cannot be resolved by the affected parties the regulator is often asked to resolve the problem. This is the case even where more formal mediation or arbitration procedures exist or where there is expected to be recourse to the courts

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[89] This is largely reproduced from "Spectrum Usage Rights", Aegis Transfinite and Indepen, 2006 http://www.ofcom.org.uk/consult/condocs/sur/

90 "Spectrum Trading Consultation", Ofcom, November 2003; Spectrum Trading and Wireless telegraphy Register Regulations, Statement, Ofcom, December 2004.

- Competition issues are best handled by the competition authorities and may be usefully supplemented by spectrum caps that can be relaxed once competition is established
- In all cases, governments require compliance with international regulations and reserve the right to change or revoke licences (without compensation) if these regulations are violated.

Data on the volume of trades is not reported in New Zealand but in Australia the volume of trades is reported by the regulator and has been as shown in the following table. The licences traded includes a number of trades between related companies (e.g. as a result of restructuring, mergers or acquisitions) and the turnover rate is the ratio of the number of trades divided by the number of spectrum licences on issue.

Year	Total licences traded	Percentage turnover rate
1998-1999	50	13.8
1999-2000	22	5.4
2000-2001	47	7.7
2001-2002	51	8.4
2002-2003	54	8.8
2003-2004	22	3.6

Source: www.acma.gov.au

In Guatemala there is a very active secondary market with approximately 26% of licences auctioned having been exchanged. Leases are not recorded and are not counted in this data. Trading has been permitted in the UK since December 2004. So far 14 trades have been notified on Ofcom's transfer register and 8 of them have been completed.[91]

Transfers of whole licences have been permitted for many years in the US and many thousands are transferred each year. There has been fewer trades involving partitioning of licences (around 1000/year) and this is in part because of the high transaction costs.[92] US initiatives in respect of spectrum leasing are aimed at reducing these transaction costs.

Some commentators have pointed to the seemingly low volume of trades as a concern. This is perhaps to be expected given the long life of most radio equipment and the need to continue to service an existing customer base mean that users are unlikely to want to change their spectrum use frequently. It has also meant that spectrum brokers, who might offer a service to bring buyers and sellers

[91] http://146.101.202.225/public-tnr/tradeDetails.do

[92] "Study on conditions and options in introducing secondary trading of radio spectrum in the European Community, Analysys, Dotecon and Hogan and Hartson for the European Commission, May 2004

together to do deals, have not appeared in the market.[93] Though in the case of Guatemala, significant trading volumes have occurred and this may in part be a result of the fact that users have been assigned full property rights. It would also appear that limitations on the duration of rights (i.e. rights are not perpetual) and the technology that can be used and users' flexibility to make trades (because of the need for regulatory approval) may have contributed to low trading volumes in Australia and the US. Also in New Zealand the ready availability of spectrum through auctions has meant users have no need to engage in trade to gain access to more spectrum.

Implications for Hong Kong

It is clear from experience so far that trading arrangements for spectrum will be evolutionary, with the detailed design of the trading systems changing over time as more is learnt about the conditions necessary to allow valuable trades to occur. The volume of trades is unlikely to be large initially unless current assignments are highly inefficient. All countries that have so far implemented spectrum trading are continuing with this policy and in most cases looking to extend it on the grounds that it has yielded net economic benefits.

Estimates of the net economic benefits of trading produced for the UK and the EU also suggest that the costs of introducing trading are small relative to the potential benefits. In the UK the net benefits of trading (without liberalisation of spectrum use) are estimated at a minimum of £20m/annum.[94] This estimate excludes any of the dynamic benefits from trade (e.g. innovation, competition benefits). Analysis for the EU as a whole counted these benefits and found that the net benefits from trading alone would be around €1bn/annum. Much greater benefits occur if liberalisation is also permitted.

In principle we would expect the situation in Hong Kong would be similar to that in other densely populated countries. Spectrum uses are similar, congestion occurs in similar bands and issues of cross-border co-ordination are as acute as in Hong Kong. A number of interviewees welcomed being allowed to trade their spectrum. The possible scale of benefits in Hong is given at the end of this chapter and indicates there would be net economic benefits in introducing the policy in Hong Kong. This policy would allow users to both transfer all or part of their rights of use of spectrum.

Recommendation 5.5: Spectrum trading should be introduced in Hong Kong. Initially, this could be done with respect to spectrum auctioned under the spectrum release plan and then extended to other bands once implementation issues have been addressed. Licensees should be able to transfer, aggregate, subdivide and lease access to their spectrum rights subject of course to meeting any requirements in their carrier licences. As suggested in Recommendation 4.11, in the longer term service/network and spectrum licences should be separated.

[93] In 2001 Australia Macquarie bank opened a spectrum trading exchange for a short time but closed this down because of the low trading volumes.

[94] These calculations assume that the level of trading is similar to that observed in Australia.

Implementation issues

Trading shifts decisions about who is assigned spectrum and in some cases the services using spectrum from the national regulator to licensees. In effect administrative decisions are replaced by market decisions. However, experience so far suggests that the national regulator will have an important continuing role in

- Deciding the overall spectrum strategy, including releasing vacant spectrum and allocating bands to new uses
- Maintaining a national register or database of assignments
- Publishing information on trading activity
- Undertaking international co-ordination and planning activities
- Defining the interference environment, so that the likelihood of harmful interference does not increase

The discussion below assumes OFTA continues to undertake these activities.

In Annex 6 we discuss issues of the scope of spectrum rights, licence duration and renewal, availability of information on spectrum use, spectrum hoarding, ex ante approval of trades, trading gains and interference management. We reach the following conclusions.

- We do not propose any change in the scope of rights of spectrum use with a move to tradeable licences
- While trading is promoted by long duration/perpetual licences or licences for which there is a general expectation of renewal, this is not appropriate in a Hong Kong context where government wishes to retain the option to terminate licences on expiry so that the spectrum can be refarmed to alternative uses
- The regulator should keep an official register of licences to indicate legal title. The register needs to be made publicly available in electronic form so that organisations can easily contact others they may wish to trade with.
- "Use it and lose it" conditions have not been found effective to deal with hoarding issues and so are not generally applied. Rather the financial incentive offered by trading is generally thought to provide a stronger incentive to use (and not hoard) spectrum than occurs under the current command and control regime.
- Trades should only need to be approved on competition grounds (see below)
- Gains from trade are not taxed specifically, so that trading activity is not unduly inhibited.
- Enforcement will continue to be OFTA's responsibility in cases of unlawful interference, however, under trading licensees are expected to take an active role in sorting out interference disputes before coming to the regulator.

Lastly we consider competition issues. These issues arise because organisations may now acquire spectrum to establish (and exploit) a dominant market position. This may be manifested by a refusal to sell spectrum at a high price (often referred

to as hold-out) or acquiring spectrum and not using it (i.e. hoarding spectrum in order to foreclose the market), in both cases with the intention of reducing the degree of competition in final markets. In industry interviews a number of organisations expressed concern that these outcomes would result from spectrum trading.

There is no general competition law in Hong Kong. However, there are competition safeguard provisions in the TO prohibiting abuse of dominance / discrimination by dominant operators (section 7L and section 7N) and also anti-competitive behaviour (section 7K) (the provision covers all licensees, not only dominant operators). Further, the TA regulates under section 7P changes in relation to a carrier licensee (e.g. mergers and acquisitions) where it has an effect of substantially lessening competition.[95] Only trades involving disposal of assets of more than 15% require the TA's approval. This may not be sufficient to prevent trades that may have an anti-competitive effect.

Additional competition safeguards are likely to be required and there are two options here – spectrum caps or enhanced competition powers for the TA that cover spectrum assets and a requirement on parties to a trade to seek advance clearance for any spectrum purchase. Spectrum caps have the advantage of certainty but risk being arbitrary. Advance clearance based on a competition assessment is more consistent with the current approach used by OFTA to determine the scope of regulation but lacks the certainty of spectrum caps and risks delaying transactions. On-balance we favour advance clearance but suggest that the regulator should commit to giving a decision within a pre-specified time period. Ideally the regulator would indicate in advance situations in which clearance is likely to be a formality. This could include trades of small amounts of spectrum between players with small spectrum holdings and/or low market shares before and after the trade, assuming the relevant market can be readily defined.

Recommendation 5.6: Additional competition safeguards should be put in place if spectrum trading is introduced. It is recommended that parties to a trade be required to seek advance clearance from the regulator and that the regulator is required to give a decision within a pre-specified time period. This may require a change to existing legislation. The regulator could give guidance on the types of trades for which clearance is likely to be a formality (e.g. where spectrum holdings/market shares do not change materially)

5.5 Liberalisation

Moving away from the traditional command and control approach of spectrum management to a system where market mechanisms have a role to play can involve not only auctions and trading as discussed in the previous section but also liberalisation. By this we mean putting in place a regime that defines spectrum usage rights in such a way that technology and potentially services deployed in a piece of spectrum can be changed.

[95] Guidelines to Assist the Interpretation and Application of the Competition Provisions of the FTNS Licence (1995) which will be replaced by Guidelines for Anti-competitive Conduct in Hong Kong Telecommunications Markets. A consultation on the latter was initiated in 2004.

In order to achieve this flexibility, and at the same time ensure that the interference environment does not become disruptive, it is necessary to define operating conditions in terms of power limits at geographic and frequency boundaries, and a set of procedures by which spectrum users can change these conditions through negotiation with other spectrum users who might be adversely affected. These aspects are discussed under implementation issues below.

In liberalising spectrum usage it is important to understand some key factors:

- Moving away from a command and control system to a liberalised environment does not mean that control taken in its widest sense should lessen overall. It is essential that if the spectrum is to be used efficiently it still has to be controlled through planning. Liberalisation simply means that the balance of control between the regulator (who establishes operating constraints) and the spectrum user (who plans operations) is moved more towards the spectrum user.
- It would be relatively easy to establish a liberalised regime based on completely unused spectrum. However, most spectrum is already heavily used and it therefore becomes necessary to accommodate existing users within any new regime that is proposed.
- In establishing liberalised operating conditions there is no right or wrong answer for the levels at which the conditions should be set. In general there is a balance to be struck between risk of interference and flexibility. While the ideal situation would be to provide a high degree of flexibility at the outset this is not generally attainable because of the need to protect existing spectrum users and a desire to ensure that the interference environment does not become immediately disruptive.
- From a technical point of view it is necessary to have a view on the characteristics of transmitters generating interference and receivers falling victim to that interference in order to derive the operating constraints that seek to control the interference to acceptable levels. It is therefore common practice for regulators to make a best assumption regarding the types of system and/or technologies most likely to first use a piece of spectrum when deriving the initial operating constraints. Some would argue that this is not technology / service neutral and that the benefits of liberalisation are therefore limited. In fact this approach is essential to establish a coherent technical framework and the important point is that liberalisation is achieved through the processes that are put in place to allow spectrum users to negotiate changes to these initial operating constraints.

International Experience

A number of countries, most notably Australia, Canada, New Zealand and the US, have already taken steps to introduce spectrum usage rights on a technology-neutral basis. It is instructive to see the extent of the technical framework that has been introduced in these countries. While each country has tended to put a slightly different framework in place depending on the frequency band in question, the frameworks that apply to the frequency band around 3.5 GHz (2.3 GHz in the US, 2.3 and 3.5 GHz in Canada), initially intended for fixed wireless access type systems but auctioned on a technology-neutral basis, have been compared. This

comparison shows that the regimes that have been put in place can be characterised as follows:

Australia – There is a significant level of detail in the technical constraints. Also a significant level of guidance and associated process has been put in place in order to manage the interference environment. Overall, good flexibility is available with lower risk of interference than New Zealand because of the more precise definition of the technical constraints. Registration of equipment (including receivers if desired) allows for first in time resolution of interference disputes not resolved through negotiation.

New Zealand – Wide flexibility is provided to band managers through limited technical constraints and process. Potentially greater flexibility is available although the requirement not to cause interference to existing users effectively imposes additional constraints. Registration of transmitters allows for first in time resolution of interference disputes not resolved through negotiation.

US – There are some service constraints. Technical constraints are not as detailed as the Australian case but include an in-band constraint unlike New Zealand. The risk of interference is higher than the Australian case and probably similar to the New Zealand case, although this is not strictly an equal comparison as the New Zealand band manager is likely to impose additional technical constraints. The responsibility for settling interference disputes resides entirely with users (except in the case of unlawful interference). Registration of equipment is not required.

The UK is actively looking at the introduction of spectrum liberalisation and there is also interest in mainland Europe.

Implementation issues

In a liberalised regime, the only constraint on spectrum use should be the controls necessary to avoid harmful interference.

The main types of interference are:

- In-band interference from co-channel transmissions across geographic boundaries
- In-band interference from out-of-band emissions falling across frequency boundaries
- Out-of-band (OOB) (adjacent channel) interference as determined by the in-band power of the transmitter and the out-of-band performance of the victim receiver.
- Intermodulation products and overload are to some extent controlled by the out-of-band limits applying to the transmitter. There are, however, situations where intermodulation products arise unexpectedly in a receiver or passively due to non-linear conductivity in metal. Other spurious emissions (e.g. harmonics / frequency conversion products) exist, both for transmitters and receivers.

It is these types of interference that have to be considered when deciding the degree of control that should be exercised under a liberalised regime.

If these types of interference and the technical factors which give rise to them are examined a number of issues having a bearing on the means by which a piece of spectrum can be packaged arise, as summarised in Annex 7.

Definition of rights

The envelope of parameters defining the spectrum usage rights should specify limits on the:

- Type of service (e.g. Fixed, Mobile or unconstrained)
- Frequency range of service;
- Geographic range of service;
- Aggregate PFD (or similar) limit at and beyond a geographic boundary
- EIRP (both in-band and OOB);
- Additional controls on OOB emissions (various options)
- Antenna height;

Additionally it could include reference receiver characteristics.

If one were to define the rights associated with receive-only terminals the appropriate parameters would be more limited and would include:

- Frequency range of service;
- Geographic range of service;

Additionally, it could include reference receiver characteristics.

A benchmark interference level should also be specified in order to aid system planning by spectrum users and to provide a trigger for enforcement.

Process for making a change of use

To make a change of use a licensee will need information concerning the spectrum rights of all potentially affected users, including licensed users, licence exempt users, government users, future users and international users. As much of this information as possible should be publicly available on a licence register. This information together with models for assessing the impact of a change of use (e.g. ITU models and possibly also industry agreed models) will be used to assess impacts and will form the basis of negotiation between users.

The change of use process should involve notification of the details of the change to the regulator, so that constraints imposed by government users and international agreements can be addressed. It is suggested that the regulator should provide an interface for dealings with government users. It is anticipated that it may not be possible to make changes to interference parameters for bands managed by the regulator, given the regulator's statutory obligations may mean it cannot negotiate such changes. If all the regulator's band management functions were to be transferred to the private sector this problem could be avoided

If interference disputes and disputes about whether a change of use that has been implemented violates a third parties' rights cannot be resolved through negotiation or voluntary mediation, then users would have the right to apply for compulsory arbitration. They would also have the option of taking complaints to the courts.

Implications for Hong Kong

As described above liberalisation provides for organic technology neutrality, that is to say technology and potentially services are allowed to change if required and if agreed with affected parties. This is different to the technology neutrality currently practised in Hong Kong. The technology neutrality practised in Hong Kong allows the licensee of a piece of spectrum to select the technology and standard to be used. The technical details of the system established and the standard adopted by the licensee will be included in the schedules of the licence. Subject to the consent of the TA, the licensee may change the technical characteristics and standard depending on its own commercial decision.

Current licences already specify technical and operational parameters and it might be expected that these would transfer over to liberalised spectrum usage rights at least initially. However there will be other implicit conditions perhaps embodied in the regulator's assignment process. These also have to be translated into the definition of rights. So although there are many similarities with the current licences some adaptation is required. However the main difference, and benefit, is that the technical and operational constraints are not fixed once and for all. They can be changed through negotiation with one's spectrum neighbours.

When considering whether liberalisation should be introduced to Hong Kong it has to be recognised that there are two important and related geographic/demographic factors. Firstly, Hong Kong is small and densely populated, and secondly, there is a border with Mainland China that has to be managed from an interference point of view.

It should be said that liberalisation is unproven with respect to small densely populated areas. In the first instance it might be expected that the opportunity for splitting spectrum packages on a geographic basis is more limited in this situation. Except in the case of low power operations it might also be expected that a change of use proposed by a spectrum user here will have an impact on users in the neighbouring region, namely Mainland China. This then becomes a formal co-ordination issue and it can be envisaged that this will reduce some of the benefits of liberalisation.

Liberalisation offers benefits providing the flexibility it offers is not compromised by technical constraints that may be necessary to reflect the characteristics of the territory in which it is to be implemented. The benefits potentially apply to Hong Kong as much as anywhere else. Consideration should therefore be given to its introduction in Hong Kong on a gradual basis while taking account of its progress in Europe for example and subject to fulfilment of regional and international obligations relating to the use of spectrum.

Recommendation 5.7: The release of new spectrum should be packaged on a technology neutral basis in the short term if there are no overriding policy reasons for specifying the technology to be used. The licensee should have the right to change its spectrum use subject to operating within the technical boundaries of their licence. In the longer term we suggest a move to technology and service neutral licences is considered where practical and if there are no overriding policy reasons or international / technical constraints on the service that may be provided.

To allow users to breach the technical boundaries of their licence and seek to accommodate this through negotiations with spectrum neighbours involves a step

change in the way spectrum is managed in Hong Kong. It in effect requires the regulator to relinquish command and control management of the spectrum completely. We do not think this appropriate in a Hong Kong context at present given the importance attached to the achievement of social and other public policy objectives.

5.6 Costs and benefits of trading and liberalisation

The benefits of trading and liberalisation that are likely to be realised over the next 5-10 years will depend largely on the frequency bands where they are applied and the extent to which the use of these bands is inefficient from an economic point of view (i.e. higher value use is possible). This suggests that the greatest benefits will come from applying these instruments to bands that are already occupied, intensively used and where users have been there for some time. In practice, trading and liberalisation have most often been applied to newly released (typically auctioned) spectrum.

Examples beneficial trades that have occurred elsewhere include the following[96]

- In New Zealand the majority of trades have been within AM and FM broadcasting. The main other trades involved the sale of GSM spectrum in a private deal and the sale of rights at 28 GHz

- In Australia trading allowed the creation of a broadband wireless service at 28-31 GHz, the aggregation of PMR licences and a regional wireless access provider (Austar) and a city focussed wireless access provider (Unwired) to swap access to their respective 2.3GHz and 3.5GHz spectrum in the city and regional areas to provide more cost effective networks for both operators.

- In the US trading the most prominent outcomes from trading was the creation of national mobile network by Nextel who aggregated local private mobile radio licences through secondary trading and applications to the regulator.

In addition, we note that a "false scarcity" of 3G spectrum in Europe was created by lack of flexibility in 2G licences. Spectrum at 900 and 1800 MHz had to be used for 2G services and this in part contributed to high prices paid for 3G licences which in turn have had a negative impact on companies in the sector. The same pressures did not exist in Canada or the US where licensees had the flexibility to use 2G licences for 3G technology and could also acquire spectrum through the secondary market.

As far as we are aware estimates of the costs and benefits of trading and liberalisation policies have only been produced for the UK and the EU. Elsewhere these policies have been adopted based on the economic arguments presented at

[96] See "Towards more flexible spectrum regulation", WIK, Federal Network Agency, Germany, 2005; "Radiocommunication Inquiry Report", Productivity Commission, Australia, 2002. "Review of Radio Spectrum Policy in New Zealand, Ministry of Economic Development, 2005; "Study on conditions and options in introducing secondary trading of radio spectrum in the European Community, Analysys, Dotecon and Hogan and Hartson for the European Commission, May 2004

the start of this chapter and a general belief that markets are likely to perform better than command and control mechanisms.[97]

Table 5.3 lists the net present value of the costs and benefits of trading and liberalisation produced for the UK and the EU using similar methodologies. These estimates were produced for a 20 year time horizon and assuming a real discount rate of 6%.

The European estimates shown in the table are for the 25 EU members plus 3 other countries that have implemented EU telecoms legislation (Iceland, Liechtenstein and Norway) and seek to estimate the benefits and costs associated with a co-ordinated approach across Europe to implementing trading and liberalisation. In deriving these estimates it is assumed that some countries implement these policies in the absence of co-ordination, although absolute estimates assuming no trading or liberalisation occur in Europe are also provided (and these are substantially larger than those shown in Figure 5.3).

Figure 5.3: Benefits and costs of spectrum trading and liberalisation

	Trading	**Liberal**	**UK estimates (NPV) – 2004**		**European estimates (NPV) – 2004**	
			£M		**€M**	
Benefits			T	T&L	T	T&L
Reassign to higher value users/use	✓	✓	62	156[98]	220	450
Reduced transaction costs	✓	✓	n.c.	n.c.	n.c.	n.c.
More competitive markets	✓	✓	62	>62[99]	220	8000
Service innovation		✓		n.c.	990	92650
Total			*124*	*218*	*1210*	*101,100*
Costs						
IT and admin set up costs (regulator)	✓	✓	3	3	46	70
On-going admin costs (regulator)	✓	✓	3	5-10	3	40
Admin costs (industry)	✓	✓	3	8		
Increased costs of interference mgt		✓		n.c.		
Total			*9*	*16-21*	*49*	*110*
Net impact			**115**	**197-202**	**1161**	**100,990**

n.c. = not calculated

[97] There is a parallel here with the early adoption of policies of privatisation and promoting competition in telecommunications markets.

[98] Estimated from Ofcom (2003) adjusted for revised assumptions in Ofcom (2004)

[99] This is an underestimate as the specific competitive benefits from liberalisation were not calculated

The issue we need to address is the possible scale of costs and benefits in a Hong Kong context. To produce estimates for Hong Kong we have started with the conservative UK estimates and assumed that

- trading volumes are proportional to GDP, as the smaller the GDP the less the use of spectrum. In other respects the Hong Kong spectrum management regime is similar to that applied elsewhere, and congestion is experienced which suggests that users who would like to gain access to spectrum may not be able to do so and trading may allow this to change. Hong Kong GDP is 8% of UK GDP. [100]
- value of spectrum in Hong Kong is 71% of the value in the UK, where this percentage is the ratio of Hong Kong to UK GDP per capita
- set up costs vary with GDP/capita
- on-going administrative costs are assumed to be proportional to GDP
- administrative costs for industry are 5% of the benefits from trade.
- competition benefits are small – we have pro-rated the UK estimates by GDP
- innovation benefits have the potential to be very large but are not quantified because of their speculative nature
- trading/liberalisation occurs across all the main licence types of spectrum use.

The results are given in Figure 5.4 and show there is a net positive impact from both trading and liberalisation. In both cases the estimates are conservative by not accounting for the potentially large benefits from more rapid adoption of innovative services. It might be argued that the administrative costs are underestimated because of the need to undertake competition assessments in some cases. Given the nature of trading activity observed elsewhere it seems unlikely any significant activity will be required more than once a year and it could be much less than this. Furthermore, our estimate of benefits is on the low side. If even only 1% of the benefits from service innovation estimated for the EU were counted then this would add around a further $100m in the case of trading and $9bn in the case of trading and liberalisation.

[100] Estimates of UK and Hong Kong GDP and population were taken from the CIA World Factbook. http://www.cia.gov/cia/publications/factbook/geos/uk.html

Table 5.4: Benefits and costs of trading and liberalisation in Hong Kong

	Trading	Liberal	Hong Kong estimates (NPV) – 2004	
			$HKM	
Benefits			T	T&L
Reassign to higher value users/use	✓	✓	49	124
Reduced transaction costs	✓	✓	n.c.	n.c.
More competitive markets	✓	✓	69	>69
Service innovation		✓		n.c.
Total			*118*	*193*
Costs				
IT and admin set up costs (regulator)	✓	✓	30	30
On-going admin costs (regulator)	✓	✓	3	8
Admin costs (industry)	✓	✓	2	6
Increased costs of interference mgt		✓		n.c.
Total			*35*	*44*
Net impact			**83**	**149**

n.c. = not calculated

6 Essential public services and broadcasting

6.1 Introduction

This Chapter is concerned with the management of spectrum used by essential public services and broadcasting. It was agreed at the kick-off meeting for the study that spectrum used by defence would be outside the scope of this study, and so this chapter is concerned with the management of spectrum used by

- government departments
- the maritime, meteorological and aeronautical industries
- broadcasting.

Essential public services and broadcasting taken together are significant users of radio spectrum. They are typically reserved spectrum to meet their operational requirements and broader policy objectives. In Hong Kong, as in most other countries, the process for deciding how much spectrum to allocate to government versus other users and the efficiency of government use of spectrum is not transparent.

Use of spectrum by essential public services and broadcasting potentially denies access to spectrum by either other "essential" services provided by private operators (e.g. transportation and electric utilities) or commercial users now and in future – thereby potentially raising costs and/or limiting the supply of services. If this is the case there could be economic and social benefits from encouraging more efficient use of spectrum by essential and broadcasting services. This line of argument has led some governments to review spectrum use by essential public services and broadcasting and to consider mechanisms that encourage more efficient use of spectrum by these services. The main focus of these efforts has been on spectrum use by government departments and other public sector agencies.

In this Chapter we consider whether essential public services and broadcasting in Hong Kong should face stronger incentives for efficient spectrum use through the application of either administrative or market-based tools.

6.2 Effectiveness of current spectrum use

Current and expected future spectrum use by essential services differs considerably between each of 1) government departments, 2) the maritime, meteorological and aeronautical industries and 3) broadcasting and so we discuss each category separately below. We have not undertaken a detailed audit of spectrum use by essential public services and broadcasting. Our comments on the effectiveness of current use of spectrum by these services are based on assignment data made available to us by OFTA and observations concerning characteristics of the equipment used (digital vs analogue and channel bandwidth).

Government departments

The main uses of spectrum by government departments are for fixed microwave links and private mobile radio including trunked systems. As noted in Chapter 2, the occupancy of bands reserved for government use is lower than in commercial bands, suggesting more efficient use of spectrum might be achieved by reallocating spectrum from government to non-government use. We also noted that to be effective the policy on giving government users priority on hilltop sites might need to be changed.

One way of enhancing the efficiency of government spectrum use would be to encourage these users to share networks for fixed and mobile applications.

Maritime, meteorological and aeronautical industries

As discussed in Chapter 2 congestion problems are experienced in the aeronautical communications bands in Hong Kong and there is therefore a good case for moving to 8.33 kHz channels, possibly through the application of spectrum pricing.

Broadcasting

The main way in which broadcasters could make more effective use of spectrum would be to migrate from analogue to digital technology, though the nature of the terrain and buildings in Hong Kong will limit to some extent the efficiencies that can be achieved.

In the case of radio broadcasting there is vacant VHF and L band spectrum for digital audio broadcasting but little evidence of market demand for the service in Hong Kong. The international situation with respect to the technology and equipment is highly uncertain and so it is likely to be beneficial to wait and see whether any of the alternative digital technologies for audio services (i.e. DAB, DMB or DRM) is likely to be adopted on a more widespread basis before introducing such services into Hong Kong. This is consistent with current policy under which applications for digital audio broadcasting licences will be considered when the following conditions materialise

- "The market potential if digital audio broadcasting and the associated non-broadcasting applications becomes clearer
- The price of digital audio broadcasting receivers comes down to an affordable level for consumers
- The worldwide penetration of digital audio broadcasting services picks up momentum."[101]

In the case of TV, it is clear that analogue to digital migration will occur in North America, Japan, Korea and Western Europe over the next 5 or so years. Digital terrestrial TV (DTT) transmissions have commenced in many of these countries. DTT transmissions will start on a commercial basis in Hong Kong in 2007 and the government's objective is to switch-off analogue TV services within five years from

[101] Para 20,"Consultation paper on digital terrestrial broadcasting", Legislative Council Panel on Information Technology and Broadcasting, December 2000

the start of DTT simulcasting.[102] Of the five multiplexes available, one will be used for simulcasting existing services, two will be assigned to the incumbent broadcasters for HDTV and other services and two have been held in reserve. Decisions concerning the remaining two multiplexes will be left until SFN operation is confirmed feasible in the local environment. Policy on spectrum released at switchover (up to sixteen 8 MHz channels will be available on a territory-wide basis) has not yet been decided.

From our interviews with industry players it is clear there is demand for

- the available UHF spectrum for DTT from the existing terrestrial broadcasters and pay TV operators and
- future spectrum released by analogue switchover for fixed and mobile TV broadcasting services, interactive TV and datacasting

This might suggest that the incumbent broadcasters should be given stronger incentives to migrate to DTT, however, we note that delays in the start of services have largely been caused by incumbent licensees waiting for Mainland China's self-developed standard. Under the market-led approach, the Government will allow the incumbents to wait for Mainland China's standard until the end of 2006. If there is no Mainland standard after the deadline, the European DVB-T standard will be adopted. The proposed switchover period of up to 5 years is similar to that proposed in a number of other countries and is necessary to build out the transmission network and to give households sufficient time to buy digital equipment.

The basis on which access to UHF spectrum for DTT and possibly other services such as mobile TV is to be provided depends on broadcasting policy considerations. Government may choose to reserve the spectrum for particular services that are intended to meet certain public interest objectives or, if these objectives can be met through existing assignments, then a more market based approach could be used to determine who is assigned spectrum and for what purpose. This issue is discussed further below.

6.3 Encouraging more efficient spectrum use – essential public services

In this section we discuss the general issues that arise when applying mechanisms to encourage more efficient spectrum use by public sector agencies supplying essential services.[103]

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[102] "Implementation Framework for Digital Terrestrial Television Broadcasting in Hong Kong", Legislative Council Brief, CTB (CR) 9/1/9 (06) Pt. 21. March 2006

[103] Essential services supplied by the private sector can in principle be treated in the same way as other private sector users of spectrum. This is because they are able to make trade-offs between the relevant financial costs and benefits from using more or less spectrum, taking account of any regulatory constraints on the services they must provide. If the cost of using spectrum rises or falls then they can adjust their prices to final users to reflect these changes, just as is the case when the costs of other inputs change.

Potential mechanisms to encourage efficient spectrum use by government departments and other public sector agencies include:

- administrative review
- quantitative restrictions
- capitalising spectrum holdings
- financial incentives.

Administrative review

Use of spectrum by public bodies could be made subject to periodic review by the regulator to ensure the services in question share spectrum where practical, do not hoard spectrum and more efficient technology or systems to meet their needs are implemented in a timely manner. In addition, such a review should assess and take account of likely future spectrum requirements of government users. The outcome of such reviews, in terms of changes in spectrum use and future requirements, should be made public and incorporated in the overall spectrum strategy including the spectrum release plan. Such reviews should be led by CITB, as policy issues are likely to arise, but it will be important that technical support is provided by the regulator.

The main issues with such an approach are that

- the regulator may have difficulty determining whether spectrum use is efficient given requirements may be intermittent and/or needed only in times of emergency. There are no standard efficiency benchmarks that can be used except by comparison with non-government applications which may in any event be different in nature.
- the review may require changes in spectrum use that may be difficult to achieve without additional budget provision. Typically the final services must be provided (e.g. police or fire services) and if the user does not have the budget to purchase new equipment or move to other bands then there may be little that can be done.

Nevertheless, periodic reviews have the advantage that they make users aware of the importance of efficient spectrum use and may stimulate any necessary changes in budgets and organisational arrangements required to finance changes that promote more efficient spectrum use. The box below briefly describes the approach proposed by the Netherlands government.

Box: Netherlands proposals for promoting efficient spectrum use for public interest purposes.

The assignment of spectrum to public interest uses (e.g. emergency services, defence, police, air traffic management etc) will be based on a needs justification plan submitted to the Ministry of Economic Affairs.

Possibilities for third party use of the spectrum will be explored.

Users will be expected to use the minimum spectrum required to achieve their public interest objectives, taking account of the opportunity to use innovative technology.

Frequency use is to be assessed every three years to ascertain whether the relevant frequencies still meet the asserted needs and are used efficiently. This assessment may involve monitoring actual use of frequencies.

Source: "Radio Spectrum Policy Memorandum 2005", Ministry of Economic Affairs, The Netherlands

Quantitative restrictions

Quantitative restrictions would comprise limits on the amount of spectrum a user may have reserved for its use. Any additional spectrum that may be required would have to be justified by detailed proposals or acquired in competition with commercial users. This is clearly a rather blunt instrument, as it assumes that the current position gives an indication of the "appropriate amount" of spectrum required and so does not allow for reductions in spectrum use.

If detailed justification of additional spectrum requirements is to be an effective means of promoting efficient spectrum use then there needs to be an organisation with the competence to judge whether applications for additional spectrum are well founded or not. This may be problematic in some areas as specialist knowledge may only reside with the user making the spectrum application.

We note that the Independent Audit of public sector spectrum holdings in the UK[104] recommended that there should be a presumption that new public sector spectrum should be met through the market in all but exceptional cases. Issues associated with government users "buying" spectrum are discussed below.

Capitalising spectrum holdings

One approach to recognising the value of the spectrum resource used by public sector agencies would be to include the capital value in their balance sheets. This assumes of course that it is possible to value the spectrum used. In the absence of spectrum pricing and trading in Hong Kong this could prove difficult. However, there could be analogies here with the treatment of land and other assets of such organisations.

Financial incentives

Financial incentives for more efficient spectrum use may be given in a number of ways including the application of

- administered incentive pricing (AIP), by which we mean prices set by the regulator that are intended to reflect the opportunity cost of the spectrum
- purchasing spectrum through auctions
- allowing users to trade their spectrum.

The potential benefits from applying these approaches include the release spectrum when it is not needed or as a result of the adoption of more spectrally efficient technologies, moving to frequency bands where spectrum is plentiful

[104] "Independent Audit of Spectrum Holdings", An Independent Audit for HM Treasury, Professor Martin Cave, December 2005

and/or moving to use alternative services (e.g. wired alternatives or public services). Furthermore future demand may be moderated.

The beneficial incentive effects of pricing mechanisms, such as AIP, auctions and trading, arise most clearly in the case of private sector users of the spectrum – a rise in the cost of using spectrum will trigger consideration of ways of reducing this cost. However, incentive structures in private and public sector agencies often differ and this can impact on the effectiveness of applying spectrum pricing in the public sector. The differences are summarised in the Box below. The key point is that public sector budgetary arrangements need to be sufficiently flexible to allow public sector organisations to "profit" from economising on spectrum use and/or to increase their expenditure on spectrum use (where this is thought necessary) within their overall budget constraints.

Box: Incentives in private and public sector organisations

A commercial entity has a strong incentive to maximise profit by maximising revenues and minimising costs – in other words to choose those outputs that have the highest private value and to minimise their cost of production. Not for profit organisations may also have closely related incentives, namely to produce outputs consistent with their mandate to produce some kind of public value and to minimise unit costs in order to maximise production of their mandated output.

The incentives in government agencies can be very different, in particular in relation to costs. To the extent that a reduction in resource use is expected to result in smaller budgets in the future there can be an incentive to spend up to the allowed budget rather than to reduce actual costs relative to the budget. There is also an incentive to hoard assets that might be required in the future such as land and spectrum in case they are required in future.

In the UK, the Independent Audit of Spectrum Holdings has suggested that public bodies selling or returning spectrum should be allowed to benefit from any financial gains or cost reductions they make. However, for such mechanisms to work as well as incentives on private sector bodies government must make a credible commitment not to revisit the terms of the "contract" after the event when surpluses or profits are realised and efficient spectrum use is common knowledge. For example, if the level of AIP was large relative to existing budgets there may be a reluctance to allow agencies to "profit" from decisions that free up spectrum in which case incentives would be weak.

New institutional arrangements and processes that provide commitment not to remove gains from more efficient spectrum use for a given period of time will be required. The multi-year price cap regime used in the utilities sector provides a possible model.

Turning to the application of AIP, trading and auctions to government users we note that generally economic analysis suggests that it is efficient for all users to pay the opportunity cost of the spectrum they use and for other policy instruments to be used to deliver the outputs desired from publicly provided services – for

example through changes in budgets.[105] This means building the future cost of spectrum arising from pricing or auctions into budget processes so that the public sector acquires spectrum, as it does for other inputs, at commercial rates. The production of a forward-looking statement of spectrum requirements by the public sector will help facilitate this budgeting process.

AIP would apply to current use of spectrum by public sector bodies in bands that are currently or are expected to become congested e.g. some fixed link and PMR bands. AIP would be set for some time (we have suggested 5 years) and so users would be readily able to build this into their budgeting processes.

Auction prices and the value of traded spectrum would be less certain given the current absence of trading and the relatively infrequent nature of auctions. We therefore suggest that additional spectrum needs of public sector users are met through spectrum reservations for at least the next 3 years, until a market in spectrum has started to develop. If there are competing demands for frequencies reserved for use by the public sector then AIP would apply in any event.

Finally we need to consider whether public sector users should be permitted to trade their spectrum. At present this would not be possible on practical grounds because such users are not licensed. Licensing would first need to be introduced and then the possibility of trading considered. We think there could in time be benefits to public sector users being permitted to trade their spectrum. But there would need to suitable internal government controls in place to ensure users did not sell off spectrum to meet short term budget pressures and thereby undermine their capacity to deliver the services they are obliged to provide. In these circumstances there may be no option for the regulator other than to give the organisations concerned more spectrum (if it is available) so that service levels can be maintained.

All of this discussion depends on public organisations having budgetary freedoms to keep any savings and spend them on other inputs and not being able to simply reduce their output in response to the increase in the price of spectrum. We have not been able to meet with the Financial Services and the Treasury Bureau to determine what might be feasible in Hong Kong. Therefore we are not making any assumptions on feasibility for the purpose of the recommendations in this report.

International experience of applying financial incentives to government users of spectrum is limited. Two examples are as follows

- in the UK, government users pay the same administratively determined spectrum prices for their spectrum access as commercial users. The recent Independent Audit of public sector spectrum holdings concluded that AIP is likely to remain a fundamental element in encouraging improved spectrum efficiency for public sector spectrum holdings.
- in the US, a number of bands have been identified for potential reallocation from government to non-government use. The costs of moving government

[105] It can be shown that subsidising inputs is inefficient and that policy should be focussed on outputs. "An Economic Study to Review Spectrum Pricing", Indepen, Aegis Systems and Warwick Business School, Ofcom, February 2004. http://www.ofcom.org.uk/research/radiocomms/reports/independent_review/spectrum_pricing.pdf

users from these to other (less highly desired) bands are identified and the bands are auctioned but are only released to private sector bidders if the revenues raised exceed 110% of the cost of moving the government users. This mechanism for paying for moving costs gives government users an incentive to move and ensures the benefit to the private sector exceeds the economic costs of the reallocation.

Recommendation 6.1: There should be periodic reviews of spectrum use by government. Periodic reviews of government spectrum use should

- **assess the efficiency of this spectrum use**
- **assess demands for future use**
- **make proposals for improving efficiency now and in future**
- **draw conclusions on future spectrum requirements for government users**

The results of such reviews should be published, subject to any public interest concerns, and should be an input to future spectrum strategies and release plans. See also Recommendation 4.5.

Recommendation 6.2: The regulator should continue to reserve spectrum for government users, but this policy should be reviewed once market mechanisms have been applied more extensively to private sector use of spectrum in say 5 years time.

Recommendation 6.3: Assuming government users have sufficient budgetary freedoms to benefit from efficient spectrum use, then AIP should be applied to the use of spectrum by government users in bands where there are potentially competing demands for spectrum – either from government or commercial users. At present this means applying AIP to UHF PMR bands and fixed links band in congested bands, for example bands below 16 GHz.

6.4 Encouraging more efficient spectrum use - broadcasting

In the case of broadcasting incentives for efficient spectrum use are also desirable, particularly in the case of the UHF spectrum used by analogue TV which could alternatively be used to provide a range of fixed and mobile digital TV services. The issues here are somewhat different from those for other essential public services. The service providers are privately owned but the services provided are regarded as providing benefits that are external to the supplier (e.g. promoting cultural and educational objectives). It is sometimes argued that this justifies free or low cost access to the spectrum.

It is common practice elsewhere for broadcasting policy objectives in respect of universality, plurality and diversity to determine the use and assignment of spectrum to broadcasting services. Technically efficient spectrum use is then achieved within the constraints imposed by broadcasting policy. Financial incentives for efficient spectrum use are rarely applied. Only a few countries have assigned frequencies to broadcasters by auction (e.g. Denmark (radio),

Netherlands (radio) and New Zealand (TV and radio)). Trading of broadcasting spectrum is permitted in New Zealand.

The potential efficiency benefits from the application of spectrum pricing, auctions or trading[106] to broadcasting include

- Short run responses by existing users in terms of optimising the use of spectrum and other resources (such as transmission infrastructure), although in practice the scope for doing this may be rather limited
- Moderation of demands for more spectrum from either industry and/or government. When there is a cost to such demands the relevant "users" will weigh up the costs and benefits more carefully
- Long run changes to policy that result in the reallocation of spectrum from low to high value uses
- Increased incentives for users' and manufacturers' long term investment and research and development decisions to be aimed at economising on spectrum use
- Removing potential distortions to platform choices in a converged communications market
- Promoting fair competition between spectrum users who for historical reasons have gained access to frequencies through different mechanisms.

As mentioned above it can be demonstrated that economic welfare (i.e. efficiency) is promoted if any policy intervention intended to achieve public interest objectives is focussed on outputs rather than inputs.[107] In the case of broadcasting this means making spectrum available on the basis as for other services, and making compensating adjustments to output focussed policies (e.g. subsidies or reduced broadcasting licence payments in return for the provision of specific content).

In the Hong Kong context, public interest objectives for broadcasting are met through programme obligations and the only alternative policy option to low cost spectrum[108] is likely to involve payments to broadcasters in return for fulfilment of their programme obligations, unless of course broadcasters were able to fund these through profits made on other programming.

If such output focussed policies are not feasible then a number of alternative policy approaches that could promote more efficient spectrum allocation and assignment decisions include

- *Transparent definition of public service broadcasting*: This involves identifying clearly when TV and radio services fulfil certain public interest objectives (as specified for example in certain programming obligations) and when they are

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[106] In respect of trading, we note that this could be constrained by broadcasters' coverage and programme service obligations. If DTT multiplex capacity is tradeable, then some of the benefits from spectrum trading may already be realised.

[107] The following also reach this conclusion. Sally Holtermann. February 1976. "Alternative tax systems to correct for externalities, and the efficiency of paying compensation." *Economica*, Volume 43169. Gloria Helfand. November 1999. "Controlling inputs to control pollution: when will it work?" *Association of Environmental and Resource Economists Newsletter*, Volume 19(2). Page 17. http://www.aere.org/newsletter/Newsletter_Nov99.pdf

[108] The cost is low relative to the potential market value of the resource.

largely for entertainment purposes and so attract minimal if any positive programming obligations (as is generally the case with pay-TV). Access to spectrum for public interest services could be reserved while that for other services could be assigned by auction as is the case for other communications services. This approach is consistent with placing all service providers on an equal footing in a converged communications market.

- *Cost/benefit assessment*: Undertaking cost/benefit analysis of spectrum allocation decisions weighing the welfare benefits of different competing uses of spectrum that might be used for broadcasting or other communications purposes (e.g. the UHF band). In this regard we note that estimates of the consumer and wider societal value of TV and radio services have been made in a number of countries and such estimates can be used to inform these decisions.[109] Even if these values are not known it can be instructive to have estimates of the value of alternative services that might use the spectrum under consideration as this gives an indication of the value forgone if the spectrum is allocated to TV broadcasting.
- *Capitalising spectrum value*: Capitalising the value of spectrum used by broadcasting on the balance sheet of the relevant policy bureau i.e. CITB. The argument being that this would induce policy makers to make appropriate trade-offs when arguing for more spectrum for broadcasting services. However, there are a number of practical difficulties with this option including valuing the spectrum and the detailed operation of the incentives.

Of these options, we suggest that the first is the most desirable in a converged communications environment so that spectrum for broadcasting is only reserved where services clearly meet public interest objectives that would not be met by commercial services. If this is not possible, then cost benefit analysis could assist in placing some rigour on decisions.

Recommendation 6.4: It would be desirable for broadcasting policy to draw a clear line between services that are intended to achieve public service broadcasting objectives and services that are purely commercial. The latter should access newly released spectrum (e.g. in Band III, L band and UHF spectrum released after switchover) in the same way as other commercial services (e.g. commercial telecom services), just as commercial broadcasting services pay market rates for access to satellite capacity or capacity on wired networks. Policy trade-offs in this area could also be made more transparent by assessing the potential value of services forgone as a result of spectrum use by broadcasting.

[109] "Valuing the Canadian Broadcasting Corporation, A Finn, S McFayden, and C Hoskins, Journal of Cultural Economics, 27, 20003; "Irish Public Service Broadcasting: A Contingent Valuation Analysis, L Delaney and F O'Toole, Trinity College, Dublin, February 2004; Measuring Public Service Broadcasting, R Foster, J Egan and J Simon, www.ofcom.org.uk. Delivering Public Value: BBC Licence Fee, http://www.bbc.co.uk/thefuture/related.shtml

7 Implementation Plan

We have recommended a strategy for spectrum management that is aimed at promoting the transparency and predictability of spectrum management in Hong Kong, while meeting spectrum management objectives.[110] Our recommendations are focussed on

- improving the flow of information on current and planned future spectrum use from the regulator to industry
- making policies and factors determining decisions more explicit
- applying a mix of administrative and economic tools to incentivise more efficient use of spectrum and to support the timely and economically beneficial release of spectrum for new services.

Out of the twenty five (25) recommendations made in previous chapters, we envisage that the following recommendations *may* need legislative change for full implementation:

- **Recommendations 4.11**. The existing regulatory regime may allow the separation of the terms and conditions governing spectrum use from the service licence. For example, S 7(6) allows the regulator to issue 'other licence' to cover the terms and conditions of spectrum use; S 8(1)(b) allows the regulator to manage the terms and conditions of spectrum use through apparatus licensing. Although it is possible that the existing legislation may permit the allocation of frequencies without reference to the provision of any specific service or to specific apparatus (for example, by reference to all services and all apparatus), the avoidance of any doubt may require legislative change to ensure certainty on the matter.
- **Recommendation 4.14:** The extension of the licensing framework may require legislative change for the avoidance of doubt.
- **Recommendation 5.5**. The same point applies here as in the case of Recommendation 4.11, in relation to the separation of service /network and spectrum licensing.
- **Recommendation 5.6**. The changes envisaged for the protection of competition in the trading of spectrum may well require amendments to existing legislation.

This chapter draws on the analysis and recommendations presented in previous chapters to provide a spectrum release plan and an indicative timetable for the implementation of our recommendations.

7.1 Spectrum release plan

Based on the criteria identified earlier for spectrum release there is a case to be made for the release of three major tranches of spectrum:

[110] In respect of economic and technically efficient use of spectrum, the introduction of innovative services, supporting Hong Kong's position as a gateway to Mainland China and meeting public policy objectives including ensuring there is sufficient spectrum for essential public services.)

- Mobile bands at 800, 900 and 1800 MHz which have either been made available by migration of legacy mobile systems or where spectrum has been idle.
- Bands at 2.3 and 2.6 GHz which have already largely been cleared of users and for which demand could come from more than one type of radio application
- Spectrum in Band III, at UHF (potentially released by analogue TV switch-off) and at L-band which would be of interest for digital multimedia services.

In addition there are a number of other smaller bands that could be made available to the market but it will be necessary to determine the degree of interest in these bands before embarking on their release.

In the longer term there are already discussions being held worldwide regarding the requirement for spectrum for systems beyond IMT-2000. These discussions will lead to decisions being made (or deferred) at WRC-07. Should decisions be made at WRC-07 regarding the designation of parts of the spectrum between 3.4GHz and 4.99 GHz for 4G systems, it may become necessary to start a refarming process in order to make the spectrum available at a later date. While this situation cannot be regarded as an immediate release of spectrum, the planning for its future release has to be made in a timely fashion and it has therefore been included in the plan below.

An illustrative process and timing for the release of the spectrum is shown in the table below. Such a process is critical for the Government and industry's requirement for a predictable and transparent spectrum policy.

Figure 7.1: Illustrative Spectrum Release Plan

Frequency band	**Method of release**	**Comment**
Year 1		
825 – 851 MHz	Packaged to provide North American pairing in the lower two bands and GSM pairing in the upper two bands. GSM – divide between existing GSM operators. 800 MHz pairing (CDMA2000 by policy decision, otherwise technology neutral) – auction	Partially encumbered until November 2008
870 – 890 MHz		Partially encumbered until November 2008
925 – 935 MHz		
1780 – 1785 MHz	Paired – divide between existing PCS operators	
1875 – 1880 MHz		
2300 – 2400 MHz	Packaged on a technology and service neutral basis. Auction	Currently partially encumbered.
2500 – 2690 MHz		
Year 2		
825 – 851 MHz left-over		Consult on market interest.

1785 – 1805 MHz		
1900 – 1905 MHz		
2010 – 2020 MHz		
UHF TV spectrum (678 – 686, 798 – 806 MHz)	Technology neutral[112]; Either auction or administrative decision	Timing and services linked to successful implementation of single frequency network (SFN) for digital terrestrial television
1466 – 1480 MHz	Technology neutral[112]; Auction	Timing and demand linked to decisions concerning UHF TV spectrum – consult on market interest
Band III (216 – 223 MHz)	Technology neutral[111]; Auction	Timing and demand linked to decisions concerning TV spectrum and global developments in digital audio radio – consult on market interest
Year 3		
9.8 – 10.7 GHz		To be replanned – consult on market interest.
Future Release		
UHF TV spectrum (vacated spectrum after analogue switch-off)	Technology and service neutral; Either auction or administrative decision	Quantity unknown at this stage – policy decisions required to determine whether spectrum is auctioned on a technology and service neutral basis or not.
3.4 – 4.2 GHz 4.4 – 4.99 GHz	Potential refarming required	Review in the light of WRC-07 outcome.

7.2 Indicative implementation plan

Figure 7.2 gives and indicative implementation timetable. In practice the timetable will depend on government decisions following this report and the time taken to implement any new legislation and so the indicative timetable refers to short term actions which we anticipate could occur in the next two years and subsequent longer term actions.

In putting together the implementation plan we have assumed that

[111] Service neutrality may also be considered.

- The establishment of a spectrum strategy and the associated spectrum release plan will produce the most benefits in the short term and so are the main priority
- The process leading to the introduction of spectrum trading within current legislation should be started
- A review of government use of spectrum should be carried out in the medium term
- In the longer term, and dependent on policy decisions and the passing of legislation where necessary, the extension of trading along with liberalisation, the introduction of AIP, and the licensing of receive-only systems and / or government use should be considered.

It is also important to note that the implementation of new spectrum management approaches as implied by the implementation plan will require organisational changes within the regulator. In particular, it will be necessary to provide additional resources in terms of technical, legal and economic expertise which will be required to develop spectrum management practices based on market mechanisms.

Figure 7.2: Indicative Implementation Plan

Activity	Timing
SHORT TERM	
Policy objectives (CITB)	While these should ideally be in place first with all other activities flowing from them, it is recognised that there could be delays in putting these into place. It is assumed that they are broadly known a priori to all parties so that other activities may commence immediately.
Spectrum strategy statements (OFTA)	The spectrum strategy, potentially based on material in this review, should be developed immediately. After consultation through appropriate channels the spectrum strategy with any necessary amendments resulting from the consultation should be published within months. The strategy should be reviewed every three to five years. Policy statements regarding specific issues should continue to be issued as and when required.
Spectrum release plan (OFTA)	In parallel with the spectrum strategy, the spectrum release plan should also be developed immediately. Similarly, after consultation through appropriate channels the spectrum release plan should be published

	within months. Implementation of individual strands within the plan can then commence. The spectrum release plan should be reviewed at least every 3 years with a consultation / amendment / implementation cycle.
Trading and liberalisation within existing legislation (CITB and OFTA)	The introduction of trading may occur in limited form within the existing legislative framework. Proposals should be made for this and put through the chosen consultation process before implementation. New releases of spectrum should be on a technology neutral and tradeable basis subject to any policy constraints.
Legislative changes (CITB with support from OFTA)	The longer term activities noted below will likely require legislative changes. Given the length of time this can be expected to take it would be prudent to at least initiate the process in the shorter term, contingent on any necessary policy decisions being made.
MEDIUM TERM	
Review of Government use (CITB and OFTA)	Government use should be reviewed with a view to balancing government and non-government needs. Spectrum identified as no longer required by government and opportunities for sharing can be fed into the spectrum release plan when reviewed.
LONGER TERM	
Extension of trading and liberalisation (CITB and OFTA)	Further benefits of trading are obtained from increased flexibility in licensing including the introduction of service neutral licences where technically feasible. Proposals should be developed and presented through the consultation process.
Introduce AIP (CITB and OFTA)	Where congestion cannot be relieved by making more spectrum available AIP should be introduced. The full opportunity cost should be assessed and a plan to phase in the pricing developed. This should then be put through the consultation process before

	implementation.
Extension of licensing (CITB and OFTA)	Initially a policy decision needs to be taken on whether licensing should be extended to receive only systems and government use. In the event that a favourable policy decision is made proposals for receive-only systems should be developed and put through the consultation process before implementation. With a similar dependency, the licensing of government use can be implemented.

Annex 1: Hong Kong stakeholders interviewed

Corporate & Users Associations
Hong Kong Telecoms User Group
Amateur Radio Societies

Domestic Free TV Broadcasters
Asia Television Limited (ATV)
Television Broadcasts Ltd (TVB)

Government Departments
Civil Aid Service (CAS)
Civil Aviation Department (CAD)
Fire Services Department (FSD)
Government Flying Service (GFS)
Hong Kong Observatory (HKO)
Hong Kong Police Force (HKPF)
Independent Commission Against Corruption (ICAC)
Marine Department
Radio Television Hong Kong (RTHK)
Transport Department

Mainland China Operators
China Unicom (HK)
China Telecom (HK) (initial contact made and discussions to be continued in April)
Note: China Netcom (HK) (contacted and advised meeting to be scheduled in April);
China Mobile (HK) declined

Pay TV Broadcasters and Satellite Users
Cable & Satellite Broadcasting Association of Asia (CASBAA) and member representatives: Bloomberg L.P., Time Warner Inc., Turner International Asia Pacific Ltd.
REACH
STAR Group Ltd.

Satellite Operators
APT Satellite Holdings Limited
Asia Satellite Telecommunications Co. Ltd.

Sound Broadcasters
Hong Kong Commercial Broadcasting Co., Ltd
Metro Broadcast Corporation Limited

Telecom Operators
China Motion Telecom International Ltd. (CM Tel)
China Resources PEOPLES Telephone Company Ltd. (CR PEOPLES)
HK Broadband Network Ltd. (HKBN)
HKC Network Ltd.
Hong Kong Cable Television Ltd. (Cable TV)

Hong Kong CSL Ltd. (CSL)
Hutchison Global Communications Ltd.
Hutchison Telecommunications (Hong Kong) Ltd.
Hutchison Whampoa Ltd.
New World PCS Ltd (New World Mobility)
PCCW Ltd.
SmarTone-Vodafone
Telecom Digital Holdings Ltd. (TSL)
Towngas Telecommunications Fixed Network Ltd.
TraxComm Ltd.
Wharf T&T Ltd.

Utilities
Airport Authority (AA)
China Light & Power Co., Ltd (CLP Power)
Citybus Co., Ltd.
Hong Kong Electric Co., Ltd (HKE)
Kowloon-Canton Railway Corporation (KCRC)
Kowloon Motor Bus Co., Ltd. (KMB)
Mass Transit Railway Corporation (MTRC)
New HK Tunnel Co., Ltd.
Tate's Cairn Tunnel Co., Ltd.
Western Harbour Tunnel Co., Ltd

Annex 2: International market information

This Annex contains:

- information relevant to international situations; it supplements the overview and Hong Kong specific market demand information included in Chapter 2
- tabular information summarising the spectrum congestion and potential spectrum supply.
- A description of the purpose, process and assumptions for forecasting demand in the key service areas.

Cellular services

International situation

Most countries still have spare spectrum in the GSM, 3G or extended bands, either nationally or in some geographic regions. Options considered by regulators include reserving sufficient spectrum for a new operator, releasing more spectrum to the existing operators, auctioning the spectrum for mobile services, auctioning the spectrum in conjunction with liberalisation.

With operators in most countries now well underway with their rollout of 3G services, their strategic focus is shifting back to their older 2G networks. With the greater spectral efficiency of 3G over 2G and the common core network between GSM and WCDMA, there are significant benefits to operators to shift the use of their current 2G spectrum from 2G services to 3G services. The option to do this depends on the spectrum management framework in place. In some countries, the regulators are beginning to consider this issue, typically within the context of a wider spectrum review, while in countries which have already implemented spectrum liberalisation, the operators are already moving in this direction. For example, in Australia, Telstra has announced it will decommission its CDMA network (at 850MHz) in order to deploy a 3G WCDMA network.

Longer term, the industry is at the early stages of planning for Super 3G. While the specifications for Super 3G are still being developed, it is likely the technology will have an element of frequency flexibility and the ability to utilise non-contiguous frequency bands – reflecting the reality of current spectrum usage and the differing situation in each country.

Private Mobile Radio

International situation

One of the key benefits to users of PMR is that the costs are fixed. There are generally no on-going line rental charges or airtime costs – users communicate free of charge within the range of the radio. The signal is broadcast to all users within range – anyone with a radio switched on can hear messages, hands free, together with everyone else on the frequency. In an emergency, instant communication with several people can be vital, and in everyday working situations it can be very useful and save a lot of time. Larger PMR systems use

trunking technology, the most popular being the long-established analogue standard known as MPT1327 and the more recent digital TETRA standard. Trunking enables a pool of frequencies to be shared by a large number of users with a substantial improvement in the number of users that can be accommodated per radio channel.

Internationally, work is progressing in standards bodies such as ETSI to develop digital PMR standards that could be deployed in existing PMR bands alongside existing legacy services.

Terrestrial broadcast TV

International situation

Broadcast television has very different characteristics and take-up patterns in different regions and countries. Around ten different technical standards for analogue TV are in use around the world, and while viewers in some countries (e.g. Holland) make almost exclusive use of cable services, others (France, UK) remain largely dependent on off-air broadcasts.

Most developed countries are now undergoing, or planning, a transition to digital TV broadcasting, which will provide greater spectrum efficiency, and allow new services such as high definition TV (HDTV). Similar to the analogue case, several standards have emerged: ASTC in the Americas, ISDB-T adopted in Japan and DVB-T in most other areas.

Radio

International Situation

Unlike television, analogue radio has used standards that are (largely) global, using the MF (525-1606 kHz) and VHF (88-108 MHz) bands for AM and FM services respectively.

Globally, a number of digital radio services have been developed. In the US, subscription-based digital satellite radio has proved popular, as it provides contiguous coverage beyond urban areas, while greatly expanding the choice of radio programmes. The terrestrial US broadcasters have also developed a technology, now branded HD-Radio, which allows the addition of digital signals in the channels adjacent to their existing services. This technology, which has been shaped by the particular competitive environment of US radio, has had a more uncertain launch.

Elsewhere the European DAB standard, which operates at Band III (174-230 MHz) and L-band (1452-1492 MHz) has been quite widely adopted, but with varying degrees of success. In the UK, market penetration is growing fast, but in other countries (Sweden, Canada) take-up has been very low.

Other standards exist in Japan (ISDB-T) and Korea (DMB), though these have been designed for multimedia mobile broadcasting, rather than simply for radio services.

A digital technology had also been developed to provide a digital transition for AM services operating in the long, medium and short-wave bands (150 kHz – 30 MHz).

Initially developed by international short-wave broadcasters, Digital Radio Mondiale (DRM) is now being widely promoted for domestic use in the MF band.

Satellite services

International situation

Satellite operations globally mainly use allocations at C-band (6/4 GHz), Ku-band (14/12/11 GHz) and Ka-band (30/20 GHz) with sound broadcast and mobile applications operating at L- and S-band (around 1.5 GHz and 2 GHz respectively). Primary services provided by satellites can be broadly classified into broadcasting, broadband connectivity and telecommunications (fixed and mobile). Of these, TV broadcasting is the most extensive application globally with extensive capacity being used to support this service in terms of video channels for programme distribution etc. Dedicated satellite sound broadcasting systems have also been deployed in parts of the world but the extent of these is limited.

Broadband services have long been promoted as a viable satellite service but have never become extensively used in densely populated parts of the world. There is however potential for this service in those parts of the world where population density is low and infrastructure needs to be provided or where economic development is rapid and network roll-out also needs to be rapid.

Mobile satellite communications have a chequered history with significant allocations being made available for use by these systems. Terrestrial competition has severely limited the potential subscriber base to the extent that the evolution of traditional mobile services provided by Inmarsat, along with one or two other systems, might be regarded as the only commercially successful offering.

Satellite communications links also support large international trunk terminals although these services are somewhat in decline.

Purpose, process and assumptions of forecasting

The purpose of spectrum demand forecast is to translate and map the spectrum requirements of (the most likely) future service developments in Hong Kong to the frequency spectrum bands so as a big picture of the future spectrum usage can be painted. The identification and/or ‘quantification’ of future demand in specific high usage or most congested frequency bands can help us better understand the sources, applications and distribution of demands. It will provide a reference frame for us to formulate the most effective options of spectrum management policies (command and control or other marketing mechanisms).

There is no simple and direct way to translate future service demand into future spectrum forecast (ie MHz) because it is affected by many factors:

- Technology standards: a trade-off between national or proprietary standards and international standards, choice from a number of available international technology standards (eg WCDMA or CDMA2000);
- Engineering factors: Spectrum planning and allocation, spectral efficiency and interference management will be different for the different radio technologies;
- Investment decisions: for most services there is a trade-off between using more spectrum and investing in more infrastructure leading to an economic demand for spectrum rather than an absolute level of demand;

- Economic or commercial factors: mass production of radio equipment at affordable price, trade-off between cost efficiency of provisioning and tolerance to interference;
- Political, regulation and management: flexibility versus controllability/compliance

We shall quantify the future spectrum demand in terms of the percentage growth relative to the baseline service, and this growth rate will give an indicative measure of the relative usage and congestion in the targeted spectrum bands.

The forecasting process will also be limited by the set of assumptions being used, the baseline scenarios (ie service development scenarios) upon which the forecasting is built, and also the forecasting model itself. These will be clearly stated in the specific forecast.

There are two broad ways of converting service demand into spectrum demand:

- service sizing parameters (eg number of subscribers, number of links, channels or radio systems, etc.);
- traffic intensity parameters (eg erlangs for voice applications, data rate per second for data applications, etc.)

Demand forecasts for services requiring spectrum have been developed for the short (1-3 years), medium (3-5 years) and long (5-10 years) term. Demand forecasts for services or technologies beyond a time frame of five years will have intrinsic limitations, and will have lower value and reliability as the time horizon extends.

As noted above, demand uncertainty is caused through a large range of factors including a combination of technology, regulation, competition and user behaviour. To better manage this uncertainty, a scenario planning approach has been adopted for demand modelling. For each of the services considered, a steady growth scenario and a high growth scenario have been developed. The two scenarios provide an assessment of the potential impact on spectrum demand under different assumptions.

The demand study does consider the impact on demand of substitute technologies (such as fibre for fixed links) and spectrum versus infrastructure tradeoffs (such as installing more base stations in a mobile system versus upgrading the capacity at existing sites to utilise additional spectrum). However, this has been done within the context of the current spectrum price and allocation arrangements. Changes to spectrum prices or allocation methods will shift the demand profile.

The demand forecasts have focussed on the four service types for which there is likely to be the greatest amount of congestion:

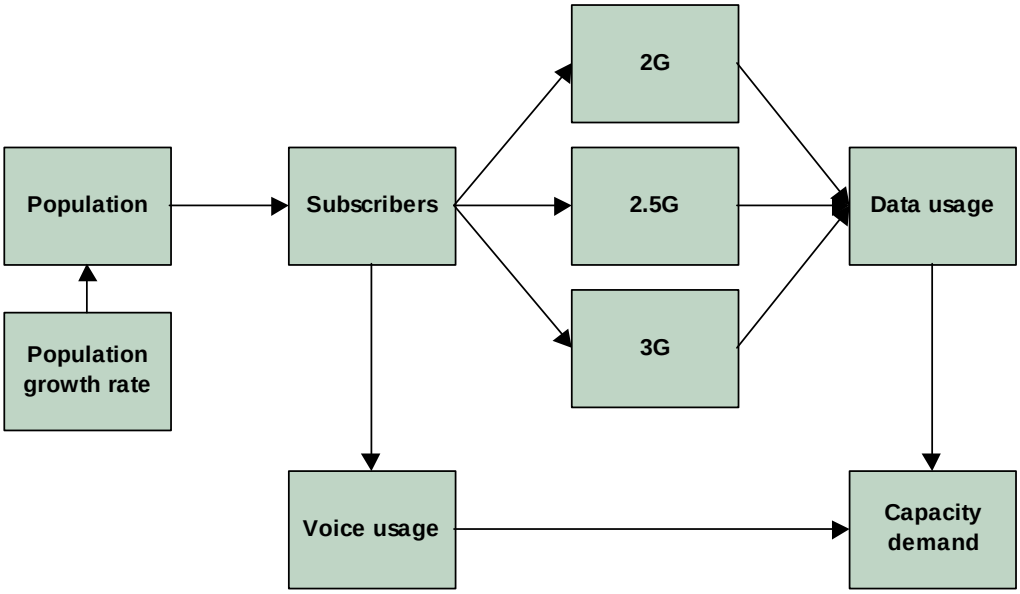
- mobile voice and data
- broadband wireless access
- private mobile radio
- terrestrial fixed links.

Spectrum requirements for broadcast services are driven by policy choice regarding the number of licensed stations in the market rather than by end user demand, and this has not been modelled. Similarly, aeronautical, maritime and meteorological usage is primarily within spectrum bands dedicated for their

exclusive usage and demand and usage is co-ordinated within the industry on a global scale, and this has also not been modelled.

The demand model for the mobile voice and data services is shown in Figure A2.1.

Figure A2.1: Mobile voice and data demand methodology



Source: Ovum

The population figures are based on the data provided by the HK Census and Statistics Department. The starting base figures for numbers of subscribers, growth rates and voice minutes have been sourced from Wireless Intelligence[112], a joint venture between Ovum and the GSMA and other Ovum data sources.

[112] www.wirelessintelligence.com

Annex 3: Hong Kong Allocation Table 30 MHz- 30 GHz

The frequency column in the table is contiguous, but it should be noted that a small amount of rounding has been applied for the purpose of clarity (e.g. by 0.1 MHz). Also, only major current usage has been shown, once again for the purpose of clarity – other allocations (e.g. Safety) of equal importance exist.

Congested spectrum is indicated thus **(!)**

Potentially available spectrum is indicated thus **(*)**

Frequency band	**Current usage**	**Comments**
MHz		
29.7 – 87	Fixed & Mobile	Includes some paging /wireless microphones / amateur/ aero 12.5 kHz PMR – little congestion
87 – 108 (Band II)	Sound Broadcasting	Intensively used **(!)**. *87 – 88 MHz not used for sound broadcasting in HK.*
108 – 138	Aero & MetSat	Aero intensively used **(!)**
138 – 156	Mobile	12.5 kHz PMR
156 – 163	Maritime	
163 – 174	Mobile & Paging	12.5 kHz PMR
174 – 329 (Band III 174 – 230)	Mobile/Fixed/Paging/OB	12.5 kHz PMR Part of 174-230 for broadcasting – could be considered for use by DAB/DMB **(*)**. L-band alternative.
329 – 335	Aero	
335 – 400	Mobile	Mainly Government Use
400 – 406	Met	
406 – 430	Mobile & Fixed	Government Use incl. Police

Frequency band	Current usage	Comments
		TETRA.
430 – 440	Radiolocation and Amateur	
440 – 470	Mobile & Paging	25 kHz PMR Congested **(!)**.
470 – 806 (Band IV 470 – 590) (Band V 598 – 854)	TV Broadcasting	Intensively used because of HK topology (need co-ordination with Mainland for shared use with neighbouring Guangdong province). Target to switch off analogue TV by 2012 and some 16 TV channels could be released **(*)**. DVB-T or Mainland standard. HD requirements. Mobile TV.
806 – 826	Trunk Mobile & Paging. 806 – 807 is guard band for DTT 819.1 – 823.1 is for LPD	Congested **(!)**. Some TETRA but mostly analogue.
826 – 842.5	CDMA in 831.59 – 834.09	831.59 – 834.09 MHz will be cleared after Nov 2008 and can be considered for re-allocation together with vacated frequencies in 825 – 831.59 MHz 834 - 842.5 MHz has not been allocated for any service and its use need further study and coordination with Mainland
842.5 – 851	No usage **(*)** (Mobile)	842.5 – 851 MHz has not been allocated for any service and its use need further study and

Frequency band	Current usage	Comments
		coordination with Mainland
851 – 871	Trunk Mobile & Paging RFIDs	Congested **(!)**. Some TETRA but mostly analogue.
871 – 879	CDMA in 876.59 – 879.09	876.59 – 879.09 MHz will be cleared after Nov 2008 and can be considered for re-allocation together with vacated frequencies in 871.59 – 876.59 MHz.
879 – 890	885 – 890 reserved for EGSM **(*)**	A few frequencies in 885-890 MHz are for country park coverage. A guardband may be needed to separate EGSM from future allocation of new service in the band
890 – 915	GSM	
915 – 925	RFIDs, LPD, Government use, etc	
925 – 935	930 – 935 reserved for EGSM **(*)**	A few frequencies in 930 – 935 MHz are for country park coverage. A guardband may be needed to separate EGSM from future allocation of new service in the band
935 – 960	GSM	
960 – 1427	Aero / radar/ GPS etc	
1427 – 1429	No usage	To be planned **(*)**
1429 – 1518	Fixed	1452 – 1492 potentially available for DAB/DMB - 8 blocks have been made available in middle of band **(*)**.
1518 – 1710	MSS/GPS/Radio Astronomy/MetSat/Sound Broadcast Programme Feed	

Frequency band	Current usage	Comments
1710 – 1880	PCS	A few frequencies in 1780 – 1785 / 1875 - 1880 are for country park coverage 1785 – 1805 centre gap (Tx/Rx separation) **(*)**
1880 – 1905	DECT in 1880 – 1900 PHS in 1895 – 1906	
1905 – 1980	3G (unpaired & paired)	
1980 – 2020	Mobile Earth Station transmission in 1980 – 2010 (licence exempted)	2010 – 2020 is available spectrum for 3G (unpaired) service and its assignment is subject to further study **(*)**
2020 – 2025	3G (unpaired)	
2025 – 2110	No usage **(*)**	2025 – 2110 centre gap and its use for new application is subject to further study including guardband for 3G service
2110 – 2170	3G (paired)	
2170 – 2300	Mobile Earth Station reception in 2170 – 2200 (licence exempted) ENG in 2200 – 2290	
2300 – 2400	Some assignments for Government use and ENG (to be largely vacated by end 2006)	BWA candidate **(*)**
2400 – 2500	ISM (RLANs) in 2400 – 2483.5 MHz & Mobile Earth Station reception in 2483.5 – 2500	Mainly licence exempted band
2500 – 2690	ENG links (To be vacated by end 2006)	BWA candidate **(*)** 3G expansion band **(*)**

Frequency band	Current usage	Comments
2700 – 3400	Aero/Met/Radar	
3400 – 4200	FSS downlink	
4200 – 4400	No usage (Aeronautical)	
4400 – 4990	Fixed Mobile	4400-4940 mainly for Government use of fixed services for security and emergency purposes. 4940- 4990 assigned for Government use (video link for emergency service)
4990 – 5150	No usage (Radioastronomy and aeronautical)	
5150 – 5350	RLANs	
5350 – 5470	No usage (Aeronautical)	
5470 – 5725	RLANs	
5725 – 5850	ISM & FWA	
5850 – 6425	FSS uplink	P-MP distribution systems in 5850 - 5950
6425 – 8500	Fixed & OB	Fixed congestion **(!)**
8500 – 9800	Radar	
9800 – 10.7	Fixed/Radar/Amateur	Some parts to be planned **(*)**
GHz		
10.7 – 13.25	Fixed & Satellite downlink (BSS & FSS)	Fixed & OB links. Little satellite use. Fixed congestion **(!)**.
13.25 – 13.75	No usage	

Frequency band	Current usage	Comments
	(Aeronautical/Radiolocation)	
13.75 – 14.5	Satellite uplink	Fixed & OB at top of band. Little satellite use.
14.5 – 15.4	Fixed & OB	Fixed extends down to 14.4 GHz in band below. Fixed congestion **(!)** (BSS use reduces channels available)
15.4 – 17.3	Aero/Radar	
17.3 – 17.7	No usage for Satellite uplink	May be used for satellite uplink in future
17.7 – 18.4	MMDS. No usage for Satellite uplink /downlink	May also be used for satellite uplink / downlink in future
18.4 – 18.8	MMDS. No usage for Satellite downlink	May also be used for satellite downlink in future
18.8 – 19.7	LPD in 18.82 – 18.87 GHz No usage for Satellite downlink	May also be used for satellite downlink in future
19.7 – 21.2	No usage for Satellite downlink	May be used for satellite downlink in future
21.2 – 23.6	Fixed.	May also be used for satellite downlink in future
23.6 – 24	No usage (Radioastronomy)	
24 – 24.5	ISM & Radiolocation in 24.05 – 24.25	
24.5 – 31.3	LMDS. No usage for Satellite uplink	May also be used for satellite uplink in future

Annex 4: Land rights and trading in Hong Kong

1. Rights Sold

The government usually sells land with a lease for 50 years. Other major land providers in Hong Kong include the MTR and KCR. Government has granted these companies the right of property development for the estates alongside their railway stations. The landlord will own the property right for 50 years, but government has the rights to

(i) take back the lease if the conditions (eg environmental protection requirements, development conditions, etc.) of sale attached to the lease are not fulfilled by the landlord. In these circumstances, the landlord will not receive any compensation because there has been a breach of the lease conditions;

(ii) buy back (i.e. resumption right) the lease according to the conditions attached to the lease. These conditions are empowered by an appropriate ordinance (eg Road Ordinance, Railway Ordinance, Urban Redevelopment Ordinance, etc.) Compensation will be paid to the landlord based on certain criteria (e.g. ex-gratia compensation based on the market price of a 5 to 7 years old equivalent lease)

(iii) change the conditions of the lease as long as there are appropriate provisions stated in the lease. Compensation is agreed through bilateral negotiation.

2. Approach to selling leases

Leases are sold through a land auction in either open bid or sealed bid, or granted for special purposes (eg school). The Government has recently adopted a new land auction system which involves publication of a one-year plan (lease list) detailing future leases that will be sold to the public. There is a reserve price for each lease in the list, and the list is open for initial bid. A bidder who has interest in a lease can express his interest by committing to participate in a lease auction which starts at a proposed initial bidding price. If that proposed initial bidding price is at least 80% of the reserve price, the Government will hold an auction for that lease. This mechanism ensures that there are always bidders in lease auctions. A lease auction will be held when there are committed interested bidders to the leases in the lease list. Open auction bids start at the proposed initial bidding price, and competitive bidding will be used when there is more than one bidder for a lease. The timetable for auctions is driven by market demand

3. Trading

Leases are tradeable as long as the conditions of the original lease are fulfilled. The new lease may have a new set of conditions (eg the use of the property may change from industrial to commercial) if approval is obtained from the Lands Department. If there is an anticipated increase in the commercial value of the lease as a result of the change the lease conditions, government will determine and demand a price premium from the landlord. Leases can be aggregated or subdivided as long as the attached conditions are fulfilled.

4. Trading gains

A profit tax is levied when lease is sold or transferred (ie transaction). There is no compensation for trading losses.

5. Lease renewal

The government renewed all leases in late the 1990s when they reached the end of their leasehold period without demanding any payment from the lease owners. These decisions are always at the government's discretion

Annex 5: International experience of spectrum trading

Introduction

A number of countries, most notably Australia, Canada, Guatemala, New Zealand and the US, have already taken steps to introduce technology-neutral spectrum usage rights. In this Annex we summarise key elements of the licensing regime and trading in each country. What this shows is that in all cases a mixed regime applies, with both tradeable and non-tradeable licences, spectrum and apparatus licences and more or less flexibility in what systems may be deployed.

Spectrum licences are generally defined to be licences that allow the use of spectrum within a specified frequency range and area subject to certain technical constraints. Apparatus licences generally specify the operation of a particular type of radiocommunications transmitter (or receiver) at a particular location subject to certain technical constraints. The key difference between apparatus and spectrum licences is that the deployment of transmitters is specified in the former but not the latter and this considerably limits flexibility of spectrum use.

At the end of the Annex we give an example of the licensing framework that has been introduced in Australia, Canada, New Zealand and the US for the frequency band around 3.5 GHz (2.3 GHz in the US, 2.3 and 3.5 GHz in Canada) initially intended for fixed wireless access type systems but auctioned on a technology-neutral basis.[113] There is a significant difference between the Australian approach which specifies a wide range of parameters and allows for registration of terminals in order to reduce the risk of potential interference problems, and the US where the technical framework is minimal and spectrum users are expected to resolve any interference problems that might arise. The approach taken depends on attitudes to controlling interference with Australia taking a more conservative approach than the other countries.

Australia

The Radiocommunications Act provides for three types of licences: apparatus, spectrum and class licences. Of these, spectrum licences are the least prescriptive as licensees are able to determine which devices operate within defined geographic and spectral boundaries. The following table taken from the Productivity Commission Report on Radiocommunications lists the key attributes of these licence types.

Commercial spectrum licences, normally assigned by auction, may be traded subject to any limits imposed by the Minister. Trading may occur through direct negotiation or a spectrum trading exchange, or by leasing from a band manager. Spectrum licences are defined in terms of Standard Trading Units (STUs) defined by geographic and bandwidth boundaries. STUs are the basic building blocks of a spectrum licence. Licence holders are able to sell, lease, repackage and change

[113] This is largely reproduced from "Spectrum Usage Rights", Aegis Transfinite and Indepen, 2006 http://www.ofcom.org.uk/consult/condocs/sur/

the use of STUs assigned to them. Spectrum licences typically have a duration of up to 15 years and there is no guaranteed right of renewal. Trades must be notified to the regulator so that they can be recorded on the public register. In addition devices (i.e. transmitters) must be registered to provide information required for interference management. Also in disputes involving lawful interference (i.e. interference arises though both parties are operating lawfully) a first in time rule in respect of device registration has operated to determine which user has precedence.

Figure A5.1: Key attributes of current licence type

Attribute	*Apparatus licence*	*Spectrum licence*	*Class licence*
Licence period	≤ 5 years	≤ 15 years	Ongoing[a]
Renewable	Yes	No[b]	No
Tradeable	Yes	Yes	No
Divisible	No	Yes	No
Combinable	No	Yes	No
Third party use	Yes	Yes	na
Compensation	No[c]	Yes	No
Enforceable	Yes	Yes	Yes

[a] Until revoked. [b] Spectrum licences can be renewed where it is deemed by the Minister or ACA to be in the public interest (RC Act, s. 82). [c] Apparatus licensees may receive a partial refund of their licence fees. **na** Not applicable.

Source: Radiocommunications, Inquiry Report No 22, Productivity Commission, July 2002

Apparatus licences which have a duration of 1 to 5 years are also tradeable and trades must be approved by the regulator. Third party use or operation of apparatus licences is permitted. These licences generally authorise the operation of a particular type of radiocommunications transmitter or receiver at a particular location.

There is a public database of assignments which holds all information concerning spectrum and apparatus licences. All licences must be compliant with the national spectrum plan and may be varied by the regulator or cancelled by the Minister without agreement or compensation.

Competition issues are addressed through the application of competition law and the limits on spectrum holdings which have been imposed in some auctions.

Spectrum licensees are expected to sort out interference issues, though in cases of unlawful interference the regulator has enforcement powers. In addition, in cases where there are disputes over interference issues the regulator may intervene to help resolve the dispute or to appoint an independent conciliator.

The Productivity Commission (2002) reports that the annual turnover rate for licences was 14% in the first year and 4-8% in subsequent years. Trades have occurred in a number of bands including 500 MHz, 800 MHz, 1.8 GHz, 2GHz, 2.3GHz and 3.4 GHz. It is difficult to judge whether these trading volumes are

high or low, however, Australian commentators note that the turnover rate is not dissimilar to that for housing sales.

Spectrum licences are intended to be technology neutral, although a likely use is often assumed when setting licence parameters. This flexibility has allowed the market to determine the best use of the spectrum for the provision of new and innovative services. For example spectrum released within the context of 3G and LMDS (but without an actual restriction to these uses) has been used by the spectrum owners for broadband wireless access. The ability to trade spectrum has allowed a regional wireless access provider (Austar) and a city focussed wireless access provider (Unwired) to swap access to their respective 2.3GHz and 3.5GHz spectrum in city and regional areas to provide more cost effective networks for both operators.

Canada

Exclusive transferable and divisible licences have been auctioned by Industry Canada (IC). Written notification of transfers must be submitted to IC and once transfers are registered the original licence is amended and a new licence issued. Leasing is not officially accommodated but may be achieved by the two parties to the lease jointly applying to IC for a licence transfer for a defined period of time. There are proposals however to consult on ways of improving processes for third party access to spectrum licences.[114]

Licences that have been auctioned[115] typically have a 10 year duration with a strong expectation of a further 10 years renewal. Spectrum grid cells (with an area of 25 square km) are the smallest permitted geographical unit for a spectrum licence – generally there is no minimum limit on the amount of spectrum that can be transferred. Spectrum licences that have been issued on a transferable basis include 24/38 GHz licences for fixed wireless broadband, PCS licences at 2 GHz, MCS licences at 2.5 GHz, WCS and FWA licences at 2.3/3.5 GHz. The government has the right to reallocate spectrum to meet international obligations without compensation. There is a publicly available database of licences. In practice relatively little trading has occurred.

Most licences continue to be assigned administratively and are apparatus licences which are not tradeable, although the government plans to consult on the possibility of applying longer terms of licence and transferability and divisibility to a wider range of radio licences.[116]

Competition issues are addressed through the Minister's powers to limit eligibility to bid (depending on the market power of the entity), creating spectrum set asides and establishing maximum aggregation limits in addition to the normal operation of competition law. The Minister exercises these powers on a case by case basis.

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[114] Section 11.4, Consultation on a Renewed Spectrum Policy Framework for Canada and Continued Advancements in Spectrum management, Industry Canada, May 2005.

[115] These include licences for fixed wireless broadband (24/28 GHz), cellular and PCS licensees and wireless communications services at 2.5GHz, 2.3/3.5 GHz.

[116] Op. cit. Industry Canada May 2004.

Industry Canada generally encourages licensees to sort out interference problems themselves and to ask the government to intervene only if they are unable to solve the problems on their own.

Guatemala

A system of 15 year tradeable property rights in spectrum has been introduced for spectrum that has been assigned since 1996. These rights, called TUFs (Titulos de Uso de Frecuencias), are technology and service neutral and are assigned through auction (if there are competing demands for the spectrum) or on a first come first served basis (if there are no competing demands). Individuals may apply for any unused spectrum, and if there are no public objections or interference issues and no other competing demands they may receive title within 15 days. The process takes longer (up to 4 months) if an auction is held.

Title to spectrum is recorded on a computerised registry or database that is publicly accessible. Considerable trading has occurred with 41% of TUFs having been traded by 2004.

There are no specific safeguards against anti-competitive acquisition of spectrum. However, WIK (2005) report that there is no evidence of undue concentration as a result of spectrum acquisitions and trading. This may be because the regulator has released a considerable amount of spectrum into the market.

Interference disputes are intended to be resolved privately. Where this fails the regulator intervenes though there is always the possibility of recourse to the courts.

New Zealand

In 1989, a market in spectrum was created under the management rights regime (MRR) which is a regime of tradeable property rights with a Registrar and a Register of Radio Frequencies. It encompasses two tiers of spectrum rights.

- Management rights created by the Crown most of which have been sold through auction (some have been retained by the Crown e.g. for broadcasting). These rights are technology and service independent and give the right holder an exclusive right to a national band of spectrum for a period of up to 20 years. These rights are renewable on payment of a sum determined by the government around 5 years in advance of licence expiry. If the licensee does not accept the government determined payment then the licence will be auctioned.

- Tradeable spectrum licences, which are assigned by the owner of the management right, give the right to transmit according to the parameters given in the licence.

The licence register establishes legal title and records details of management and tradeable licences. Of the spectrum used primarily for telecommunications and broadcasting approximately 30% has been converted to the management rights regime. Relatively few trades have occurred and this is partly because the government has released considerable amounts of spectrum onto the market.

In addition, there are apparatus licences (termed radio licences) which are not tradeable and are generally assigned on a first come first served basis. The majority of spectrum is managed under this approach. These licences have a one

year duration and the issue of whether licences not required for essential services should be tradeable in future is under review.

Competition issues have been addressed through spectrum caps and the application of competition law. While there has been relatively little trading the government does not believe there is any evidence of hoarding for anti-competitive purpose.

The government encourages licensees to sort out interference problems themselves. If disputes cannot be resolved there is provision for the parties to ask for compulsory arbitration. This replaced a system whereby interference disputes were to be referred to the courts. In practice, licensees have always solved disputes before reaching the courts or arbitration.

United Kingdom

Spectrum trading was introduced in December 2004 in the UK for certain licence classes, namely public access mobile radio, wide area paging, common base stations, private business radio, fixed wireless access, broadband wireless access and a range of fixed services. Partial, total and concurrent trades and leases are permitted. Trading is being extended to new licence classes each year and all newly auctioned spectrum is tradeable.

Existing licensees may apply to have their licences converted to tradeable form. This involves replacing annual non-tradeable licences with tradeable five year rolling licences. These licences are in effect perpetual though the regulator has the power to revoke the licence with 5 years' notice for spectrum management and other reasons.

The nature of licences issued under the Wireless Telegraphy Act varies depending on the frequency band and its actual or likely use. WT Act licences adapted for trading will define the right to transmit in terms of a transmitted power or eirp and a "spectrum mask" where this may specify conditions experienced at the frequency/geographic boundary. Different parameters may apply to different frequency bands. Examples of licence conditions that will apply to the 872-876/917-921 MHz and 1452-1492 MHz auctions are given on Ofcom's website.[117] Such licences might be termed "spectrum licences". Existing licences for national services (e.g. public mobile and fixed wireless) are defined in this way.[118]

For some licence classes defining transmission rights in a generalised way is not practical because of the interleaved nature of frequency use (e.g. PMR, fixed links) in which case current "apparatus licences" will continue to be defined as in the past.

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[117] See the following presentation for proposed technical details http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_872/presentation.pdf and http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_1452/220506slides/220506slides.pdf

[118] For national licences having exclusive use of a portion of spectrum, assignments are self managed and there is no need to register terminals except to satisfy health concerns (e.g. mobile network base stations).

Trades are subject to the regulator's approval, though the regulator will only refuse a trade under certain limited conditions (e.g. the trade violates or seeks to avoid other licence obligations, for national security reasons, the trade violates international or EU law or Directions from the Secretary of State). There have been four completed trades and a further transaction is in progress at the time of writing.

The regulator provides (on its website) information on the UK plan for making frequencies available for assignment (including their allocated use and whether they are tradeable), the Wireless Telegraphy Act Register which provides basic licensee information and the Trades Notification Register which displays details of proposed trades notified to the regulator, trades in progress and completed trades.[119]

Spectrum pricing will continue to apply to licences that are made tradeable on the grounds that this promotes efficiency when markets are thin, reduces the likelihood of anti-competitive hoarding and helps to address windfall gain issues.

Competition issues are to be addressed under competition law. The arrangements for dealing with interference disputes have not changed from those that applied under the previous regime, namely the regulator intervenes if the parties involved cannot settle disputes amongst themselves.

United States

Most spectrum in the US is designated for specific uses or users, though the degree of flexibility varies widely. For example the PCS licences permit any fixed or mobile use and any technology (interference constraints are defined in terms of boundary limits), whereas television broadcasting licences are narrowly defined in terms of use and technology. In 2002 only about 7% of the spectrum in the 300 MHz to 3000MHz range was allocated for flexible use.[120]

Licence transfers have been permitted for many years in the US, subject to FCC approval. In addition, since 1996 the FCC has introduced measures to encourage secondary markets in spectrum as a way of promoting more efficient use of spectrum. The first set of measures comes under the general heading of partitioning and disaggregation rules. The second broad set of measures comes under the heading of spectrum leasing.

Partitioning and disaggregation rules allowed licensees to divide their licences by geography and frequency respectively. They applied to the following services: cellular, PCS, MDS, 800 and 900 MHz specialised mobile radio (SMR), 39 GHz fixed link services, wireless communications services and general wireless communications services (GWCS). The level of activity promoted by these rules was low. Counsel to the Rural Telecommunications Group (RTG), noted that "less than one-tenth of one percent of licences auctioned by the FCC have been through

[119] http://146.101.202.225/public-tnr/tradeDetails.do

[120] "A Proposal for a Rapid Transition to Market Allocation of Spectrum", Kwerel and Williams, OPP Working Paper Series No 38, November 2002, FCC.

the partitioning or the disaggregation process".[121] She suggests there is no incentive on licensees to partition or disaggregate their spectrum. Three main reasons are given:

- Carving up the spectrum devalues the asset (and licensees may have a view to later sale)
- Licensees may want to serve the area in the future
- Even if they are interested in trading, transaction costs are often too high. This is partly due to the rules laid down under the FCC's "Intermountain Decision" concerning what is and what is not a transfer of control. The process took a minimum of 3 months and could take 6-12 months if there are objections.

Partitioning and disaggregation are an imperfect substitute for spectrum leasing and have not worked well. As a result, the FCC made a series of proposals for spectrum leasing in its First and Second Report and Order on Secondary Markets (2003 and 2004, respectively).[122] In broad terms the proposals permit spectrum leasing by many licence classes and leave most but not necessarily all responsibility for compliance with interference, service and technical regulations with the licensee. Two types of leasing are permitted

- *De jure*, under which the licensee retains legal and operational control over the leased spectrum and is responsible for legal and regulatory compliance.
- *De facto*, under which the licensee retains legal control but operational control is passed to a third party (the lessee) who is responsible for legal and regulatory compliance.

In order to realise enhanced flexibility in spectrum use the FCC has relaxed a range of technical and service rules and has accelerated the approval process. In many cases (where foreign ownership, eligibility and competition issues do not arise) requirements for *ex ante* approval of transfers and leases have been removed.[123]

The FCC has permitted leasing by commercial and non-commercial licensees though in the case of public safety services spectrum may only be leased to other public safety organisations. In its Second Report and Order, it also made clear that spectrum leasing could include sharing by cognitive radio and other forms of opportunistic spectrum use and the creation of private commons in which mesh or peer-to peer networks could access spectrum rather than using more congested unlicensed bands.

Licences for new services are auctioned. Licences have a ten year duration and there is a strong expectation of renewal.

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[121] Transcript of the Public forum on Secondary markets in Radio Spectrum, May 23, 2000

[122] The FCC has not proposed a system of property rights because users prefer a leasing approach and because a property rights approach would not be feasible under Section 301 of the 1934 Communications Act.

[123] These transfers and leases are processed electronically overnight. Although, there is still the possibility of *ex post* petitions objecting to the trade up to 30 days after notification.

Up until January 2003 the FCC had a policy of applying spectrum caps to address competition issues but since then competition issues have been addressed on a case by case basis, as it was considered that this was more likely to give an efficient outcome and was more consistent with general competition policy.[124]

The FCC has a relatively relaxed approach to interference management. Users are expected to work out interference disputes wherever possible.

Comparison of technology neutral licensing approaches for specific bands

The table below compares the framework put in place by Australia, Canada, New Zealand and the US for licensing spectrum around 3.5 GHz. While each country has tended to put a slightly different framework in place depending on the frequency band in question, what this comparison shows is that parameter values defining the rights (to whatever degree in each country) are generally derived from a foreseen use in the frequency band in question. There is a significant difference between the Australian approach which specifies a wide range of parameters and allows for registration of terminals in order to reduce the risk of potential interference problems, and the US where the technical framework is minimal and spectrum users are expected to resolve any interference problems that might arise.

[124] Para 6, 2001 Biennial Regulatory Review Spectrum Aggregation Limits for Commercial Mobile Radio Services, FCC 18 December 18, 2001 WT Docket 01-14.

Figure A5.2: Licensing framework comparison

	Australia	**New Zealand**	**US**	**Canada**
Example auction / date	3.4 – 3.6 GHz / 2000	3.4 – 3.6 GHz WLL / 2002	2305 – 2360 MHz Wireless Communication Services (WCS) / 1997	2.3 GHz WCS 3.5 GHz FWA / 2004
Frequency packaging	26 parcels of 3.5 MHz 2 parcels of 4.5 MHz	9 parcels of 2 x 7 MHz (i.e. all paired)	2 parcels of 2 x 5 MHz 2 parcels of 5 MHz unpaired	1 parcel of 2 x 15 MHz (WCS) 3 parcels of 2 x 25 MHz (FWA) 1 parcel of 25 MHz unpaired (FWA)
Geographic packaging	14 areas (major cities and towns) 5 regional areas	Management rights = national.	52 Major Economic Areas 12 Regional Economic Areas	172 Tier 4 service areas
Technology / service	P-P and P-MP services expected. Technology neutral. Frequency parcels allow for pairing but this is up to the bidders.	Intended for WLL but technology / service not mandated. TDD v. FDD noted as a potential problem.	Fixed / Mobile / Radiolocation. Satellite DARS allowed to compete in some frequency blocks. Technology not specified.	FWA = Fixed WCS = Fixed / Mobile Technology not specified. Even though there is band pairing TDD can be used anywhere.
Duration	15 years. No right of renewal.	20 years. No right of renewal.	10 years with renewal expectancy as long as “substantial service” provided.	10 years with 10 year renewal expectancy if put to use to an acceptable level.
Splitting and transferability	Divisible and tradeable in STUs where the smallest dimensions are 0.25 MHz and ~9 km. Resulting licences must have a minimum contiguous bandwidth of 2.5 MHz.	Responsibility of band manager. Management rights can be transferred.	Partitioning and disaggregation.	Transferable and divisible (but no smaller than 25 sq km).
Spectrum cap	Specific limits on Telstra. 67.5 MHz for all other bidders.	Not more than 3 parcels	None	100 MHz in a service area (WCS and FWA combined)

Annex 6: Issues in spectrum trading

Nature of licences

For spectrum to be tradeable, introduction of spectrum licences, which are separate from licences to establish network and to provide final communications services (e.g. mobile or fixed carrier licences). is recommended. This makes transactions simpler to achieve and does not confuse carrier obligations with obligations in respect of radio transmissions (e.g. power limits and other transmission parameters). It also provides the flexibility required for spectrum liberalisation.

Suppose spectrum licences, separate from network/service licences, are to be introduced, there should be conditions specifying the extent of permitted usage in terms of frequency and geography[125], and transmission parameters in terms of emitted power levels and field strength constraints at the geographic and frequency boundaries. These licences may specify the use of a block of spectrum (e.g. in the case of mobile services) or specific frequencies (e.g. for PMR or broadcasting services).

Separation of network/service licences and spectrum licences would also mean that fees associated with access to frequencies would need to be associated with the frequency licence. Such fees would include charges to recover the regulator's costs of managing spectrum and any SUF that may be payable.

Rights under the Spectrum Licence

The rights granted under tradeable spectrum licences need not necessarily be perpetual or unrestricted. In the UK, tradeable spectrum rights may be revoked (without compensation) for "spectrum management" reasons the scope of which is not clearly defined. By contrast the regimes in Guatemala and New Zealand do confer on holders of spectrum licences a right to exclude use of the spectrum by others without the holder's permission or to receive compensation if the rights holder's interests are harmed. In the former case this may have helped promote spectrum trading.

The rights granted under the spectrum licences should be clearly defined in order to give rights holders greater certainty that their rights will not be unlawfully deprived within the validity period of the licence (or if they are, they will receive compensation) and should therefore encourage greater long term investment than under a system where weaker rights are granted that may be revoked without compensation. Transaction and enforcement costs may also be lower because rights are clearly defined. However, against these economic benefits government's flexibility to change rights and to generate income are limited. Whether this results in a loss or a gain in economic welfare is debatable, as it could be argued that 1) government should face the full economic costs of its demands for spectrum for social or other purposes and 2) the economic costs of time limited rights outweigh any economic gain from the revenue government may raise from re-auctioning spectrum. However, we note that these arguments have not proved persuasive in most countries that have implemented spectrum trading.

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[125] It would also be possible to specify the time dimension but this is not commonly used.

If the rights of spectrum access could be varied and revoked, then the conditions under which government may wish to vary or revoke licences need to be made as clear as possible so as not to block trading activity. In this regard we note that the TA is empowered to vary or withdraw frequencies, bands of frequencies or parameters assigned, or vary the purpose for which and the conditions under which the frequencies or bands of frequencies are to be used, provided that the TA has given reasonable notice of the intended variation or withdrawal to the licensee which has been assigned the relevant frequency, band of frequency or parameter. Ideally the extent of these powers would need to be clarified if spectrum trading was introduced.

Licence duration and renewal

The issue of the duration of these licences and the conditions (if any) for licence renewal then need to be considered. In principle, perpetual licences best promote trading because at the time of trade there is no limit on the time period the purchaser has to exploit the licence and hence it is worth more than a time limited licence. The higher the value of the licence the more likely it is that trades will occur because the gains from trade are more likely to exceed any transaction costs. In addition, with time limited licences all licences holders have incentives to reduce investment towards the end of the licence period if there is no clear prospect of licence renewal.

However, in practice governments are reluctant to grant perpetual licences in case they wish to reclaim the spectrum for an alternative purpose which will not occur through market transactions (e.g. for licence exempt use or for social purposes). An intermediate position that has been adopted in a number of the countries that have introduced trading (e.g. Canada, New Zealand, the UK and the US) is to define licences as having a fixed term and to indicate that they are renewable at the end of that term unless certain specified conditions apply. These conditions might include

- Government decision or direction that the spectrum is required by another service
- Refusal to pay a renewal fee
- Compliance with international or other regulations
- Public interest reasons.

Other countries, such as Australia, have made no commitments concerning licence renewal and as noted above this is thought to have inhibited trading.

Trading is therefore likely to yield greater benefits if the government commits to renewing licences under certain clearly specified circumstances and undertakes licence renewal a reasonable time in advance of licence termination. In the UK and New Zealand the process starts 5 years in advance of licence termination.

Information

There needs to be an official register of licences to indicate legal title. In addition, this register needs to be publicly available in an electronic form so that organisations can find parties to trade with in a low cost manner. Sufficient information needs to be given so that licensees can contact each other easily. Contact details, frequency used, geographic area and service supplied need to be

given as a minimum. Details of transmission parameters might also be given. There will be limits on the amount of detail that can be provided for some services for national security reasons.

Publication of plans for future spectrum releases by the regulator becomes even more important with trading as organisations now have to decide whether to acquire spectrum through the market or whether to wait and buy it from the regulator.

Under bi-lateral trading outcomes depend on the buyer's and the seller's relative bargaining power and efficient trades may fail to occur, because of information asymmetry. Information provided by the regulator on the nature and number of trades and traded prices could help reduce failures caused by information asymmetry. While publication of the details of individual trades could inhibit certain trades, there is potentially a role for the regulator to provide aggregate market information. Spectrum brokers also have a potential role here in providing information on licence value and thereby facilitating transactions between parties.

Ex ante approval of trades

Trades (and possibly leases) will need to be registered on a licence database or register. The question then arises as to whether *ex ante* approval for trades or leases is required for reasons other than potential anti-competitive acquisitions. Possible reasons might include:

- to ensure that leases are not in breach of the licence conditions
- to check that the licensees had paid all spectrum licence fees before registering a trade
- to check that the trade does not result in an increase in levels of interference into neighbouring countries and specifically that any cross border interference levels are not exceeded.
- to check the trade does not violate any other regulations governing use of the spectrum (e.g. ITU radio regulations as embodied in the Hong Kong allocation table).

There are two options here

- licensees self certify that trades are compliant with licence conditions and, possibly also, are required to have interference calculations certified by an independent engineer (as is done in Australia and New Zealand) or
- the regulator checks and approves trades.

There is a good case for putting responsibility for compliance on the licensees, so they undertake appropriate due diligence and use their own resources to expedite the trade. This also helps speed up the trading process (see the US experience described above). In this instance the role of the regulator in approving trades is limited to simply checking that all the relevant forms are have been filled in. If the regulator takes on more responsibility for approving trades then there is also a risk that the regulator may be at fault if any subsequent interference problems occur.

Our view is that, subject to the competition issues discussed below, there should not be any need for the regulator to give ex ante approval to trades of spectrum licences in a Hong Kong context. A possible exception may be trades of licences in bands used by organisations for private communications. Users in these cases are

smaller and there is therefore a greater risk that parties to the trades are not fully aware of their responsibilities.

Trading gains

Conversion of existing licences to licences that may be traded or leased or trading itself could give rise to financial gains for licence holders. Such gains are often regarded as politically unacceptable on fairness grounds. It is for this reason some administrations have only allowed spectrum that was initially auctioned to be traded. None of the countries we have reviewed have a specific tax for gains from spectrum trading, though the duties and taxes applying to income and gains from other transfers of property generally apply. We note that in the UK AIP applies to some licences that are tradeable (though not those that have been auctioned) and this in effect returns to government some of the value of the spectrum.[126]

In the Hong Kong context there is a precedent for taxing gains from trade in the case of land. The question is should such a tax be imposed in the case of spectrum. The main reason for not doing so is that it could have an adverse economic impact by inhibiting innovations that enhance the value of spectrum and inhibiting trades and/or leading companies to engage in barter or other costly arrangements that hide the value of the transaction. Against this there are the benefits of raising money for the public purse. We think the efficiency issues are overriding in this case, given the importance of a well functioning ICT sector for the Hong Kong economy and so recommend that gains from trade are not taxed specifically.

Competition issues

Most countries where spectrum trading has been introduced have adopted an *ex post* approach to competition issues, though in some cases *ex ante* spectrum caps have been applied. In this regard we note that:

- in New Zealand the Radiocommunications Act deems spectrum management rights and licences to be assets for the purposes of competition legislation which prohibits the acquisition of assets if the acquisition would be likely to have the effect of substantially lessening competition. The taking of advantage of substantial market power for exclusionary purposes is also prohibited. Potential purchasers of spectrum may apply to the Commerce Commission for clearance or authorisation. In addition, there has been a move towards the use of spectrum caps to control spectrum acquisition. Such caps have been applied only to spectrum that has been auctioned.
- in the US, the FCC reviewed arguments for and against spectrum caps in 2001 and in doing so took into account the degree of competition in mobile markets. The FCC concluded that it "should move from the use of inflexible spectrum

[126] In principle trading alone should provide sufficient incentives for efficient spectrum use. However, there are some possible exceptions to this. In the case of government users, AIP might promote efficiency more effectively than trading, since such agencies may be more responsive to an actual cost (with AIP) than an opportunity cost (with trading), as cost minimisation is likely to be an important objective for these entities. AIP could also promote efficiency more effectively where trading may be slow to emerge, or where the best way to define the rights to be traded is unclear. Note that because AIP in the UK are generally set well below the market value of licences it is unlikely to inhibit trading unless transaction costs are high.

aggregation limits to case-by-case review of spectrum aggregation".[127] The limits lapsed in January 2003

- in Australia, the Productivity Commission recommended that the spectrum limits applied in auctions should be repealed in favour of case-by-case review under competition legislation. The Government did not accept this recommendation.[128]
- in New Zealand and Australia there has been consideration of "use it or lose it" conditions to deal with potential spectrum hoarding. In both cases the practical difficulties of determining when "service implementation" should and has occurred have been noted. In this regard we also note it may be difficult to distinguish behaviour aimed at protecting rights for some future use from behaviour aimed at eliminating competitors. There are good commercial reasons for users to "hoard" spectrum and waiting has a flexibility value, particularly in rapidly changing technology markets. In addition to competition issues, hold-out could result in inefficient use of spectrum.[129] If OFTA considers this to be a serious problem it could in principle exercise its powers to withdraw frequencies granted to a licensee on spectrum efficiency grounds.

In Hong Kong the TA may require additional powers to address competition issues in spectrum markets. There are two possible approaches, one or both of which could be applied

- Enhance OFTA's competition powers to address the impact of the acquisition of spectrum assets on competition and to allow or require clearance for trades. In a liberalised spectrum environment this may be difficult to implement as the use of the spectrum and the relevant market for this use may not be known in advance.
- Apply spectrum caps to limit the amount of spectrum that may be held by an organisation. In practice these caps apply only to spectrum bought at auction. The Caps may apply for a fixed time period or until the market is deemed sufficiently competitive.

The first approach would have the advantage of applying the competition framework that OFTA uses to analyse competition issues in final markets and for mergers. A requirement for ex ante approval on competition grounds also provides parties to the trade with legal certainty.

The advantage of spectrum caps is that they provide certainty to operators and allow rapid and low cost approval/veto of spectrum acquisitions. The disadvantage is that they are inflexible, potentially permitting problematic transactions and blocking transactions that would be in the public interest.

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[127] Para 6, 2001 Biennial Regulatory Review Spectrum Aggregation Limits for Commercial Mobile Radio Services, FCC 18 December 18, 2001 WT Docket 01-14.

[128] The Productivity Commission's Radiocommunications Inquiry Report, Government Response, 2002.

[129] This issue is discussed in the context of property rights in "Designing Property Rights for the Operation of Spectrum Markets", M Cave and W Webb, Warwick Business School, August 2003

Interference Management

Interference management does not greatly change under an environment where licences are tradeable. The key change is licensees are expected to take more responsibility for sorting out interference issues – as they now "manage" their spectrum holdings – but the regulator will continue to have a role in enforcement in cases of unlawful interference. In cases of lawful interference, there is a choice between the regulator playing an informal role or having more formal mechanisms for arbitration or dispute resolution through the courts. We note that in practice the latter are rarely used but their existence helps concentrate the minds of the parties to a dispute to come to an agreement.

Annex 7: Interference issues with liberalised spectrum rights

Aggregation of interference

Insofar as a victim receiver is concerned it is generally the aggregate level of interference that is of concern even though in some instances the aggregate level will be dominated by one of the sources of interference. It is therefore considered that a licence should have an aggregate emission limit both for in-band emissions and out-of-band emissions, although the mechanism for controlling the latter is not straightforward.

Defining the limits in terms of aggregate limits reduces the risk of unacceptable interference compared to the situation where each device has its own limits[130].

In order to provide technical clarity and to aid the resolution of disputes it is suggested that the link between receiver tolerable interference and aggregate emission limits should be declared, including any assumptions made about the apportionment of the total interference budget. This declaration should be made by the regulator when the rights to use spectrum are first established.

Deployment of systems

Moving from a command and control system to a liberalised regime potentially means that deployment becomes variable. Changing spectrum use from a fixed system to a mobile system causes the biggest uncertainty and potential for interference if carried out without co-ordination with other spectrum users. It is therefore suggested that when current licences are converted into liberalised spectrum usage rights any deployment restrictions (whether explicit or implied) associated with current licences should be carried over, at least initially. Such restrictions can then be relaxed or removed if required through negotiation with other spectrum users. In the case of new licences it would be possible to define the rights either with or without deployment restrictions. An absence of deployment restrictions would be preferable but whether this can be achieved will depend on existing spectrum neighbours.

Determination of neighbouring users

There are two aspects to this determination; what triggers a need to negotiate a change of use and who are the neighbours with whom one has to negotiate, both at the frequency boundary and at the geographic boundary?

The trigger for negotiation occurs when a proposed change of use requires modification to any of the parameter values contained in a licence such that the modifications could cause increased levels of interference to other users of the radio spectrum operating in accordance with their licences.

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[130] It can be noted that many of the countries practising liberalisation do not define an aggregate limit and are content that a limit per device is appropriate.

The identity of frequency boundary neighbours should be determined by out-of-band emission overlap and not spurious emissions except in the case of high power transmitters, although if the OOB emission mask is specified in absolute terms this should not matter. Geographic boundary neighbours should be determined by distance from the boundary depending on proposed power increase, frequency band and possibly height. In establishing suitable distances there are two options:

- The regulator issues non-mandatory guidelines on a distance appropriate to the power increase, frequency etc
- Users initiating a change of use determine an appropriate distance based on their own expertise or advice from others.

In both cases, and subsequent to a change of use being implemented, it will still be open to other users with whom no negotiation has been carried out to take action through the courts or an arbitration procedure to enforce their rights however defined.

Access to relevant data will be required for spectrum users to be able to identify their neighbours.

Spectrum quality

Given the uncertainties in propagation it is difficult to guarantee that a particular level of interference will not occur unless significant margins are built in thereby leading to a degree of inefficiency. It can also be argued that transmit rights should be sufficient to determine the interference environment in which receivers operate. Information on spectrum users' transmit rights has to be made publicly available for this to be the case.

However, from a spectrum user's point of view there are two main questions that have to be addressed if the transmit rights-only approach is adopted:

- If I want to change my transmit rights how do I determine whether the proposed change is going to be acceptable?
- With respect to my receivers at what point can I claim that I am receiving too much interference, or conversely, what level of interference should I assume I when planning my system?

In order to make an assessment in the first case, knowledge of the other spectrum users' system deployments and planning criteria would be required. This will not necessarily be in the public domain and will therefore need to be obtained as part of direct negotiation with the other spectrum users.

Insofar as the second case is concerned, it will be difficult for a spectrum user to determine the overall level of interference from transmit rights with any accuracy. This could potentially lead to gross inefficiencies when users make assumptions as part of their planning process. Furthermore, as noted later, a level that if exceeded would support a request for an investigation by the authorities is also required.

It is therefore considered appropriate that a benchmark interference level be associated with the spectrum usage rights in order to indicate likely spectrum quality for planning (and enforcement) purposes and for the basis of discussions in negotiations.

Receiver performance

The performance of receivers has not in the past been an explicit requirement insofar as licence conditions are concerned. In making a frequency assignment there is however an implicit link to receiver characteristics which are used to determine whether an assignment is possible or not. It is clear that any assessment of interference requires some knowledge of receiver performance. If future assessment of interference, as part of the negotiation process between spectrum users, is to be left to the market place then it seems necessary that reference to a minimum receiver performance be maintained where currently available (e.g. in the technical frequency assignment criteria used by the regulator) and introduced where not.

It is important to note that the minimum receiver performance is not meant to be mandated. It serves as a benchmark with which the interference environment can be assessed. If an operator chooses to use receivers having a performance in some way inferior to the minimum receiver performance, then they will not be protected from interference levels higher than those used for the assessment. They may however choose to negotiate with a neighbour to reduce the neighbour's emissions such that its inferior receivers operate satisfactorily.

Intermodulation and overload

There are varying views on whether this is a significant enough issue to incur additional regulatory burden. It appears there are three options:

- On the basis that it does not occur very often do not introduce any regulatory requirements (apart from OOB / spurious limits for transmitters which will be there anyway) on the grounds that the benefits of additional regulation are not sufficient to outweigh the costs of enforcement/restrictions on spectrum use. Overall both the costs and benefits are likely to be small given the infrequency with which these problems occur.
- Specify a minimum receiver performance to reduce the risk. Receivers not meeting this specification cannot expect to be protected. However, it may not be possible to protect receivers that do meet the specification unless the next option is implemented.
- In order to ascertain responsibility for correcting the problem (i.e. who has priority) it will be necessary to register all transmitters (above a certain power) and receivers (if they require protection). This first-in-time method has been adopted in Australia.

Some prefer minimal regulatory control and are prepared to take the risk associated with such an approach, whereas the others regard receiver registration as an acceptable burden if it ensures protection. Receiver registration could be made optional.

Co-ordination and mitigation techniques

Aggregate power limits at geographic boundaries (measured in terms of power flux density (PFD) or other appropriate measure of field strength) are likely to result in significant buffer zones where operations will not be possible without some sort of agreement being negotiated. The form of negotiation and the methodology to determine a satisfactory sharing arrangement may or may not be defined. Co-

ordination methods are often defined by regulators with respect to specific shared frequency bands and these co-ordination methods are referenced in licences where appropriate. While it is often the case that co-ordination methodologies are developed and agreed within international technical gatherings (e.g. ITU and CEPT) it is not necessarily the case that such methodologies cover all situations.

In situations where co-ordination methodologies do not exist it might be expected that spectrum users would establish their own approach to arrive at an agreement

In any event whenever a change to a PFD limit is negotiated and agreed the new limit has to be recorded as part of the licence.

Propagation modelling and measurements

In undertaking system planning and for negotiations between spectrum users it might reasonably be expected that internationally agreed propagation models would be used. It is however recognised that these models do not cover every situation.

The framework should therefore allow alternative propagation models to be used to determine the interference environment, if agreed by relevant parties, and should not preclude the use of measurements for the same purpose.

Enforcement

Enforcement of licence conditions by the regulator will continue to be an essential part of any new liberalised regulatory regime and it might reasonably be expected to take on a more important role. Enforcement is designed to prevent harmful interference from happening but there is a certain imprecision associated with this measure.

The question arises as to what the measure should be that allows a spectrum user to make an enforcement request. If the trigger were to be based on the aggregation of the PFD limits for all licences (each of which has its own aggregate limit) this would result in an unrealistically high level having to be reached before an investigation could be requested. It is recommended that an aggregate receive PFD level based on realistic assumptions be set such that if higher levels than this are experienced an investigation by the regulator may be called for.