

**2017 Research project delegated by National Communications Commission
GRB: PG10606-0131**

**Spectrum management and regulations
study under the framework of Digital
Convergence Acts**

Executive Summary

Telecom Technology Center

Dec 2017

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I. Introduction

This research “Spectrum management and regulations study under the framework of Digital Convergence Acts” is aiming to study harmonized use in spectrum management, spectrum releasing, and utilizing spectrum. Administration may refer to country case-study from this research, with evaluation of domestic market, in order to design an innovative regulations framework which is capable to meet the needs from industry and inclusion of state-of-art technology.

This study analyzes the latest administrative trend of spectrum management, especially with a focus on enhancing efficiency of spectrum use. With a variety of research methods, including literature review and interviews with stakeholders, our goal is to provide a comprehensive research for policy-makers. This research mainly concentrates on spectrum regulations and policies, subjects from spectrum management, secondary spectrum trading mechanism, spectrum sharing, spectrum reallocation, to management of interference.

There are several key findings of this research, which can be summarized in the following paragraph.

- Administrators take more initiative, rather than regarding themselves as pure regulators. They cooperate with industries, developing cutting-edge technology in order to promote national economy in the global ICT market.
- Since spectrum is a limited resource, it’s critical for administration to review regularly, if there is necessity to reallocate spectrum, in order to bring the greatest benefits for society.
- There are three conditions which will invoke license revocation, including violation against spectrum license, failing to renew license and spectrum allocation required by administration.
- While a license falls due, some administrations design a procedure to review if the licensee qualifies to have a license renewal.

Otherwise, when the qualification of licensee does not meet the regulations of license renewal, spectrum will be reverted to administration for further reallocation.

- Spectrum reallocation requires administration to review feasibility and compensation which may incur. Compensation for incumbent, such as financial compensation, new frequency provided by administration for frequency transferring and a combination of the both.
- Regarding mechanism of secondary trading, it can be categorized into leasing or transferring. With spectrum transferring, most administrations review transferring applications on a case-by-case basis. Some regulators review applications with the presence of fair trade committee, in order to maintain fair competition in markets. On the other hand, spectrum leasing is relatively less constrained, compared to spectrum transferring. In the most cases, when both parties reach leasing agreement and be approved by administration, the agreement comes into force.
- Spectrum sharing is an alternative in addition to secondary trading. By deploying new technology, such as dynamic spectrum access (DSA) and spectrum sharing database, underutilized spectrum can be regarded as new opportunity to create more spectrum efficiency.
- Imposing more obligation on stakeholders regarding to solve interference issue. Such as administrator of spectrum sharing database and spectrum lessor.

II. The latest trend of spectrum management and allocation among international administrations

This chapter analyzes the latest development of spectrum management and allocation among international administrations. To reinforce scope of research, we discuss and analyze seven comparative countries and organizations, including International Telecommunication Union (ITU), European Union (EU), United Kingdom (UK), Japan, United States (U.S), Australia and Singapore. The related countries are as follows:

1. International Telecommunication Union (ITU)

ICT Regulation Kit has been published since 2004, the content is mainly based on telecommunication regulation book. The kit aims at equipping developing countries with practical guidance regarding telecommunication policy-making and relative items, such as design of regulatory framework. Content of the kit includes technology evolution, influence of market competition and impact of regulation concerning traditional phone to next generation network (NGN). Each kit is composed of several subjects and are revised on a regular basis.

(1) Spectrum sharing and secondary trading

Spectrum can be shared in several dimensions; time, space and geography. Radio efficiency, applicable technology standard, device specifications and type test certification will all be taken into account by administrations. There are several criteria which administrations shall consider regarding spectrum sharing.

- Administration shall evaluate fully, to decide amount of spectrum which shall be assigned to sharing or exclusive basis.
- Acquire comprehensive information from stakeholders, such as technical standard and required amount of spectrum, in order to tailor policy which meets market's demand.
- Administration shall consider complementary measures for

spectrum reallocation. For example, fiscal compensation or additional frequency for spectrum transferring, for incumbents who are affected.

- Making policy to enhance spectrum efficiency, such as using spectrum utilization fee as incentive, to allocate different operations and user transferring.

Secondary spectrum trading enhances efficiency and cost-effectiveness. Since secondary trading occurring when spectrum being more valuable to buyer than the incumbent, the market mechanism facilitates trading among spectrum holder. With secondary trading, value of spectrum to stakeholders will be further disclosed. In addition, secondary trading is easier for newcomers to acquire spectrum. Thus, this would facilitate a healthier competition in market.

(2) Competition issues regarding secondary trading

Infrastructure with nature of competitiveness, is one of the factors to create a fair and competitive environment. The scarcity of spectrum then incurs possibility of monopoly. As a result, administration is responsible to create a regulatory framework which guarantee a fair competition for stakeholders.

The design of mechanism, license conditions and qualifications are critical to create a fair competition. Via a regulated spectrum allocation, administrations is able to create a much fair market environment.

If there is a lack spectrum cap, monopoly created by one company with sufficient fiscal resource may cause a huge and unfair loss to end costumers. Therefore, the necessity to establish spectrum cap is critical for administrations, in order to prevent harmful consequence in market, such as cartel, monopoly or violation against anti-trust.

2. European Union (EU)

According to decision of Article 6, paragraph 2 and 4 in Radio Spectrum Policy Programme (RSPP), EU has assigned 3.4-3.8GHz, 2500-2690MHz, 900-1800MHz and 800MHz for Wireless Broadband (WBB). In accordance with same Article, EU requests its member countries to grant permission to industries for spectrum transferring or leasing on 790-862MHz, 880-915MHz, 925-960MHz, 1710-1785MHz, 1805-1880MHz, 1900-1980MHz, 2010-2025MHz, 2110-2170MHz, 2500-2690GHz and 3.4-3.8GHz.

With spectrum is under-utilized, EU decided to allocate partial frequency for non-exclusive use. C band (3.4-3.8GHz) as an instance, which is assigned for non-exclusive use. With spectrum sharing and coexistent services, this band provides both satellite earth station for information transiting and wireless broadband use.

However, controversy rises regarding the nature of spectrum license, especially with the basis of exclusive use or sharing use in license's condition. Legitimacy of spectrum sharing often become a debate among stakeholders and administrations. European Commission (EC) reminds member countries shall evaluate individual market, such as development of wireless broadband service. Furthermore, Radio Spectrum Policy Group (RSPG) suggests that each member country's decision regarding non-exclusive spectrum use shall be respected, since spectrum sharing may encounter diversified factors in each country respectively.

Sharing radio frequency in the EU can be done in two ways: the CUS model (also called license-exempt approach); or a variety of different implementations of the LSA model, in which different users need a license to access a shared band. Even though many applications still depend on exclusive access to spectrum, shared bands are increasingly recognized as the breeding ground for wireless innovation that stimulates the development and deployment of more resilient wireless technologies.

The main difference between the two pillars relates to the regulatory guarantees for accessing shared bands. The CUS model provides all users with shared or "collective" usage rights to access a particular band. To manage interference, CUS users rely on technical usage parameters that are specified in spectrum regulations (in combination with a degree of self-regulation for the sharing rules). These parameters can, for example, be specified in harmonized equipment standards. Legally based on the concept of a general authorization, the CUS model allows lower regulatory constraints, but means more responsibility for spectrum users to share spectrum efficiently and manage interference effectively.

The LSA concept, in contrast, gives users shared spectrum access rights that are guaranteed by a regulator, making it possible to ensure a predictable quality of service. Each user needs an individual (but not exclusive) license to access a particular frequency band. Such authorizations depend on the specific sharing conditions in a band, which need to be sufficiently attractive and predictable for new investment in equipment and networks. Under such a licensed regime, interference management is the responsibility of the spectrum management authority, which sets the access parameters through regulation and license conditions. A user that receives such a usage right, for example by acquiring a license through a spectrum auction, is often also entitled to be protected against harmful interference.

As for technology adoption, cognitive radio in the use of TV white space (TVWS) as an example, EU encourages development and innovation on spectrum sharing. Nevertheless, with experiment and development result of white space devices (WSD), RSPG has discovered that complexity of physical deployment and cost of investment are more than original expected. As a result, due to enormous cost and considerable technical complexity, TVWS has encountered great difficulty to be adopted as a spectrum sharing solution within European Union.

3. United Kingdom (UK)

The basic legal source of wireless broadband in UK can be traced to Communications Act 2003 and Wireless Telegraphy Act 2006 (WT Act). The previous mainly constructs policy framework of general communication, the latter becomes source of regulations on wireless broadband.

Telecommunication policy in UK used to be highly regulated, however, as technology evolves, spectrum policy as an example, has been modified to more inclining to market liberalization. Spectrum transfer and lease are instances that regulators has removed barriers on spectrum use.

Ofcom issued Trading Guidance Notes in 2011 regarding further spectrum trading process, including spectrum transfer and lease. Process of spectrum transfer is more complex comparing to spectrum lease. Transfer involves the notification and the grant by Ofcom of a new license to the purchaser whereas leases are contractual between the parties and does not involve Ofcom. For spectrum transfer, both transferor and transferee are granted their own WT licenses from Ofcom that authorize use of spectrum. However, for spectrum lease, leaseholder is not granted its own license, but derives authorization to use spectrum from the lease.

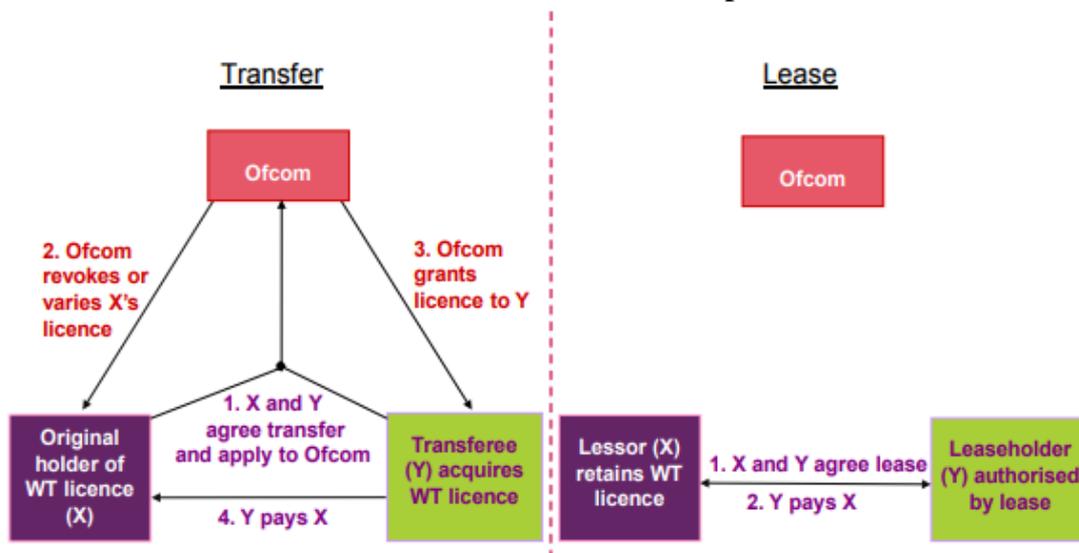


Figure 1 Difference between transfer and lease

The Trading Regulations offer the parties various options as to how to structure transactions. Transfers may be, outright or concurrent; and total or partial. With an outright transfer, the rights and obligations of the person making the transfer become the rights and obligations of the transferee to the exclusion of the person making the transfer. After such a transfer, the original licensee (that traded the license) no longer has any rights and/or obligations under the traded license. In a concurrent transfer, the transferred rights and obligations become rights and obligations of the transferee while continuing, concurrently, to be rights and obligations of the person making the transfer. Such a transfer enables licensees to share rights to use spectrum. The number of concurrent license holders is not limited in the regulations, and so joint holdings by three or more licensees might be possible. As well as allowing parties to trade all the rights and obligations under a license, we permit the transfer of only some rights and obligations in certain cases. This will result in the rights and obligations under the license being partitioned (divided) into two distinct licenses. The rights to use spectrum can be partitioned by frequency, geography or time.

In addition to spectrum trading, another duty of Ofcom is to protect interests of consumer and facilitate competition in telecommunication market. Thus, utilizing spectrum use is essential. Ofcom set two different policy positions regarding auction on 2.3 and 3.4GHz. Considering 2.3 GHz has already been broadly used, while the opposite situation for 3.4 GHz. Thus, if BT/EE continually acquires auction bands in 2.3GHz, it will control nearly 50% spectrum in this band. As a result, Ofcom suggested establishing a spectrum cap of 255 MHz, to exempt BT/EE from attending auction of 2.3GHz. On the other hand, considering the band is less commercially used and lack of applications, Ofcom takes different approach on 3.4GHz such as removing barriers for industry, operators acquiring large and continuous frequency is encouraged and permitted.

4. Japan

Spectrum management in Japan is more controlled by administration. Further review and examination are required by administration before assigning spectrum to individual user. Even though a revised draft of Electronic Radio Wave Act was purposed in 2011, suggesting that replacing current administration-centered mechanism with market-lead auction mechanism, the draft, however, did not pass finally. Moreover, there is no further proposal to modify the current regulation since the last attempted draft failed.

Two points can be concluded from the necessities for retaining current administration-centered mechanism in Japan. First, spectrum allocation relates to a country's development regarding its technology policy. As a result, while scarce resources like spectrum being under control, it facilitates industry strategy demonstrated by government. Second, broadcasting industries have been used to low spectrum utilization fee. High bidding price of spectrum auction creates difficulty for current industries, especially after broadcasters made a huge investment in digital television and upgrading content quality from 4K to 8K.

Currently, a license for using spectrum individually does not exist in Japan. Spectrum license is usually issued under a radio station, clearly identifying the exact band that is available for operation. In the other word, any radio station can correspond to its available frequency, thus, spectrum management can be enforced by regulating radio stations. According to statistic, radio stations that ought to require license has already increased to 164 million by 2016, this number is not including the registered and unlicensed radio stations. Hence, Japanese administration has always emphasized importance on spectrum utilization and dynamic reform regarding spectrum use. Recently, with the goal to deploy 5G in 2020, amount of 2700MHz shall be guaranteed for a variety of wireless communication use under 6GHz, and amount of 23GHz shall be

guaranteed for research and technology development above 6GHz. Increasing economic benefits of spectrum utilization and accelerating spectrum reassignment are two main goals of Japanese telecom policy.

However, conventional regulations set more difficulties for efficient spectrum refarming and reallocation. Fundamental rules adopted by administration during a spectrum releasing review which mostly abides to the original license conditions. If there is a necessity to alter incumbent frequency allocation, Japanese administration shall provide a spared frequency for reallocation and 10 years as transition period for licensee. Under multiple bureaucratic and administrative constraints, spectrum reallocation usually requires a vast amount of time which regarding frequency transition, therefore, it also creates barriers for mobile communication industry, on adopting state of art technology.

In accordance to 'Report of 2020 Radio Wave Policy', spectrum sharing mechanism shall be developed to utilize spectrum use. For instance, with strict regulations on device and daily operation, band of 3.5GHz can be shared between 4G service of mobile communication and incumbent user of satellite communication service.

For detailed mechanism design of spectrum sharing, legal regulations has not been confirmed. Yet, the report purposes three directions for future policy decisions. First, radio stations which involving spectrum sharing shall conform common technological standard, in order to eliminate possibility of interference. Second, a spectrum sharing database shall be established to prevent frequency interference and facilitate cooperation among users. Third, if interference still occurs, stakeholders can conduct negotiation to resolve issues by interest-related parties. However, if too many stakeholders are involved, cost of negotiation would be quite high and time-consuming as well. Considering to enhance the efficiency of spectrum use, a properly designed mechanism is still required to be established before deployment of spectrum sharing in Japan.

5. United States (U.S)

In August 2017, FCC implements a unified regulatory framework for Wireless Radio Services (WRS), which enhances market competition and facilitates utilization of spectrum. The harmonized regulatory approach FCC adopts today replaces the existing patchwork of service-specific rules regarding renewal, comparative renewal, continuity of service, and partitioning and disaggregation performance, with clear, consistent rules of the road for WRS licensees.

In the WRS Reform notice of proposed rulemaking (NPRM), the Commission proposed to adopt renewal requirements for numerous WRS based on the Commission's model for the 700 MHz Commercial Services Band licensees. Under this three-part approach:

- renewal applicants would file a detailed renewal showing, demonstrating that they are providing service to the public (or, when allowed under the relevant service rules or pursuant to waiver, using the spectrum for private, internal communications) and substantially complying with the Commission's rules (including any applicable performance requirements) and policies and the Act;
- competing renewal applications would be prohibited;
- if a license is not renewed, the associated spectrum would be returned to the Commission for reassignment.

In order to promote efficiency of spectrum use, FCC allows licensee of wireless radio service to partition license. Thus, underutilized spectrum can be reverted to FCC. Another common mechanism of spectrum refarming is incentive auction, which will be elaborated in the following section (chapter 3).

According to Spectrum Leasing Rules that FCC issued in 2004, there are two forms of spectrum leasing agreement, Spectrum Manager leasing and De Facto Transfer leasing. Under Spectrum Manager leasing, licensee

must retain both de jure control and de facto control over the spectrum is leased. On the other hand, with De Facto Transfer leasing, the licensee retains de jure control of the license while transferring de facto control of the leased spectrum and the associated rights to the spectrum lessee for a defined period of time. In addition, for both agreements, the term of a lease cannot exceed the term of license authorization.

According to FCC's database, FCC has passed 19 applications of spectrum control transfer, including Verizon, ATN international, DISH Network, etc. While FCC allocates spectrum, the process is abided by regulations of secondary spectrum trading as well. For example, while FCC planned incentive auction in 600MHz in 2014, successful bidder of 600MHz is obliged to complete deployment in phase one before acquiring access to secondary spectrum trading. The obligation of successful bidder in 600MHz is to provide internet coverage in licensed area after acquiring license from FCC, with at least 40% of population within 6 years, 75% of population within 12 years, respectively. As a result, the 600MHz licensee has to hold the license at least 6 years and complete the coverage obligation before access to secondary trading market.

In 2014, FCC issued Policies Regarding Mobile Spectrum Holdings, Report and order. Within the document, FCC demonstrates "spectrum screen," as a mechanism to review if spectrum transactions meet public interest. The current spectrum screen considers the total amount of spectrum suitable and available for mobile broadband held in a market by a wireless provider. The screen can trigger a more detailed competitive analysis by the FCC. Currently, the trigger occurs when a wireless provider holds approximately 1/3 or more of the available spectrum in a given market. The Commission will continue to use this 1/3 spectrum screen threshold and will evaluate transactions on a case-by-case basis. In light of recent and upcoming auctions and rule changes, the Commission added and subtracted certain spectrum bands to the screen, based on whether today that spectrum is "suitable" and available" for mobile broadband.

6. Australia

In 2015, the Australian Communications and Media Authority (ACMA) published ‘ACMA focuses on future of mobile broadband spectrum’. According to this document, ACMA adopts the contingency planning mode which is a more qualitative measure, comparing to other countries tend to adopt more quantitative method on planning spectrum use. The contingency planning mode is built on the basis of growth on mobile broadband. In the other word, suitable frequency bands shall be released for mobile broadband use in an appropriate timing. As a result, this method shall reflect the fast change in telecommunication service market with more administrative flexibility.

In accordance with ACMA’s evaluation, the current released spectrum is capable to satisfy short to middle term demands. However, in a long term perspective, the current spectrum amount would not be enough. To react with demand from future mobile broadband spectrum, ACMA proposed five strategies:

(1) Holistic approach to mobile broadband capacity growth

ACMA evaluates spectrum use for mobile broadband with several dimensions. For instance, under the incumbent frequency use, whether state-of-art technology, internet infrastructure and topology have been adopted, in order to increase capacity of mobile broadband. In addition, if frequency of mobile broadband being fully utilized with most suitable technology. As for telecommunication industry, whether mobile broadband operators deploying adequate infrastructure or enlarging scope of topology network, are also critical perspectives when reviewing use of spectrum use.

(2) Transparent spectrum management planning process

ACMA shall focus on not only amount, but also quality of released spectrum. As a result, ACMA has planned four stages for spectrum management which are monitoring, initial investigation, preliminary re-planning and reallocation.

(3) Utilizing the often long lead-times to reduce effect on incumbents

From preliminary confirmation of target frequency for auction to actual spectrum releasing, the transition period can be up to 10 years. ACMA leverages this long transition period to provide flexible timeframes to the incumbents, regarding implementing new equipment arrangements.

(4) Exploring opportunities for increased spectrum sharing

Concerning the feature of mobile broadband service, frequency band is mostly exclusive-used. However, new technologies such as LTE-U, LAA, LSA and ASA, as well as reformed regulatory mechanism, these evolution indicates more potential opportunity on developing spectrum sharing.

(5) Influencing international spectrum harmonization

Standardization and harmonization of international mobile broadband not only enlarge economic scope of telecommunication market, but also facilitate international roaming. ACMA regards that Australia shall leverage frequency-harmonized trend on developing relative ICT policy. Even though ITU and APT recognize an extensive range of available bands on international mobile telecommunication, it is recommended that ACMA focuses on certain bands which are technically feasible and with potential for development regarding domestic and international market.

In accordance with the report, “Influencing international spectrum harmonization” commissioned by ACMA in 2017, subjects as 5G, IoT and Dynamic Spectrum Access (DSA) haven been reviewed and provided with their feasibility and potential development in Australia. Regarding candidate bands for 5G, there are several consultations, such as ‘5G and mobile network developments’ published in February 2016, ‘Options for 5G mobile broadband spectrum (reallocating 1.5 and 3.6GHz)’ in October 2016, and ‘Future approach to the 3.6 GHz band’ in July 2017. Furthermore, ACMA issued the latest consultation documents in September 2017, collecting comments concerning developing 5G service in 26GHz.

7. Singapore

Singaporean government published Smart Nation in 2013 as a vision for nation's development. Within this vision, heterogeneous work (HetNet) is regarded as a critical infrastructure for information, communication and technology. HetNet refers to a network structure which is composed of multiple telecommunication systems, in order to realize the scenario of E3A (Everyone, Everything connected Everywhere, All the time). As a part of HetNet, Time-Division Duplexing (TDD) is adopted as a technology on deploying small cell network in populous areas. Because the feature of TDD contains flexible adjustment of uplink and downlink, which is able to provide higher capacity for users.

Infocomm Development Authority of Singapore (IDA) announced that in order to evaluate the deployment of HetNet network, void TDD bands in 2.3 and 2.5GHz were open for application to relative telecommunication experiments in January 2015. IDA understood that period of experiment can last from 6 to 9 months before collecting more meaningful results, thus, IDA decided that due of license will fall on 30 September, 2015. IDA also took initiatives to conduct a series of HetNet experiments with industry, to evaluate potential interests for costumers and enterprises. On the basis of those experiments, IDA required not only evaluation of potential business models, but also the most optimal method for future HetNet deployment.

Similar to the previous HetNet instance, IDA collaborated with relative industry to conduct proof of concept regarding TVWS. In order to verify whether feasibility of TVWS exists in Singapore. With support of IDA, Singapore White Space Pilot Group (SWSPG) had been established by ICT industries, and it carried out a series of TVWS pilots in Singapore. Furthermore, IDA issued a consultation of "Proposed Regulatory Framework for TV White Space Operations in the VHF/UHF Bands", and announced its policy in June 2014.

In addition to issuing technical regulations of TVBDs, IDA also made an exemption rule, Telecommunications Notification 2014 (Exemption from sections 33, 34(1) (b) and 35) (Amendment No. 2), concerning some limits imposed with wireless communication device. As a result, devices of TVBDs is therefore able to use the corresponding bands. Besides, IDA decided TVBDs must under examination of General Equipment Registration (GER) and be enlisted. Moreover, manager of geographical database is obliged to apply Services-Based Operator (SBO) on the basis of service in accordance with Telecommunication Act. IDA issued the framework of regulations for TVWS in November 2014.

Though Taiwan has developed potential use of TVWS, there are some fundamental discrepancies between Taiwan and Singapore. For instance, Taiwan adopts single-frequency-network (SFN) for broadcasting planning framework, resulting in less white space resource. Additionally, with high coverage of DTV, less available and continuous channels and diverse topography, those factors contribute to considerable complexity regarding promoting TVWS in Taiwan.

IDA introduced two measures to maintain fair competition regarding spectrum releasing on 700MHz, 900MHz, 2.3GHz and 2.5GHz. First, auction is divided into New Entrant Spectrum Auction (NESA) and General Spectrum Auction (GSA). The definition of ‘new entrant’ refers to whom has not yet provided mobile communication system and service in a national-wide scope. Thus, enterprises asides from SingTel, StarHub, M1 and their subsidiaries are eligible to apply to attend NESA. Meanwhile, according to if there is any new entrant attending auction, amount of spectrum cap will be varied as well.

Since Singapore is located in the Association of Southeast Asian Nations (ASEAN) region, multiple neighboring country borders lead to potential interference. As a result, spectrum harmonization becomes more salient in this region. After negotiation, ASEAN countries agreed on 2020 is the due time for digitalization of wireless television.

III. Research for Incentive Auction Mechanism in U.S.

This chapter analyzes framework and development of incentive auction in U.S, and on the basis of research, providing advice to NCC in Taiwan regarding planning an incentive auction mechanism, which suits domestic market and current legal environment.

1. General mechanism design of incentive auction

American wireless frequency policy has marked a milestone in Middle Class Tax Relief and Job creation act of 2012 (Spectrum Act). The most innovative policy in this act is incentive auction. The mechanism of incentive auction aims to encourage underutilized carriers relinquishing their spectrum usage rights, in exchange of incentive payments. However, this initiative is conducted on voluntarily-joining basis, commencing with market force to decide the supply and demand in spectrum market. The reallocated spectrum will be released through the auction route and reassigned for mobile broadband use, to promote efficiency on spectrum.

National Broadband Plan issued in 2010 demonstrated difficulty engendering while FCC reallocating spectrum. One of the critical factors is due to certain rights affiliated with licenses. As a result, spectrum reassignment costs greatly, in terms of finance, as well as long operation process for frequency transition and spectrum evacuation.

The main goal to design incentive auction is to promote efficiency regarding spectrum use, in addition to prevent unnecessary interruption for broadcasting service. With the distinct procedures in incentive auction, it provides broadcasters with unique opportunity to acquire incentive payment, which also facilitates refarming process and generate spectrum resource for mobile broadband service.

The broadcast incentive auction itself will comprise two separate but interdependent auctions -- a reverse auction, which will determine the price at which broadcasters will voluntarily relinquish their spectrum usage rights; and a forward auction, which will determine the price companies are willing to pay for flexible use wireless licenses.

The lynchpin joining the reverse and the forward auctions is the “repacking” process. Repacking involves reorganizing and assigning channels to the remaining broadcast television stations in order to create contiguous blocks of cleared spectrum suitable for flexible use. The vast majority of stations that remain on the air after the auction will be assigned channels in the TV band; in a few markets where the post-auction TV band is not large enough to accommodate every station, stations may be assigned a channel in the wireless band.

In order to be successful, each of the components must work together. Ultimately, the reverse auction requires information about how much bidders are willing to pay for spectrum licenses in the forward auction; and the forward auction requires information regarding what spectrum rights were tendered in the reverse auction, and at what price; and each of these depend on efficiently repacking the remaining broadcasters.

The reverse and forward auctions will be integrated in a series of stages. Each stage will consist of a reverse auction and a forward auction. Prior to the first stage, the initial spectrum clearing target will be determined. Broadcasters will indicate through the pre-auction application process their willingness to relinquish spectrum usage rights at the opening prices.

Based on broadcasters’ collective willingness, the initial spectrum clearing target will be set at the highest level possible (up to 126 megahertz of spectrum) without exceeding a pre-determined national aggregate cap on the interference between wireless providers and TV stations (“impairments”) created when TV stations must be assigned to the wireless band. Under this approach, the auction system will establish a band of wireless spectrum that is generally uniform in size across all markets. Then the reverse auction bidding process will be run to determine the total amount of incentive payments to broadcasters required to clear that amount of spectrum.

The forward auction bidding process will follow the reverse auction bidding process. If the “final stage rule” is satisfied, the forward auction bidding will continue until there is no excess demand, and then the incentive auction will close. If the final stage rule is not satisfied, additional stages will be run, with progressively lower spectrum targets in the reverse auction and less spectrum available in the forward auction.

The final stage rule is a set of conditions that must be met in order to close the auction at the current clearing target; failure to satisfy the rule would result in running a new phase at the next lowest clearing target.

The final stage rule is a reserve price with two components, both of which must be satisfied. The first component requires that the average price for low impairment licenses in the forward auction meets or exceeds \$1.25 per MHz-pop at a 70 MHz cleared benchmark. Alternatively, if the spectrum clearing target at a particular stage is greater than 70 MHz, then the first component will be met if the total proceeds of the forward auction exceed the product of \$1.25 per MHz/pop x 70 MHz x the total number of pops for the high-demand Partial Economic Areas (PEAs) with at least one Category 1 block in this stage. This alternative formulation will allow the auction to close if the incentive auction repurposes a relatively large amount of spectrum for wireless uses, even if the price per-MHz-pop is less than the benchmark price.

The second component of the final stage rule requires that the proceeds of the forward auction be sufficient to meet mandatory expenses set forth in the Spectrum Act. If the requirements of both components of the reserve price are met, then the final stage rule is satisfied.

On January 18, 2017, the auction satisfied both of the conditions of the final stage rule, assuring that the auction will close in Stage 4.

2. Advice to Taiwan on mechanism design of incentive auction

Incentive auction designed by FCC is an innovative mechanism, in order to enhance efficiency of spectrum management. However, current spectrum regulations and policy-making backgrounds can vary substantially in respective countries. Comparing with the U.S, there are three main differences existing in Taiwanese policy and regulation context that shall be considered.

Firstly, incumbent users acquired spectrum via diverse routes. In the U.S, incumbent users of 600MHz were broadcasters. Moreover, American media and broadcasting industry acquire spectrum via the auction route. However, spectrum in Taiwan was not released with commercial auction mechanism. Therefore, it is difficult to build the comparison of consideration, especially for mobile broadband providers who would like to evaluate potential cost on bidding new spectrum. Thus, it is critical for administration to consider an alternative incentives design in Taiwanese market. In addition to aware that American mechanism is not completely applicable in Taiwan.

Secondly, corresponding band is assigned to different radio services. While American incumbent users were broadcaster on 600MHz, the condition in Taiwan is different. Currently, digital wireless channels mainly use CH 24 (530-536 MHz) to CH 34 (590-596 MHz). As for 703-803MHz, this band has been allocated to mobile broadcast use. For 608-698MHz, there are some existing radio channels are still in use, waiting for further planning. Comparing to the band released in the U.S locating from 615-698MHz, this band is not used by broadcasters in Taiwan. As a result, administration shall evaluate the current situation of spectrum in use, for further consideration on reassigning spectrum.

Thirdly, diversity of regulatory context exists in respective country. Regarding current Telecommunication Act in Taiwan, it does not authorize administration to conduct similar act as reverse auction. Article 55 in the latest version of Telecommunication Management Act, a similar measure

with incentive design is set to facilitate administrations reallocating spectrum. The main difference between the U.S and Taiwanese mechanism will be the lack of reverse auction for the latter. However, a proportional revenue receiving from spectrum auction will be assigned as incentive for encouraging incumbent to relinquish spectrum usage rights. Only there will not be any auction mechanism involved when spectrum is reverted to administration.

Further advice on the design of incentive auction can be concluded in several parts. First, a precise valuation of spectrum shall be conducted. Regarding the mechanism in the US, there are two critical components. First of all is preparation and conduction of reverse auction; secondly, refers to forward auction. During preparation process of reverse auction, cost generated from, such as incentive payment, repacking process and operation for frequency transition shall all be considered. Thus, spectrum valuation in incentive auction is more complicated than conventional spectrum auction. Within the bill of Telecommunication Act, adopting auction route for spectrum reallocation is not prohibited. However, administration shall make a full evaluation and set reasonable bidding price, to avoid the amount of reverted spectrum is less than expected.

Second advice is to amend Telecommunication Management Act. Currently, Article 61 allows administration to repack spectrum. However, this article is based on the frequency supplement plan, which is not necessarily compatible to dedicated radio service, which may cause further issue. Moreover, repacking process may involve equipment replacement and frequency transition, therefore, potential cost may emerge. As a result, the new amendment shall authorize administration to provide compensation to incumbents, as an incentive to promote collaboration.

Thirdly, increase flexibility on refarming mechanism and expand applicable scenarios, such as authorizing administration providing incentive payment or new channel for frequency transition, are also important to motivate incumbent users to involve in this new mechanism.

IV. Adjustment of Spectrum Regulatory Framework under the framework of Digital Convergence Acts

1. Global development on spectrum management

In accordance with Chapter 2, we have discovered a general trend among global administrations on promoting spectrum efficiency. Regulators have gradually reached a balance between market forces and administrative regulations. Moreover, with the state-of-art technology, administrations have developed comprehensive regulatory frameworks, covering from market competition to interference elimination.

Spectrum reallocation is mainly based on each administrations' frequency plan, which is designed in accordance with domestic market. In order to serve the public interest, administrations will make comprehensive evaluation before making decision on spectrum reallocation, trying to eliminate the impact on industry and end users. Compensation is one of the complementary measures with spectrum reassignment. There are fiscal compensation, new channel for frequency transition and a mixed measure combining the both.

The principle and procedures of reclaiming spectrum are usually stipulated in the telecommunications legislation and regulatory instruments of each country. Causes of reclaiming can be divided into three kinds, one is violation against license conditions, another is spectrum reassignment planned by administration, and the other is license set to expire without renewal. Concerning the cost incurred from process of reclaiming, most countries have established spectrum relocation fund. Except for compulsory reclaiming due to violation against license condition, other two kinds of scenario are applicable to require fiscal compensation from the relocation fund.

Regarding secondary trading, spectrum leasing and control transferring are highly concerned by global administrations. As a result, most administrations review applications on a case-by-case basis. In addition to difference of regulatory framework in each country, sometimes

telecommunication administration review the application with fair trade commission, because scarcity of spectrum is a key factor attributing a fair competition environment. Moreover, some countries establish spectrum cap for licensees who have already owned spectrum usage rights. For instance, while planning auction for 2.3 and 3.4GHz, Ofcom set spectrum cap for two band respectively.

Another form of secondary trading is spectrum leasing, it is relatively simple in regard to administrative process. As long as both parties reaching consensus, with permission from administration, the agreement will come into force. Regarding spectrum transferring, licensee needs to file application to administration, with lessee's qualification meeting license requirements, before spectrum being transferred. In some countries' process, the administration needs to revoke licensee's license first, then grants the license to the lessee. In general, spectrum transfer is more complex compared to spectrum leasing. However, in order to promote economic efficiency of spectrum use, more administrations are willing to grant the concept of title to spectrum via auction and secondary trading.

Deployment of the latest technology, such as dynamic spectrum access and spectrum management database, not only facilitates the mechanism of spectrum sharing, but also utilizes the dispersed spectrum. Spectrum sharing mechanisms, such as CBRS in the U.S and LSA in Europe, have demonstrated their progress both on regulatory framework and pilot result. As a result, these global cases can be served as good case study and regulatory reference for local administration.

Finally, with regard to reducing interference, making users in different tiers to be accountable and reforming current regulatory framework are both alternatives compared to conventional monitoring from administration. Since diverse technologies and frameworks deployed on spectrum, more users are involved in spectrum use. By distributing monitoring work to more stakeholders, interference issues shall be detected and solved with higher efficiency.

2. Further discussion of spectrum management under the framework of Digital Convergence Acts

National Communication Committee (NCC) published the bill of Telecommunication Management Act in 2017, which is in accordance with the principals of Convergence Acts. Spectrum management framework is demonstrated from Article 52 to 62, which is composed of spectrum planning, admission to application, spectrum releasing, spectrum allocation and spectrum reclaiming. Regarding promote flexibility of spectrum usage, which is illustrated in Article 52 (unlicensed spectrum use), Article 57 (spectrum sharing), Article 58 (leasing between telecommunication operator) and Article 59 (secondary trading). Concerning spectrum reclaiming, Article 55 is established with reference in incentive auction in the U.S. Generally, the bill is removing regulatory barriers and including innovative spectrum management frameworks from other countries. In addition, issuing respective license for both radio service and radio frequency is also a key reform in the bill of Acts.

(1) Releasing frequency and service license respectively

Main feature of the new telecommunication framework is changing the current one-to-one correspondence between radio service license and spectrum usage rights. In the other word, the future process for operators to acquire qualification to provide radio service is separated from acquiring spectrum license. Furthermore, with a spectrum license, an operator can then register as provider of a variety service, as long as in compliance with technological standards and usage regulations. For example, if there are two services in the future, mobile broadband and mobile IoT. Under the new framework, operator can register as a provider for both services if he has a correspondent frequency license. In this case, acquiring license of service provider and spectrum is two individual process. However, with current regulations, operators must submit a bid for two service licenses, respectively. After acquiring one service license, the correspondent spectrum usage rights are affiliated within service license.

(2) Operation of secondary trading

In accordance with Paragraph 2, Article 59 in Telecommunication Management Acts, there are two issues of requesting the administration to address and consider for further planning. Firstly, whether reforming the current spectrum cap concerning secondary trading, the administration needs to plan beforehand earlier than releasing new frequency. Secondly, whether permitting concurrent license or further collaboration between operators, the administration can refer to Article 58 for observation on spectrum leasing framework; and Article 58 and 59 for discussion about re-authorization the use of spectrum.

(3) Compensation of spectrum reclaiming

Refer to other countries' spectrum regulations, Article 61 in the new Telecommunication Management Acts includes compensation mechanism. While cost is incurred due to spectrum reallocation and equipment update according to administration's new frequency supplement plan, spectrum user would be offered fiscal compensation by administration.

For the fiscal source of compensation, since spectrum reallocation occurs irregularly, it seems more flexible to draw up budget for this incidental cost as a complementary measure with spectrum reallocation.

(4) Incentive for spectrum reclaiming

Incentive payment for encouraging users to relinquish spectrum usage rights does not exist in current regulations. However, the similar concept will be included in Article 55 in the new Telecommunication Management Acts. In addition, "Specific Radio Frequency Reclaiming Regulations" will be designed on the basis of Article 55.

Taiwanese administration has not yet adopted reverse auction as FCC has done in the U.S. However, it is necessary for administration to make a valuation of frequency before reclaiming spectrum, and consider if bidding price does not meet a government estimate in following auction. Therefore, while setting an administrative contract, government should be based on proportional government estimate or final price, or be decided by industry.

(5) Frequency interference

Regarding a variety of mechanisms and frameworks would be deployed in the future, there is different level of involvement for each user.

For example, administrator of spectrum sharing database owns a list of frequency sharing participants and frequency allocation plan. While an interference occurs, administrator of database would make a preliminary investigation, to detect if the source of interference is generated from one of the spectrum sharing users. If the result is positive, administrator can activate an internal process to solve the interference, otherwise, administrator shall notify regulator about the external interference and let regulator take over on this interference issue.

(6) Establishing spectrum sharing mechanism

Currently, NCC has commissioned another research project for analyzing the framework and regulations of spectrum sharing. The preliminary aim is to establish an innovative regulatory framework, and verify spectrum sharing's proof of concept regarding technological part. Furthermore, setting up a process to certify qualified industry as a third party to operate database, and gradually removing barriers for spectrum sharing are the long-term goal for NCC.

In addition, one of critical issues in spectrum sharing is to confirm which band is applicable for sharing use. The initial goal for administration is to figure out if the candidate band for spectrum sharing also as a candidate band for future mobile communication technology. Then, administration needs to consider a time schedule and cost for refarming, and whether to releasing this band with spectrum sharing mechanism. If refarming process being relatively time-consuming, spectrum sharing mechanism would be considered as an option for this band. Meanwhile, a comprehensive investigation about all the potential use scenarios, benefits generated from sharing, and relative measurements are required, in order to confirm the use of spectrum sharing and establish technical regulations.

V. Analysis on future reforms and adjustments in regard to Spectrum Management Acts

After adjusting the framework of domestic spectrum management and reviewing urgent policy issues, Telecommunication Management Act (2017) has been altered greatly from the current Telecommunication Acts.

Telecommunication Management Act is established with framework of digital convergence, referring to global legal cases and will therefore, create an innovative and comprehensive legal source for many new spectrum management mechanism. Concerning fundamental framework of spectrum management, it will change from the current one combining both service license and spectrum to the future one separating the service and spectrum as two individual process. In the other word, service part will be returned to regulations of service license, conversely, spectrum will become an individual right. Thus, an independent framework for spectrum license must be established, respectively.

1. General introduction of legality alternation

(1) Regulations transfer between the current and the new Act

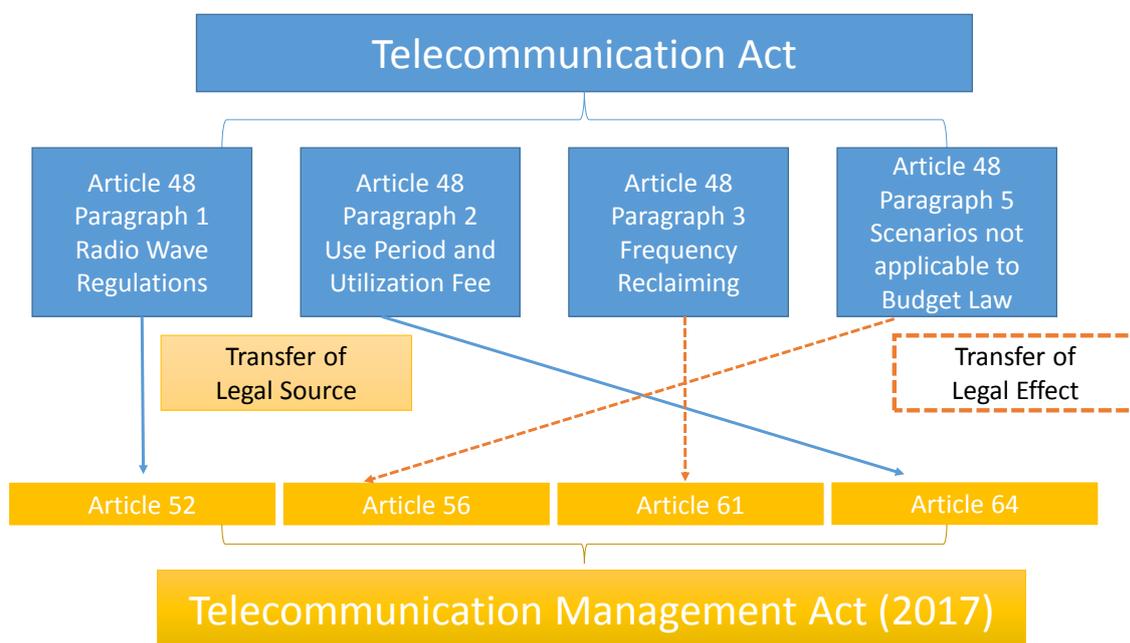
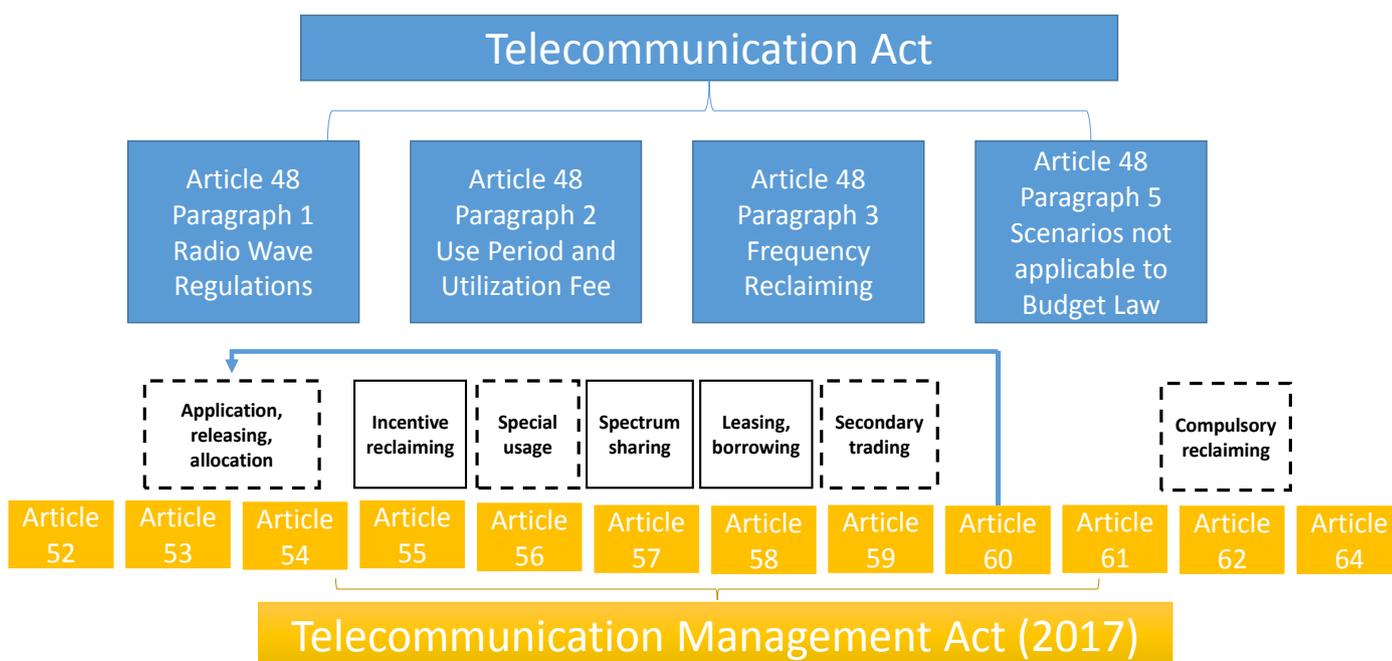


Figure 2 : Regulations transfer between Telecommunication Act and Telecommunication Management Act (2017)

(2) Sub-law transfer between the current and the new Act



[- - -] Inheriting current sub-law regulations [] Requiring new sub-law regulations to be established

Figure 3: Complementary measures of sub-law in Telecommunication Management Act (2017)

(3) Classification of sub-law transferring in Telecommunication Act

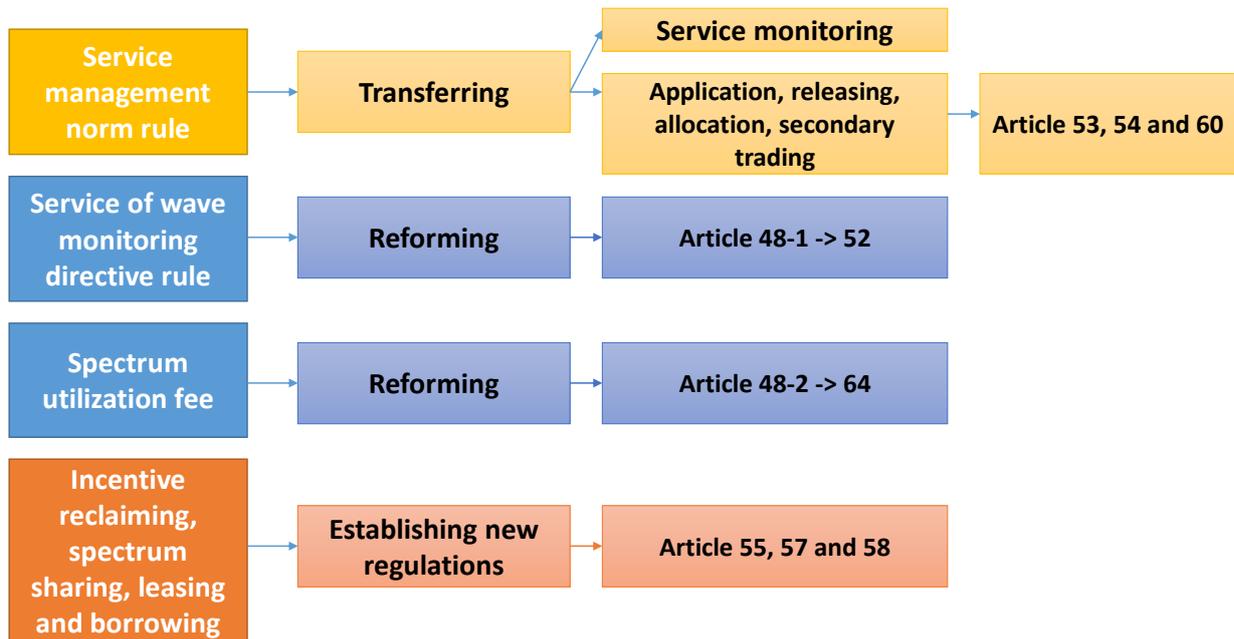


Figure 4: Classification of Sub-law transferring

(4) Framework of sub-law in Telecommunication Management Act

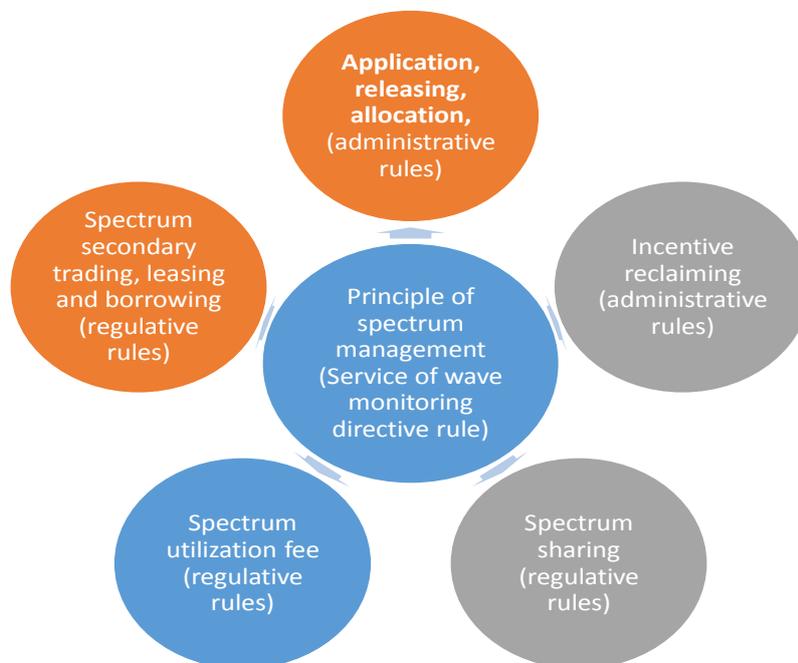


Figure 5: Framework and individual items of sub-law

2. Complementary measures of sub-law for spectrum management

(1) Spectrum Management regulations

The general spectrum management of current Telecommunication Act is Service of Wave Monitoring Directive Rule. From Article 4 to 26, there are comprehensive regulations regarding radio frequency use, such as harmonized use among individual service, prevention of harmful interference, same frequency use with different location and different time, minimum technical standard, reservation of guard band, and primary and secondary harmonized use.

(2) Operation and service management (Mobile broadband service management rules)

Mobile broadband service is the main service category for spectrum releasing which is regulated by Mobile Broadband Service Management Norm Rule. The rule can be divided into three section, operation and service monitoring, spectrum auction ruling, and spectrum usage rights transferring. In the future, Mobile Broadband Service Management Norm Rule will only reserve the sections of operation and service monitoring, and the other rules will be separated and become independent regulations. For industry who would like to provide mobile broadband service, he shall register a license for telecommunication industry identity under the new framework of Telecommunication Management Act (2017) as the first step. Secondly, he shall acquire spectrum based on frequency releasing or secondary trading rule. Lastly, he shall make a service registration with Mobile Broadband Service Management Norm Rule, in order to provide public internet access with mobile broadband.

(3) Compensation for reclaiming spectrum

In general, the regulations of reclaiming spectrum in Telecommunication Management Act (2017), has inclined to the global administrative trend. There are three prerequisites which will incur spectrum reclaiming, reallocation requested by administration (Article 61), violation against licensee on regulations or (Article 62), and termination of

spectrum license.

Concerning principle of compensation for spectrum reallocation, administration will evaluate the direct loss from licensee, such as cost of equipment replacement and frequency transfer. However, the valuation against spectrum is not included. As for the case, when violation against spectrum license occurs, the administration is authorized to revoke licensee's license without compensation. In addition, since limited operators in domestic market, administration may consider establish license renewal regulations with adjustment on spectrum utilization fee, to promote efficiency on spectrum use when a license falling due.

(4) Incentive for reclaiming spectrum

According to Article 55 in Telecommunication Management Act, administration shall decide the proportion or exact amount for incentive payment after spectrum valuation and administrative negotiation.

(5) Interference solution

Under the current framework of Telecommunication Act, the regulations of interference mainly refer to Chapter 4 in Service of Wave Monitoring Directive Rule. After the activation of new Telecommunication Management Act, legal source of the Directive Rule will be transferred to Article 52 in the new act. The interference solution is aiming to manage general use of wireless radio frequency, with compliance to frequency allocation plan.

(6) Spectrum sharing

Compared to the current Telecommunication Act, the draft of Telecommunication Management Act has already regulated the authorized conditions of legal source, regarding spectrum sharing. As a result, it is necessary to establish a new spectrum sharing management norm rule, to be the basis of operating spectrum sharing mechanism.

VI. Conclusion and Recommendation

1. Recommendations to the short-term

- Frequency for mobile broadband can be included as primary candidates for secondary trading, in accordance with Article 59 in Telecommunication Management Act (2017),.
- Auction rules and spectrum planning, from Mobile Broadband Service Management Norm Rule, can be set as an independent and basic regulations for spectrum auction, with reference to Article 53 in Telecommunication Management Act (2017).
- To clarify obligations between service and spectrum license. For example, price rate, universal service and quality of service shall categorized as obligation of service license; deployment of base station then be regarded as obligation of spectrum license.
- Spectrum cap has currently only existed in Mobile Broadband Service Management Norm Rule. Nevertheless, the establishment of spectrum cap will be included in not only regulations of secondary trading, but also regulations for spectrum license.
- Imposing more obligation on stakeholders regarding to solve interference issue. Such as administrator of spectrum sharing database and spectrum lessor.

2. Recommendations to mid-long term

- Establish regulations of spectrum renewal, in order to promote spectrum efficiency when license falling due.
- Granting more flexibility for operator's obligation regarding base station deployment. Operators only required to deploy base station when specific areas have needs.
- Establish directive norm for reclaiming underutilized spectrum with incentive payment, administrative negotiation and administrative contract.
- Establish norm rule for managing spectrum sharing. The content of norm rule shall include protection to incumbent, rights and

obligation for sharing users, rights and obligations for administrator of spectrum sharing database, and technical regulations of equipment.

- Modify Article 55 in Telecommunication Management Act, increasing conditions for spectrum reassignment. Administration can therefore reallocate spectrum and remain continuity of spectrum while conducting incentive payment.