BANGLADESH

Bangladesh
SPECTRUM MASTER PLAN

Report

Telecommunication Development Sector

Bangladesh spectrum master plan

This report is an outcome of country assistance to Bangladesh under partnership project between the International Telecommunication Union (ITU) and the Ministry of Science ICT and Future Planning (MSIP) Republic of Korea. ITU would like to thank the staff of the Ministry of Information and Communications Technology (MOICT) and the Bangladesh Telecommunication Regulatory Commission (BTRC) for their support. ITU would also like to thank Mr Siow Meng Soh for his role as an expert in preparing this report.

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1.1 Introduction

Wireless communications are increasingly important to economic and social development. Underpinning the deployment of these communications systems is the radio spectrum, which is a subset of the electromagnetic waves in between 3 kHz to 300 GHz. Regulating the use of spectrum is important to prevent interference among users and systems. In the past decade, there have been significant developments in both technological and regulatory approaches to spectrum management. There is a gradual shift from the more rigid administrative approaches to more flexible (or light-handed regulation) market-based regulation. While administrative approaches have been effective in controlling interference, such methods are often slow and unresponsive to new technological opportunities.

With the changes in spectrum management principles, regulators have moved to a more consultative approach, engaging various stakeholders for effective policy decision making. The regulator needs to take effective measures to provide information on the policies, rules and practices of the administration and provide mechanisms for feedback to evaluate polices, rules and practices. An impetus for consultative mechanisms for stakeholders arises from the need for improved short term planning and assignment processes that reflect the economic value of spectrum to the public and improved transparency in decision-making.

A spectrum master plan is a tool that provides greater transparency for industry and spectrum users indicating the demand for spectrum and the direction that the regulator is taking. It is part of the industry consultation framework for spectrum planning and decision making. The spectrum master plan should provide details about the spectrum management work undertaken by the regulator in the short-, medium-, and long-term. The work should include any emerging spectrum issues, changes to spectrum usage and the release of spectrum with indicative timeline. The spectrum master plan is therefore a strategic tool that helps the regulator to have a systematic and transparent approach to gather extensive inputs to make informed decisions. It also provides the industry with early indications on the availability of spectrum, which is crucial for organisations to plan their network investments more effectively.

Following the Connect Asia Pacific Summit in 2013, ITU is assisting selected countries in the Asia Pacific region, including Bangladesh, to develop spectrum master plans and arranging workshops related to this subject. This report is part of the first phase of the project to develop a spectrum master plan for Bangladesh.

The scope of this project is to:

- assess the current situation of the national spectrum management in Bangladesh;
- gather feedback from the industry and other stakeholders; and
- identify key areas that need to be incorporated into the spectrum master plan.

1.2 Key facts on Bangladesh

The ICT industry in Bangladesh is flourishing. The number of mobile subscribers has grown by a compound annual growth rate of 54 per cent over the last ten years and there are now well over 116 million subscribers. The telecommunication market is competitive and the regulator, Bangladesh Telecommunication Regulatory Commission (BTRC), has issued 1 948 licences to date. Bangladesh is one of the most populous countries in the world and it has attracted a number of foreign investors looking for growth opportunities. Currently, there are six mobile operators and three broadband wireless access (BWA) operators. Collectively, these operators have rolled out more than 48 000 base

stations covering over 90 per cent of the population. In terms of fixed telecom infrastructure, fibre optic footprint expansion is underway (over 23 000 km completed) and Bangladesh Submarine Cable Company Ltd has joined the SEA-ME-WE 5 submarine cable, which is expected to go live in early 2016. This will be the second submarine cable connecting Bangladesh to the world, after SEA-ME-WE4.

Table 1.1: Key facts on Bangladesh

Land area	147 570 km^2
Population	156.4 million
Mobile subscriptions	116 871 000 *
Fixed telephone subscriptions	1 138 946
Fixed broadband subscriptions	989 521
Internet density	27 per cent
*BTRC statistics for July 2014: www.btrc.gov.bd/content/mobile-phone-subscribers-bangladesh-july-2014	

1.3 Legislative framework

1.3.1 Telecommunication Act and the creation of BTRC

Bangladesh Telecommunication Regulatory Commission (BTRC) was formed on 31 January 2002 as an independent regulator established under the Bangladesh Telecommunication Act, 2001. The objectives of the Act are:

- To encourage the orderly development of a telecommunication system that enhances and strengthens the social and economic welfare of Bangladesh.
- To ensure, in keeping with the prevalent social and economic realities of Bangladesh, access to reliable, reasonably price and modern telecommunication services and internet services for the greatest number of people, as far as practicable.
- To ensure the efficiency of the national telecommunication system and its capability to complete in both the national and international spheres.
- To prevent and abolish discrimination in providing telecommunication services, to progressively effect reliance and competitive and market oriented system and in keeping with these objectives to ensure effective control of the Commission.
- To encourage the introduction of new services and to create a favourable atmosphere for local and foreign investors who intend to invest in the telecommunication sector in Bangladesh.

BTRC functions and duties include regulating telecommunication services in Bangladesh, protecting the interests of local consumers, encouraging R&D activities and investment, and promoting competition. BTRC is also empowered under the Act to allocate radio frequency and to authorize the use thereof, to monitor the use of radio frequency and spectrum management. More specifically, Section 55 of the Act states that BTRC shall have the exclusive authority to issue licences and to allocate the radio frequency. Under the Act, a Spectrum Management Committee was formed to:

a) make recommendations to the Commission on the principles of allocation of radio frequency and fixation of fees for such frequency;

b) make recommendations to the Commission for specifying the radio frequencies to be used for operating radio apparatus or for providing services by various licensees, broadcasting enterprises and other organizations;

c) make recommendations to the Commission on the methods and time-limits of allocation of radio frequencies and the revocation or modification thereof;

d) co-ordinate the international and multipurpose use of radio frequency and to frame policies thereon, to present such policy for approval of the Commission and to revise from time to time the policies approved by the Commission;

e) revise matters relating to radio frequency band in order to ensure their proper use and receipt of better information by using such band;

f) determine the technical standards applicable to radio apparatus or interference causing apparatus; and to make recommendation on the issuance of technical acceptance certificates;

g) make recommendations on the issuance of licence for radio apparatus;

h) monitor the compliance of the provisions of this Act and regulations in respect of the use of the allocated radio frequency spectrum, and to make suggestions on the actions to be taken, if any.

Whilst the BTRC has been empowered to regulate the telecommunication industry, the Ministry of Information and Communications Technology (MOICT) retains the functions to determine the general policy of the government in the telecommunication sector. More specifically, the functions of the Ministry include:

a) to take appropriate actions to facilitate exchange of information on telecommunication within and outside Bangladesh;

b) to identify the area where telecommunication technology can be applied for the purpose of developing and flourishing the local culture and social bondage; and to encourage the use of such technology in those areas;

c) to identify the fields of public and private sector investment for the purpose of developing an effective and modern telecommunication infrastructure and to encourage such investment on the basis of co-operation between the public and private sectors;

d) to undertake, on its own, research and development initiatives in telecommunication in Bangladesh and also to undertake such initiatives jointly with regional and other organizations interested in this regard;

e) to undertake educational and training programs for human resources development of enterprises which establish telecommunication system, provide telecommunication services and manufacture related products;

f) to assist, where possible, the Commission and other organizations for the purpose of enhancing the local telecommunication manufacturing capability and developing the innovative telecommunication services;

g) to assist the Commission, on its request, to control or abolish discrimination or discriminatory conduct in providing telecommunication services or in extension of such services;

h) to arrange a forum where the Ministry, Government, Commission, operators, consumers and other interested persons may meet to discuss matters of common interest;

i) to co-ordinate participation of Bangladesh in the activities of the International Telecommunication Union and other international organizations regarding policies, standards and procedure to be followed in telecommunication and training on such matters;

j) to dispose of all applications and other correspondence made to it under this Act, and to expeditiously execute its decisions.

1.3.2 ITU Radio Regulations and National Frequency Allocation Plan

At the international level, the use of the radio frequency spectrum is set out in a treaty – the Radio Regulations – ratified by the Member States of the International Telecommunication Union (ITU). Within that international framework, countries manage their national use of the spectrum through a National Frequency Allocation Table that sets out what radio services can operate, in which frequency bands, and under what conditions.

The BTRC in consultation with the Spectrum Management Committee (SMC) has produced and published the National Frequency Allocation Plan (NFAP)[1]. The NFAP details the services for which spectrum bands are allocated including where these are shared between services and, if they are shared, whether services are afforded primary or secondary status. The services are generally categorised as:

- Fixed services
- Broadcasting services
- Mobile services
- Fixed-satellite services
- Broadcasting-satellite service
- Mobile-satellite service
- Amateur
- Science services (radio astronomy)
- Radio determination (radio navigation and radiolocation).

The NFAP needs to be periodically updated as technologies and services evolve and changes to frequency allocation were made at the ITU World Radiocommunication Conference (WRC). The NFAP was first published in 2005 and subsequently updated based on the outcome of World Radiocommunication Conference in 2007 (WRC-07). A revision to the NFAP may also be required from time to time when there are:

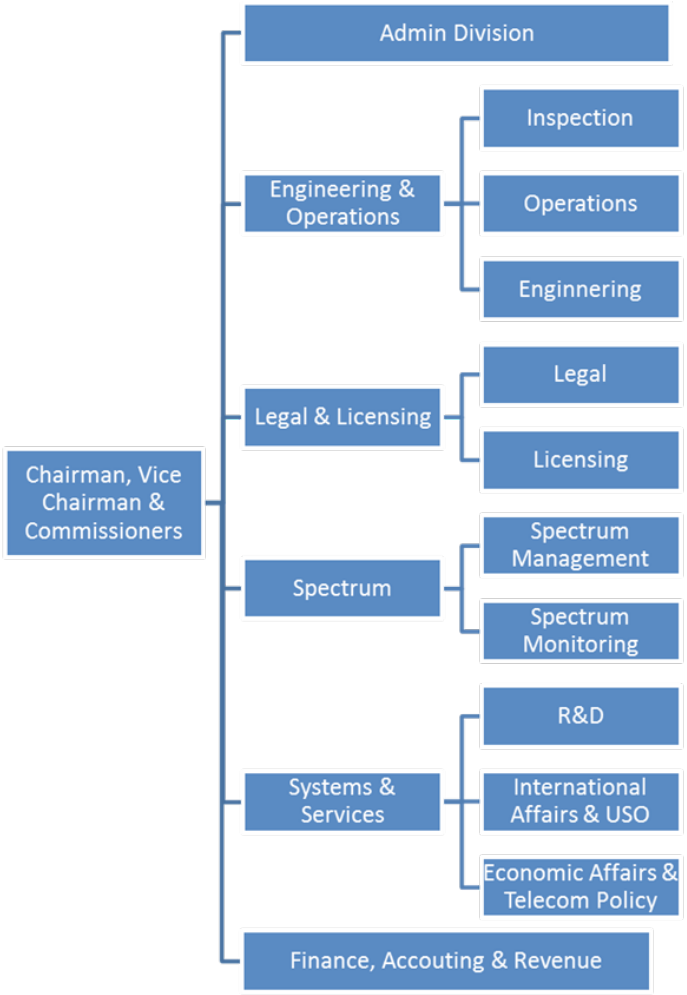
- decisions to adopt new technologies by the government;
- requests to update technology by incumbent users;
- changing demands for different radio-based applications;
- requirements arising from service based national consultative committees.

1.4 Organisation

BTRC is headed by five Commissioners and the government appoints one of the Commissioners to be the Chairman and another to be the Vice-Chairman. Figure 1.1 shows the organisation structure of BTRC. There are six divisions within BTRC each headed by a Director-General or Director.

[1] www.btrc.gov.bd/national-frequency-allocation-plan

Figure 1.1: BTRC organisation structure



Source: BTRC

Spectrum management activities are mainly undertaken by the Spectrum Division and distributed to its two Directorates. The Spectrum Management Directorate has 14 staff responsible for spectrum planning and allocation, spectrum related licensing matters, pricing, technical standards and satellite matters. The Spectrum Monitoring Directorate has 31 staff responsible for monitoring and radio interference detection.

1.5 Current spectrum management practices

1.5.1 Frequency assignment

The assignment of frequencies to users is made in accordance to the Bangladesh National Frequency Allocation Table (NFAP). Before assigning frequencies in a band, the regulator needs to decide the band and channel plans, technical standards (e.g., bandwidth, power emission, and antenna height), planning parameters (protection criteria) and interference assessment. For many services, the details are prescribed in ITU-R recommendations. Integral to the assignment process is the technical assessment which include considering the technical compatibility with existing users, the risk of interference, compliance with international allocation agreements, where necessary coordination with other countries and meeting domestic demand.

There are three major methods of granting users access to spectrum: administrative methods, using market-based methods and by permitting access to unlicensed spectrum.

Administrative method

Frequency assignment is predominantly made through the administrative method, on a first-come first-served basis. This means that licences are issued to specific users for specific purposes and under specific operating conditions including the technology, power, coverage and specified apparatus. 2G mobile, private mobile radio (PMR), fixed point-to-point links are some examples of services where spectrum is assigned through the administrative method.

BTRC assesses each frequency application based on the following conditions:

- whether the request meets predetermined criteria to ensure efficient use of spectrum;
- whether the requested frequencies will be used for services that match those in the NFAP; and
- whether the new system will cause interference and/or be interfered by an existing system.

The assignment will then take into account the parameters and restrictions that may need to be imposed on the use of spectrum. After evaluating an application, BTRC will submit its recommendation to the SMC / MOICT for final approval. Licensees will need to pay an annual fee for the frequencies assigned. The annual spectrum charges are designed such that licensees will pay a higher price for spectrum bands that are in greater demand. This is to incentivise companies to use the spectrum more efficiently and consider other less congested spectrum bands where feasible. Spectrum charges are discussed in greater details under Section 5.2.

An alternative option is selection through a beauty contest. After the formation of BTRC, Airtel Bangladesh Ltd formerly Warid Telecom International Ltd was awarded 15 MHz of frequency from GSM 1800 MHz band to operate a cellular mobile network through a beauty contest. The selection criteria included applicants' past experience in the telecom sector, proposed investment, financial and technical strength, rollout plan, tariff plan and future plan for the investment of other business in Bangladesh.

It is common for spectrum management organisations to adopt radio planning tools to ensure spectrum efficiency and enable high reuse of frequencies. The planning tools are usually integrated with a central database as part of an automated spectrum management system[2]. BTRC is currently keeping paper records while planning to move to an electronic system. The assignment procedures and guidelines have not been documented and published.

As best practice, frequency assignment process should be open, transparent and non-discriminatory for all users. Decisions will need to be taken as to how spectrum will be licensed and against which criteria assignments will be made, for example whether first come first served, time limited, geographically limited and shared use. The assignment policies should also define how competing demands on spectrum by commercial and non–commercial users will be addressed.

Market-based approach: Auction

BTRC has also adopted the auction approach for awarding spectrum to commercial operators. The first spectrum auction was conducted in 2008 to award three broadband wireless access (BWA) licences with three lots of 35MHz bands (1 lot in 2.3 GHz and 2 lots in 2.5 GHz). The BWA auction resulted in two winners and a third licence was later assigned administratively in 2013. The BWA licences are technology neutral, and whilst BWA operators currently operate WiMAX networks, they are allowed to deploy LTE or other technologies. In fact, BWA operators Banglalion, Qubee, and BIEL, have all conducted TD-LTE technology trials and are planning for commercial service.

[2] See ITU-R SM. 1370 "Design guidelines for developing automated spectrum management systems".

The second auction carried out by BTRC was for the award of the 3G licences in the 2.1GHz band. However, unlike BWA, the 3G frequencies are limited to 3G technologies (not for LTE). Teletalk, the state-owned operator secured a 3G licence (paired spectrum of 10 MHz x 2) prior to the auction. Whilst the award was decided based on an open bidding process, the Ministry made a policy decision that only four licences should be issued, one fewer than the number of mobile operators in the country. At the end of the auction, one operator Grameenphone secured 10 MHz x 2 while the remaining three operators (Robi Axiata, Banglalink and Airtel) secured 5 MHz x 2. Consequently, 25 MHz x 2 in the 2.1 GHz band remain unassigned.

BTRC will conduct an auction for a spectrum band that is meant for services that have high commercial value and where the demand for spectrum is expected to exceed supply. As a general rule, auctions will be carried out for "greenfield" frequency bands – those bands that have been just been re-farmed and sizeable amount of spectrum is available for multiple operators. Leftover spectrum is usually assigned administratively on a first-come first-served basis. For example, a 2G mobile operator can request for additional 2G frequencies anytime and BTRC will assign the frequencies if there is evidence that the operator is facing network congestion.

As part of the BWA and 3G licence conditions, operators are required to fulfil rollout obligations to avoid spectrum hoarding and to promote competition amongst operators. Operators are also required to provide acceptable quality of service as specified by the BTRC Regulations / Directives / Instructions / Orders / Guidelines. This is important to protect consumer interests and to ensure that operators put in adequate infrastructure investment. Trading of frequencies is currently not allowed.

The BWA and 3G auctions determine the one-time acquisition fees operators have to pay upfront. The spectrum awarded will still be subject to the annual spectrum charges. In addition, there are other charges such as licence fees, revenue sharing and Social Obligation Fund (see subsection 1.5.3).

Unlicensed spectrum

License-exempt or unlicensed spectrum is free from centralised control in which anyone can transmit without a license as long as they comply with rules that are designed to limit/avoid interference. Most ISM bands (Industrial, Scientific and Medical) under ITU Radio Regulation 5.150 are commonly allocated for unlicensed applications. Spectrum bands under 5.150 include 13.553 – 13.567 MHz, 26.957 – 27.283 MHz, 40.66 – 40.70 MHz, 902-928 MHz, 2400-2500 MHz, 5725-5875 MHz and 24-24.25 GHz. Since these bands are used for ISM equipment, wireless devices operating in these bands must accept harmful interference from these ISM applications. Besides the ISM bands, BTRC has also designated SRD bands (Short Range Device) for unlicensed use (e.g., hearing aid devices and remote control). SRD as the name implies, are permitted to operate at very lower power to enable many devices to coexist.

Over the years, there has been a growing interest in the use of unlicensed spectrum, particularly in the 2.4 GHz and 5.8 GHz bands. Wireless LAN (WLAN) and Bluetooth devices operate in these bands and they are now ubiquitous. The latest WLAN standard 802.11ac will enable devices to operate in a wider bandwidth to provide gigabit Wi-Fi connectivity.

1.5.2 Frequency charges

Information on the radio frequency charges is available on the BTRC website[3]. These frequency charges are designed to recover the administrative costs associated with the processing of a licence application and maintaining the spectrum free of harmful interference.

BTRC has also adopted a spectrum pricing policy and spectrum tariffs to not only cover the administrative costs but also to support the implementation of the spectrum policy that encourages the effective use of the radio spectrum. A formula-based approach has been adopted to discourage

[3] www.btrc.gov.bd/sites/default/files/radio_frequency_charges.pdf

spectrum hoarding and to encourage users to migrate to less congested spectrum bands. At present, the pricing formula is only applicable to commercial operators including cellular mobile, national PSTN and BWA. Table 1.2 shows the values for the different factors that are built into the following formula to reflect the value of each spectrum band:

Spectrum charges in Taka (BDT) = STU x CF x BW x AF x BF

Table 1.2: Factors that reflect the spectrum band value

Factor	Explanation	Value
STU	Spectrum Tariff Unit	Tk. 70/MHz/Km2
CF	Contribution Factor	Based on subscriber base; CF =1 for microwave frequencies. See tables below.
BW	Bandwidth	Bandwidth assigned in MHz
AF	Area Factor	Based on land area of 147 570 Km2; microwave frequencies AF = Link Length2 x 0.273
BF	Band Factor	BF is set higher for lower spectrum bands that are facing higher demand

Table 1.3: Contribution factor for mobile operators

Sl. #	Subscriber base related to use of frequency (lower limit inclusive & upper limit exclusive)	CF
1	From 0 to 2 million	0.70
2	From 2 to 5 million	1.20
3	From 5 to 10 million	1.70
4	From 10 to 15 million	2.20
5	From 15 to 20 million	2.70
6	From 20 to 25 million	3.20
7	From 25 to 30 million	3.70
8	From 30 to 35 million	4.20
9	From 35 to 40 million	4.70
10	From 40 to 45 million	5.20

Table 1.4: Contribution factor for BWA operators

Sl.	Subscriber Base (lower limit inclusive & upper limit exclusive)	CF
1	From 0 to 200K	0.3
2	From 200 K to 400 k	0.4
3	From 400 K to 600 K	0.45
4	From 600 K to 800 K	0.0
5	From 800 K to 1000 K	0.55
6	From 1000 K to above	0.60

Table 1.5: Contribution factor for PSTN operators

Sl.	Subscriber Base (lower limit inclusive and upper limit exclusive)	CF
1	From 0 to 25 K	0.25
2	From 25 K to 50 K	0.30
3	From 50 K to 75 K	0.35
4	From 75 K to 100 K	0.40
5	From 100 K to 150 K	0.45
6	From 150 K to 200 K	0.50
7	From 200 K to 250 K	0.55
8	From 250 K to 300 K	0.60
9	From 300 K to 350 K	0.65
10	From 350 K to 400 K	0.70
11	From 400 K to 500 K	0.75
12	From 500 K to 1000 K	0.80
13	From 1000 K and Above	0.85

1.5.3 Other licence fees

Besides the spectrum fees, Table 1.6 shows the fees and charges that may apply depending on the licence.

Table 1.6: Fees and charges

Annual Licence Fee	Fixed fee (e.g. BDT 50 million for cellular mobile phone licensees)
Revenue Sharing	Applicable to mobile (5.5 per cent of annual audited gross revenue) and BWA operators (exempted for the 1st year, 2 per cent of annual audited gross revenue in the 2nd year and 4 per cent in each subsequent years)
Social Obligation Fund	3G operators are also required to pay 1 per cent of annual audited gross revenue to fund telecom infrastructure in underprivileged areas.

1.5.4 Cross-border frequency coordination

Bangladesh is a member of the South Asian Telecommunication Regulators Council (SATRC) which was formed in 1997 by an initiative of APT and ITU Regulatory Forum for South Asia. The SATRC is responsible for discussion and coordination of all the issues relating to regulations in telecommunication including radio frequency coordination, standards, regulatory trends and issues, strategies for telecommunication development and telecommunication related international affairs.

Bangladesh shares common borders with India and Myanmar but there are currently no formal frequency coordination activities between Bangladesh and its neighbours. However, as operators are expanding their coverage along the border areas, more interference issues are starting to emerge. BTRC is starting to engage its counterpart in India to discuss interference issues along the border areas.

1.5.5 Radio monitoring

BTRC has established a good radio monitoring unit with the necessary equipment and manpower. The main radio monitoring operations are located in Dhaka. In total, there are six fixed monitoring stations (FMS) with the remaining five located in Bogra, Khulna, Chittagong, Rangpur and Sylhet. Besides the fixed direction finders (DF), BTRC also maintains five mobile monitoring stations (MMS). Together, BTRC is able to monitor the frequency range from 0.5 MHz to 3 GHz.

The monitoring stations have been effective in helping resolve interference issues and to identify illegal use of frequencies. In 2012, BTRC conducted the first country-wide spectrum scanning to check the utilisation of the GSM 1800 MHz band and to look for illegal usage in the 3G band. Some illegal usage of frequency was detected in the northern part of the country and strong GSM and CDMA signals were also detected, coming from the neighbouring country. The monitoring capability is essential when performing border coordination.

1.5.6 Equipment type approval

There is currently no type approval framework in Bangladesh. To import radiocommunication equipment, a company first needs to obtain a Dealer Possession and Radio Communication Equipment Vendor Enlistment Certificate from BTRC. A dealer with this certificate needs to submit an application and the technical specifications to BTRC before bringing any equipment into Bangladesh. The BTRC spectrum department will ensure that the equipment conforms to internal guidelines. Once approved, BTRC will issue a No Object Certificate to the dealer to import the equipment.

BTRC is currently establishing its type approval framework. As a start, it is considering the implementation of type approval for mobile phones which are high in demand. BTRC issued a consultation paper in May 2014 on the type approval of mobile phones in Bangladesh and the final decision is still being worked through. The main objectives are to streamline the process for importers and allow new mobile devices to become available in Bangladesh more rapidly.

1.6 Key spectrum users

There are four main categories of service providers that have been assigned spectrum.

Mobile operators

There are currently six operators in Bangladesh offering mobile services with over 116 million mobile subscribers. Five of the operators offer 2G GSM services and they have rolled out 3G services after acquiring licences and spectrum through auction. Table 1.7 summarises the spectrum assigned to mobile operators.

Table 1.7: Spectrum assigned to mobile operators

Operator	Systems	Mobile Spectrum Assigned	Major Shareholders	Subscriber Base (M)
Grameenphone	GSM, UMTS, HSPA	64 MHz (7.4MHz x 2 of GSM900, 14.6 MHz x 2 of GSM1800 and 10 MHz x2 of 3G)	Telenor and Grameen Telelcom	50.5
Banglalink	GSM, UMTS, HSPA	40 MHz (5MHz x 2 of GSM900, 10MHz x2 of GSM1800 and 5MHz x 2 of 3G)	Vimpelcom	31.0
Robi Axiata	GSM, UMTS, HSPA	39.6 MHz (7.4MHz x 2 of GSM900, 7.4MHz x2 of GSM1800 and 5MHz x 2 of 3G)	Axiata and NTT Docomo	25.2
Airtel	GSM, UMTS, HSPA	40 MHz (5MHz x 2 EGSM, 10MHz x2 of GSM1800 and 5MHz x 2 3G)	Bharti Airtel	9.0
Teletalk	GSM, UMTS, HSPA	50.2 MHz (5.2 MHz x 2 of GSM900, 10MHz x2 of GSM1800 and 10MHz x 2 of 3G)	State-owned	4.6
PBTL	CDMA	17.64 MHz (8.82 MHz x 2 of CDMA 800)	Pacific Group & Far East Telecom Limited and SingTel	2.4

Besides Teletalk, which is a state-owned operator, the other five operators have significant ownership by foreign telecom operators. Whilst the total subscriber base is huge, 96.4 per cent of them are 2G subscribers and only 3.6 per cent are 3G subscribers. This means that the mobile networks are currently carrying large amounts of voice minutes while the data traffic remains relatively low by international standard. This is partly because the 3G services are fairly new in Bangladesh since mobile operators (except Teletalk) secured their 3G spectrum only in September 2013. With a relatively low fixed phone line penetration, mobile has become the main means of communication for most people in Bangladesh.

Broadband wireless access operators

There are three broadband wireless access (BWA) operators (Augere, Banglalion and BIEL) offering wireless broadband using WiMAX technology.

Table 1.8: Wireless broadband using WiMAX

Operator	Systems	Mobile Spectrum Assigned
Augere	WiMAX	35 MHz of 2.3GHz band
Banglalion	WiMAX	35 MHz of 2.5GHz band
Robi Axiata	WiMAX	40 MHz of 2.5GHz band

BWA auction was carried out in 2008 way ahead of the 3G auction. Despite having a head start in deploying the networks, the total BWA subscriber base remains much smaller (less than 1 million) than the total 3G subscribers.

PSTN operator and Internet service providers

There are several PSTN operators and ISPs in Bangladesh that have been assigned spectrum to offer phone and Internet services in areas where there is a lack of fixed line infrastructure. These operators occupy spectrum in the 800MHz and 3.5GHz bands.

1.7 Current spectrum assigned

Table 1.9 summarises the spectrum allocated for delivering commercial services. These spectrum bands are mostly assigned to mobile, BWA, ISP and PSTN operators.

Table 1.9: Spectrum allocated for commercial services

Spectrum Band	Total Bandwidth	Spectrum Assigned	Spectrum Available
700 MHz	108 MHz	Spectrum being re-farmed for future reallocation	Will be available in the near future
800 MHz	40 MHz	Mostly assigned to two mobile operators (CDMA and GSM) and PSTN operators	Mostly assigned; but not efficiently used
900 MHz	50 MHz	70MHz assigned to four mobile operators	Fully assigned
1800 MHz	150 MHz	128.8 MHz assigned to five mobile operators, one ISP and one government user	21.2 MHz unassigned
1900 MHz	20 MHz	Assigned to PSTN operators	Bands are occupied by PSTN operators and not available for further assignment
2100 MHz	120 MHz for FDD and 25MHz for TDD	70 MHz assigned to four mobile operators through an auction	50 MHz FDD and 25 MHz TDD spectrum unassigned
2300 MHz	100 MHz	35MHz assigned to one BWA operator through the BWA auction; and 18 MHz assigned to an ISP	47 MHz unassigned

Table 1.9: Spectrum allocated for commercial services *(end)*

Spectrum Band	Total Bandwidth	Spectrum Assigned	Spectrum Available
2500 MHz	190 MHz	90 MHz assigned to two BWA operators and one government user	100 MHz unassigned
3500 MHz	200 MHz	Assigned to ISPs	Band is occupied by ISPs and not available for further assignment

1.8 Industry consultation

Following stakeholder consultation, mobile and BWA operators gave their views on the following issues:

- Whilst operators were keen to offer mobile broadband services, they were taking a more cautious approach. There is demand for mobile broadband in pockets of Dhaka where people own smart mobile devices, have the buying power, and expect broadband speeds of between 1.5 Mbit/s and 2 Mbit/s. However, outside these areas, the business case for mobile broadband is still limited and 3G/HSPA and BWA services have not taken off. The lack of low-cost smartphones and content was also cited as a reason for the low adoption. This being the case, operators had been careful in their mobile broadband investments and they had not acquired the entire 3G spectrum offered during the auction. Operators also highlighted that the 3G auction was held too close to the 2G renewal, which had some impact on their appetite to invest in more spectrum resources.
- Notwithstanding the above, operators expected the demand for mobile broadband in the longer term to increase due to the lack of fixed telecom infrastructure. Bangladesh has less than 10 million fixed phone lines, which makes it difficult to offer fixed broadband (based on digital subscriber line or DSL) to households. Using wireless technology therefore becomes a more cost-effective and efficient way to deliver Internet services to the masses. As mobile Internet becomes more widely available and consumers use the Internet for more applications, the demand for network capacity and spectrum will rise.
- Operators had jointly performed an analysis using the ITU tool to estimate the spectrum required to support the long term demand. Preliminary estimation suggests that a total bandwidth of 1800MHz would be required by 2020. In addition, different bands would be required for in-building coverage, high density urban areas, and rural areas.
- Dhaka in particular is highly built-up, and providing good indoor coverage has been a challenge for operators. The current approach is to raise the transmitting power to provide coverage but this is also raising some concerns around potential health issues. Wi-Fi offloading is not feasible due to the lack of backhaul circuits.
- There is also currently overbuilding of cell towers because operators do not see the benefits of sharing infrastructure. Since it is relatively easy to obtain approval to erect a new tower, operators are more inclined to reserve space for future requirements than to offer space to competitors.
- Operators welcomed the development of a long term spectrum master plan/roadmap to provide greater transparency of spectrum allocation and certainty in terms of spectrum availability. Certainty in spectrum availability is crucial for operators' internal forecasting and planning for Capex investment. Operators were also prepared to discuss spectrum management issues. For example, operators could play a greater role in assisting BTRC in forming Bangladesh positions for WRCs.
- Operators also suggested that some frequencies assigned had not been used and these frequencies should be recovered and reassigned to other parties with greater needs.

A questionnaire was also sent to operators and the responses are summarised in Table 1.10.

Table 1.10: Questionnaire and stakeholder responses

BTRC interaction with the industry	
Q1. How frequently does your organisation engage BTRC regarding frequency management issues?	The responses are not uniform. Some operators met BTRC more regularly, but others interacted with BTRC on an ad-hoc basis particularly when they encountered interference issues.
Q2. Does BTRC consult sufficiently with stakeholders regarding spectrum management issues? When there is consultation, are you happy with the process?	In general, respondents were supportive of the BTRC move towards a more consultative approach for different regulatory issues including spectrum management. Some examples highlighted included the development of the NFAP and spectrum pricing. However, there was a comment suggesting that BTRC was not fully transparent because after consulting with the industry, the regulator did not communicate effectively the rationale of its final decision resulting.
Q3. Does the BTRC make information regarding spectrum issues easily available and in a format that you can understand?	Respondents requested for greater transparency and more information on spectrum allocation and spectrum management policies to be made publicly available.
Frequency / spectrum requirements	
Q4 .What are your current and future spectrum requirements? Please indicate the frequency bands, the purpose and amount of spectrum needed by 2020. Please also indicate the methodology and assumptions in estimating your spectrum requirements.	Respondents indicated a need of between 10MHz x 2 to 20MHz x2 by 2020. All of them have indicated the preference to have spectrum in both above and below 1GHz; using spectrum below 1GHz for coverage and above 1GHz for capacity. Demand for mobile broadband will the key driver for the need for more spectrum resources.
Q5. Do you have sufficient spectrum to meet your current needs? If not, how much spectrum (and in which bands) do you need to meet your short-term needs?	Two of the respondents have indicated the need for more spectrum to meet the immediate needs, mainly to improve quality of service (QoS) and to increase capacity in high density sites.
Q6. If BTRC introduces technology neutrality today, how would it impact your network planning and services offering?	In general, respondents agreed that technology neutrality promotes more efficient use of spectrum. This approach gives operators flexibility to use the spectrum and allows them to plan their network and spectrum utilisation in advance. For example, technology neutrality would allow mobile operators to re-farm their 2G spectrum and use it for mobile broadband, either HSPA or LTE. However, spectrum assigned to mobile operators is currently technology specific and mobile operators do not have plans how to use their spectrum for other technologies.

Q7. In your opinion, does the current BTRC spectrum management practice encourage the efficient use of the radio spectrum? If not, why and how can it be improved?	Respondents have given a few suggestions to ensure more efficient use of radio spectrum and these include: • In assigning the remaining spectrum in bands such as 1800MHz and 2100MHz, greater spectral efficiency can be gained when operators are assigned contiguous spectrum. • There is a need to monitor the utilisation of spectrum and apply the use it or lose it principle. • Allocate spectrum to the highest value use or uses. • Enable and encourage spectrum to move to its highest value use of uses. • Use the least cost and least restrictive approach to achieving policy objectives; and promote consistency, predictability and transparency in decision-making • Balance the cost of interference and the benefits of greater spectrum utilization.
Frequency assignment process	
Q8. Are you satisfied with the process that the BTRC uses to make spectrum available for different radio services in Bangladesh? If not, please share your concerns.	Key issues highlighted by respondents include: • Proactive monitoring for spectrum utilisation is crucial to detect any unauthorised usage. • There is lack of clarity on the process of spectrum assignment and reasons for adopting different processes for different services/licence categories. • Whilst respondents agree with the spectrum auction approach, they were not clear how the base price was formulated.
Q9. What changes would you like to see in the process, if any?	Suggestions on how to improve the current frequency assignment process include: • Publish the processes for making spectrum available for different services, including both market-based approach and administrative process. • Review restrictions (associating spectrum to specific service or technology) to enable more efficient use of spectrum • Develop a spectrum roadmap / release plan to give the industry greater certainty and transparency in terms of spectrum availability • Re-farm under-utilised frequencies • Develop spectrum sharing arrangements to maximise spectrum usage in border areas

Future directions	
Q10. What is your view on TV white space, spectrum sharing (licensed shared access and dynamic spectrum access) and spectrum trading? Do you think BTRC should promote these methods to improve the utilisation of spectrum?	Respondents agreed that spectrum sharing and spectrum trading would promote better utilisation of spectrum resources. Different sharing methods including DSA, LSA and national roaming can be considered.
Q11. Are there radio services that you would like to offer in Bangladesh that require spectrum that is not currently available for use?	Mobile operators are following closely the IMT roadmap and more spectrum will be required when the local market is ready for faster connectivity such as LTE and LTE-Advanced. One BWA operator also highlighted the need for microwave frequencies for point-to-point backhaul.
Q12. Have you considered using alternative technologies to reduce your reliance on radio spectrum?	Technologies being considered include fibre optic transmission to reduce the reliance on microwave links as well as Wi-Fi and wired broadband to offload mobile traffic.
Q13. Are there any changes that you would like to see in the way that the BTRC manages spectrum in Bangladesh in the short term? What changes would like you to see in the mid to long term, if any?	Respondents have asked for changes in the following areas: • Review the current spectrum pricing to consider market dynamics, business viability, usage, socio-economic development and serving the masses. • Develop a roadmap that indicates the spectrum bands to be made available and the release timeline • Consider allowing technology and service neutrality • Consider allowing spectrum trading • Review the current interference management processes
Q14. What other issues would you like BTRC to consider in forming the Spectrum Master Plan?	Suggestions from respondents include: • Adopt a process to review the spectrum master plan / roadmap on a regular basis (e.g., yearly review). • The determination of spectrum release should take into consideration market demand, affordability index, breakeven point of investment and the gap between two consecutive allocations. • Spectrum monitoring process and spectrum allocation strategy details should also be made available.

1.9 Inputs from BTRC stakeholders

BTRC is aware of key issues raised by the operators and a few initiatives are already in motion.

- **Quality of service (QoS):** The key challenges for any wireless operator are to ensure that the network has sufficient capacity and coverage to offer high QoS. To achieve this, operators need to invest in more base stations and/or acquire more spectrum resources from the regulator. In Bangladesh, the general perception is that QoS is poor (e.g., high drop call rate and poor indoor coverage) but operators have been slow in putting the right amount of investment to achieve better QoS. As part of the licence conditions, operators have the obligation to meet the QoS standards/guidelines set by BTRC. BTRC recognises the importance of pushing operators to deliver better QoS and has equipped itself with the necessary tools to gather data on QoS. The regulator is assessing the right approach to encourage operators to improve service standards whether through regulatory measures or build consumer awareness through the publication of QoS statistics.
- **Infrastructure sharing:** There is limited site sharing resulting in duplication of infrastructure. BTRC has issued the guidelines for infrastructure sharing to optimise the utilisation of land space and existing infrastructure, and to promote competition by reducing the entry cost for new entrants. The guidelines currently cover only passive infrastructure including physical sites, buildings, shelters, towers/masts, power supply, grounding, air conditioning, security, poles, ducts, trenches, in-house wiring, sub-loop and local loop. However, operators have been refusing to share infrastructure on grounds of insufficient capacity. The challenge for BTRC is to tighten the guidelines to encourage sharing. When operators are pushed to deliver better QoS, the access to sites become more critical and if the approval for new sites is costly and difficult, they become more motivated to work with each other to share infrastructure, even beyond passive elements.
- **Backhaul transmission:** The availability of a robust backhaul transmission network is crucial for connecting mobile base stations. This will become more critical when operators start to deploy small cell technology. To avoid further proliferation of cluttered and hazardous overhead optical cables, BTRC has issued Nationwide Telecommunication Transmission Network (NTTN) licences to Fibre@Home and Summit Communications to be the main providers of transmission networks. Both NTTN licensees are expanding their fibre footprint across the country.
- **Re-farming of spectrum:** Some ISP and PSTN licensees are not using the frequencies assigned to them but they have been unwilling to give up the frequencies. There have been cases where these licensees managed to hold on to their frequencies after they appealed to the BTRC on grounds that they had plans to deploy the frequencies. BTRC is looking into recovering frequencies from users and it needs to develop an effective re-farming strategy (e.g., through spectrum pricing) to maximise spectrum utilisation.
- **Focus is on commercial demand:** Government agencies have sufficient frequency spectrum for their short to medium term requirements. BTRC is therefore placing greater focus to ensure the commercial sector has sufficient spectrum to support increasing demand for wireless services. Whilst there are national projects (e.g., Dhaka Metro Rail) that require spectrum for internal communications systems, BTRC will be looking for spectrum bands that are less congested and not identified for commercial services (e.g., IMT).
- **Capacity building:** Stakeholders have also raised the need for structured training to equip spectrum managers with the knowledge to better develop spectrum management practices and policies. BTRC will work with ITU to leverage ITU centres of excellence and spectrum management workshops to provide spectrum managers with the opportunity to gain knowledge on telecom policies, regulations and best practices.

1.10 Conclusions

With a large population and significant mobile penetration, the demand for radio spectrum is expected to greatly increase in years to come. The low fixed line and Internet penetration means greater opportunities for consumers to adopt mobile services for both voice communications and access to the Internet.

There is a consensus amongst stakeholders in BTRC and industry players that developing a spectrum master plan is essential. BTRC and industry players agree that a roadmap will provide greater transparency in spectrum management and will offer operators some certainty in terms of spectrum availability.

The development of the spectrum master plan should take into consideration the following:

- International best practices in spectrum management including the economic aspects of spectrum regulation such as spectrum trading and other market mechanisms.
- Current spectrum management processes that could be improved including the technology and service neutrality, spectrum sharing, frequency assignment processes, interference resolution processes and coordination processes.
- A process to assess the demand for spectrum for commercial services.
- Policy in respect of non-commercial use.

2 Spectrum management master plan

2.1 Introduction

The purpose of the Spectrum Master Plan for Bangladesh is to help to coordinate spectrum management activities in a structured and transparent manner. It has been developed by analysing international best practices in spectrum planning and charting a future roadmap for spectrum allocation between 2015 and 2020. This roadmap gives an indication of key work activities BTRC should undertake to meet future demand for spectrum.

Wireless technology is evolving rapidly and spectrum management practices need to be adjusted to meet the changing market demand. Section 2.2 highlights global trends around spectrum management practices in view of the changes in wireless technologies.

Section 2.3 of the report looks at the current spectrum utilisation and future spectrum demand for various radio-communications services. Section 2.4 translates the future demand into a list of activities BTRC can consider undertaking to ensure that changes to spectrum allocation are made in a timely manner. The publication of the spectrum roadmap helps commercial operators with their network planning investments.

Section 2.5 provides key recommendations and action items that BTRC can consider to enhance its spectrum management framework.

2.2 Global trends in spectrum management

2.2.1 Spectrum master plan document

To ensure that consumers and businesses have access to new wireless technologies, it is fundamental for the regulator to develop an up-to-date and flexible spectrum management system. This is becoming more challenging due to the pace that technology is developing; and changes to spectrum management framework and allocation often need a considerable amount of time to take effect. It is also in the interest of the regulator to ensure that the industry remains competitive and service providers are motivated to introduce innovative services to the market.

Hence, it is necessary to look ahead and consider the future of spectrum management so that new services can be introduced in a timely manner and that existing users have sufficient time to upgrade/ migrate to alternative technologies. Regulators around the world are working closely with industry players and their international counterparts to anticipate the emergence of new technologies and make necessary changes to spectrum allocation. This will give industry players sufficient time for planning, capital budgeting and implementation.

Some regulators have put forth a long-term spectrum management planning document to provide greater transparency in their thinking, highlight new opportunities and use it as a platform for engaging various stakeholders. Some of the examples are:

- Australia Communications and Media Authority (ACMA) – Five-year spectrum outlook 2013 – 2017;
- Industry Canada – Commercial Mobile Spectrum Outlook;
- Information and Communications Authority of Singapore (IDA) – Radio Spectrum Master Plan;
- Ministry for Communications and Information Technology New Zealand – Radio Spectrum Five Year Outlook 2012 – 2016.

Besides documenting the potential spectrum allocation for the next few years, any changes to spectrum management framework should also be covered.

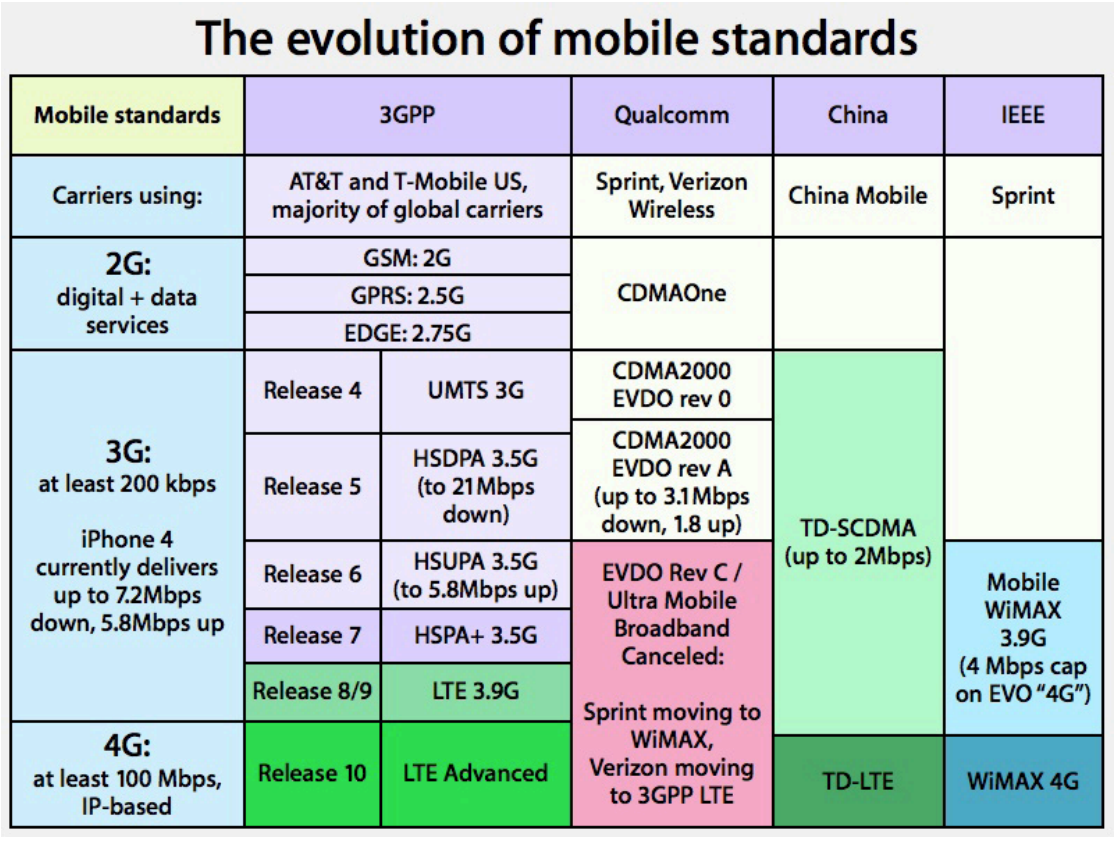
Wireless technology is rapidly evolving and spectrum management practices need to keep up with time. Over the past decade, we have seen the mass adoption of mobile services around the world, usage of mobile services shifting from voice communications to mobile broadband, and several upgrades of mobile networks to offer better service quality.

Regulators have adopted approaches to introduce some flexibility in spectrum management. The enhancement of wireless technology is also enabling better spectrum sharing and improving efficiency. Some of the spectrum management and technology trends are covered in the following subsections and regulators need to formulate their stance on these issues at some point.

2.2.2 Technology neutral regulation

Flexibility in spectrum management and access to spectrum can be increased through technology and service-neutral authorisations to let spectrum users choose the best technologies and services to apply in a frequency band. This is increasingly becoming common and administrative determination of technologies and services should become the exception and should be clearly justified. In some countries, technology neutrality is often applied to spectrum bands that are auctioned (or under spectrum rights framework) to commercial operators. The regulator specifies the emission criteria instead of the technologies that can operate in the spectrum bands.

Figure 2.1: Mobile standards



Source: ITU

The technology-neutral approach incentivises network operators to adopt the most spectrally efficient technology. Particularly for mobile communications, operators have different technology options to choose from (e.g., 2G, 3G CDMA, LTE, WiMAX as shown in Figure 2.1) and they should be given the flexibility to adopt the technology based on commercial considerations. With technology neutrality, some operators who were facing spectrum crunch proactively migrated customers to 3G

and redeployed spectrum used for 2G for new mobile broadband services. Moreover, some mobile operators have already re-farmed their 1800MHz spectrum for the deployment of LTE.

LTE is a more efficient technology to carry mobile data traffic and it helps operators to reduce the cost per megabyte of mobile traffic. Moreover, with voice over LTE (VoLTE), operators can further lower their cost by offering both voice and data using the same technology instead of maintaining a circuit-switched network for voice and an IP network for data. This being the case, operators are expected to embrace LTE and where possible, redeploy existing spectrum for LTE implementation.

Mobile technology continues to evolve and operators are expected to use carrier aggregation to enhance the data speeds and to use a mix of FDD and TDD technologies to achieve the desired network performance. The flexibility in spectrum usage thus becomes more crucial for operators to plan their network upgrade.

2.2.3 Spectrum trading

Spectrum trading is a mechanism whereby rights and any associated obligations to use spectrum can be transferred from one party to another by way of a market-based exchange for a certain price. In a spectrum trade, the right to use the spectrum is transferred voluntarily by the present user, and a sum is paid by the new user of the spectrum which is retained, either in full or in part, by the present (transferring) user. Spectrum trading can either be a full transfer or it can be leased for a defined period of time and for a particular area, while the ownership and obligations remain with the original spectrum rights holder.

Spectrum trading contributes to more efficient use of frequencies because a trade will only take place if the spectrum is worth more to the new user than it was to the old user, reflecting the greater economic benefit the new user expects to derive from the acquired spectrum. These efficiency gains will not be realized, however, if transaction costs are too high and one of the aims of any spectrum trading regime should be to keep down transaction costs. After all, the goal is to facilitate transfers by establishing a swift and inexpensive mechanism. If neither the buyer nor the seller behave irrationally or misjudge the transaction, and if the trade does not cause external effects (e.g., anti-competitive behaviour or intolerable interference), then it can be assumed that spectrum trading contributes to greater economic efficiency and boosts transparency by revealing the true opportunity cost of the spectrum.

Some advanced markets like the United States, the United Kingdom, and Australia have implemented spectrum trading. However, operators may have to get regulator consent before finalising the trade. This is deemed necessary particularly for mobile spectrum since the regulators need to ensure that operators with financial muscles are not hindering competition by acquiring too much spectrum and denying competitors access to spectrum.

In Australia, mobile operator Optus entered into an agreement in 2010 to purchase 3G spectrum licences from 3G Investments (Australia) Pty Limited, a wholly owned subsidiary of Qualcomm. The spectrum licences are for 10MHz of paired spectrum in the 2100MHz band in eight regional capital cities in Australia. The transaction enabled Optus to boost its network capacity to support growing mobile broadband which creates greater economic value than being tied up by the incumbent. In the United Kingdom, Everything Everywhere (the merger of T-Mobile and Orange) sold part of its 1800MHz spectrum to mobile operator Three UK. Everything Everywhere made the commitment to sell part of its spectrum to gain the merger approval from the regulator (to ensure that the merged entity did not have unfair advantages over its competition).

2.2.4 Spectrum sharing

There are emerging technologies that are enabling more efficient use of spectrum, either limiting the power to avoid interference to primary users, or tapping into spectrum that are unused at a given time and location. Different levels of coordination may be required for the introduction of spectrum sharing. Ultra-wideband (UWB), software-defined radio (SDR) and cognitive radio are technologies that will enable greater spectrum sharing amongst different users thereby promoting spectrum efficiency.

Software-defined radio systems are implemented on general purpose hardware where specific operational characteristics are implemented by software. Different radio systems and standards are essentially loaded as software programmes (e.g. a GSM programme or a Wi-Fi programme). A radio increases its flexibility as more of its functionality is software based. Cognitive radios on the other hand can be programmed to detect and use the frequency channel in its vicinity that is not in use.

a) Ultra-Wide Band technology

Ultra-Wide Band (UWB) is an active underlay technology, transmitting signals that spread over a large bandwidth (>500MHz). Operating at very low signal levels, UWB emissions appear as noise floor to narrowband radio systems, allowing UWB devices to operate underneath existing services. UWB technology is typically used to transmit large amounts of data over a short distance (<15m). Some applications include high speed home networking, wall or ground penetrating radars, and automotive radar.

However, turning on more UWB devices will result in a rise in the overall noise floor experienced by their systems. Existing spectrum users are therefore concerned that the rise in noise level will reduce their S/N (signal to noise ratio) margins and affecting the performance of existing systems. The concerns expressed by operators of existing radio-communications services led to significant work in ITU-R to update the protection requirements for existing services and to develop a framework for the introduction of UWB technologies that would protect existing services. To address UWB issues, ITU-R created Task Group (TG1/8), which completed its work without endorsing a common emission mask. However, TG1/8 developed key recommendations for administrations to consider when developing their framework for introducing UWB technology. Key documents produced include:

1 Report SM. 2057 presents UWB compatibility studies.

2 ITU-R SM.1754 recommends measurement techniques for generating UWB signals with various modulation and randomisation schemes. This document includes both frequency domain and time domain measurement techniques of the PSD of UWB transmissions for all UWB signal types.

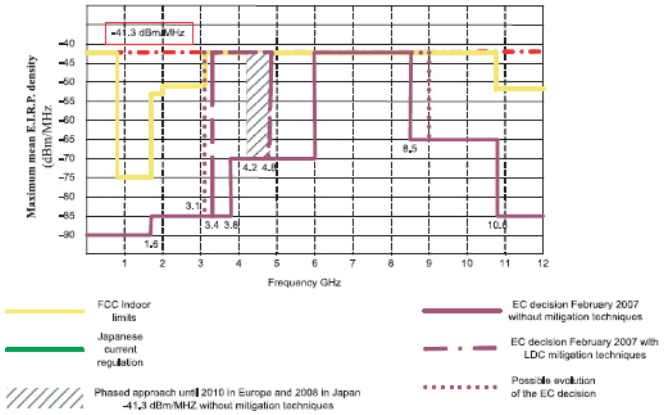
3 ITU-R SM.1755 recommends the general characteristics of UWB technology.

4 ITU-R SM.1756 recommends the framework and provides guidance to administrations considering the introduction of devices using UWB technology.

5 ITU-R SM.1757 recommends methodologies that assess the impact of UWB devices on systems operating in the spectrum band concerned. It includes a summary of both theoretical analyses and measurement studies carried out in the laboratory and in the field.

The setting of emission standards remains largely a national issue. Several administrations have allowed UWB devices and introduced emission standards by referencing the US Federal Communications Commission (FCC) or Europe ECC standards (see Figure 2.2). In the Asia-Pacific region, countries such as Australia, Japan, Korea, New Zealand and Singapore have introduced UWB technology.

Figure 2.2: Emission masks



Source: ITU

b) Light licensing

Light licensing is a way to minimise regulatory intervention and it removes the need for the regulator to coordinate frequency assignment. Instead, an automated notification and frequency assignment process is set up to allow users to register for a frequency via an online system. The system will perform an interference assessment and inform the user whether the registration is successful or not.

Light licensing is different from licence-exempt since the users still need to go through the registration process and pay a fee. The spectrum band under this approach is still controlled and there is a limit to the number of users within an area. An example of this is the Managed Spectrum Park introduced in New Zealand[4] for the 2.5 GHz band (2575 – 2620 MHz). The registration is to be performed by an Approved Radio Engineer and there is a requirement for the user to implement services within two years of allocation to ensure efficient use of spectrum. Another example is the use of 5.8GHz band in the United Kingdom[5] for fixed wireless access (FWA) services that are operating at higher power than other licence-exempt applications. Similarly, a minimum payment and registration are required.

The light licensing approach is suitable for spectrum bands that can be shared by multiple users and their protection can be established by simple analysis methodology.

c) Dynamic spectrum access

Dynamic spectrum access (DSA) enables a radio device to operate in spectrum that is not being used in a particular area, at a particular point in time. The development of cognitive radios is making this spectrum sharing possible and it can significantly increase the efficiency of spectrum. A cognitive radio is to some degree aware of the environment by monitoring transmissions across a wide bandwidth, noting areas of unused spectrum and is able to modify its transmission using appropriate modulation and coding methods. From a user standpoint the certainty of finding unused spectrum in congested areas may fall low enough to impair its usefulness as a mainstay communications device.

TV white space (TVWS) is a form of DSA and is currently being deliberated by regulators. Particularly for analogue TV broadcast, spectrum is allocated exclusively to the broadcasting services but they may not be used all the time in all locations. In some areas, TV channels are unassigned to avoid interference, or channels may be assigned for low power, localised broadcast. There are opportunities therefore for other applications to tap into the unused TV spectrum. For example, white-space devices (WSDs) are being developed to use underutilised bands to provide broadband services in rural/remote areas where spectrum is generally less congested.

4 Managed Spectrum Park by the New Zealand's Ministry of Business, Innovation and Employment: www.rsm.govt.nz/cms/licensees/types-of-licence/managed-spectrum-park

5 fcom: http://licensing.ofcom.org.uk/radiocommunication-licences/fixed-wireless-access/

However, since cognitive radios are not fully mature, regulators that have allowed the use of WSDs have put in place some coordination rules to ensure existing services are not affected. These rules should include detailed technical specifications for WSDs, protection criteria for existing services and a database providing information on which spectrum bands can be shared with WSDs. WSDs must have geo-location capability and provide location information to the national database which will return a list of channels that the WSDs may operate. WSDs may also be required to have adaptive power control to use the minimum power. Database providers also need to be authorised by the regulators. The primary users are not aware the number of secondary WSDs that are operating but they are assured protection in locations where they are using the spectrum.

d) Licensed spectrum access

The development of SDR and cognitive technology is also paving the way for the implementation of licensed spectrum access. The European Union Radio Spectrum Planning Group (RSPG) defines the LSA concept as:

"An individual licensed regime of a limited number of licensees in a frequency band, already to one or more incumbent users, for which the additional users are allowed to use the spectrum (or part of the spectrum) in accordance with sharing rules included in the rights of use of spectrum granted to the licensees, thereby allowing all the licensees to provide a certain level of QoS."

Some spectrum bands are allocated exclusively for specific services but they may not be used all the time and in all geographical areas. Unlike the TV white space and UWB, a new proposition is to enable incumbent and new users (LSA licensees) to fully coordinate the use of spectrum. LSA licenses are required to negotiate with the incumbent on the rights and guarantees for the use of spectrum. For example, a LSA licensee may negotiate a commercial arrangement with the incumbent to allow the LSA licensee to transmit at a given period of time and to get the assurance that the incumbent will not interfere during this time period. In this case, more spectrum resources become available and incumbents are incentivised to offer underutilised spectrum.

There have been interests in applying LSA for spectrum bands such as 2.3GHz and 3.5GHz. These bands have been identified for mobile broadband but they can be occupied by non-mobile incumbents. The incumbents may include many government users who are not using the spectrum everywhere in the country so there is a potential for mobile operators to negotiate with the incumbents to access spectrum for mobile broadband deployment.

In the US, exchanges such as Cantor Spectrum & Tower Exchange allow the private and public sectors to buy, sell and lease licensed radio frequency spectrum rights. This is a transparent platform enabling spectrum rights owners to offer their assets on the system for interested parties to evaluate the assets and make a bid on them.

e) Pluralistic licensing

Pluralistic licensing provides a middle ground between exclusive licensing and licence-exempt usage. This licensing scheme requires licences to be awarded under the assumption that opportunistic secondary spectrum access will be allowed, and that interference may be caused to the primary spectrum access with parameters and rules that are known to the primary at the point of obtaining the licence.

Under this arrangement, the primary licence holder accepts from the outset the risk of interference that may be later caused by secondary users sharing the same band. However the licence holder still enjoys the priority right in accessing the band. The licence holder also benefits by paying a lower licence fee by accepting the interference risk. As an example, the pluralistic licensing can enable licence-exempt cognitive radio deployment in a spectrum band awarded to a mobile operator who has accepted this arrangement.

2.2.5 Spectrum requirements for the public sector and government agencies

The demand for mobility and faster mobile broadband is not confined to general public. Government agencies are also looking at leveraging wireless technologies to improve operational efficiency and raise workforce productivity.

The defence organisations in most countries tend to be the largest users of spectrum and they therefore have a strong influence on spectrum demand. In the area of public protection and emergency services, applications such as real-time intelligence and real–time CCTV feeds are becoming common. Free-to-air public broadcasting is also generally considered as serving national interest and broadcasting spectrum is in some cases managed by a separate government body.

Other government organisations such as the transport authorities are exploring intelligent transport systems (ITS), leveraging wireless technology for better traffic management (toll collection systems), information (traffic and parking information), security (speed cameras, auto number plate recognition) and road safety (collision avoidance system).

Some countries (e.g., China, Korea and Singapore) are also looking at sustainability and developing smart cities using various technologies. The notion of smart cities necessitate the deployment of large number of sensors to gather data from parking meters, waste bins, street lights etc. Utilities administrators are also considering the deployment of smart meters to monitor the electric system more efficiently and to introduce dynamic pricing.

While these non-commercial wireless systems are generally deployed to support national interests, there is a need to ensure that the spectrum is used efficiently. Some of these applications can be supported by commercial services and this should be encouraged. Since some of the spectrum may not be used all the time, there is potential for allowing other users to access the spectrum allocated to government agencies through spectrum sharing arrangement as explained in section2.4. Since government users are key spectrum stakeholders, they should be consulted and engaged in the spectrum planning process. For example, regulators often involve other government agencies for border coordination and international spectrum activities such as WRCs and related preparatory meetings.

2.3 Future demand for spectrum

2.3.1 Mobile cellular services: Mobile broadband

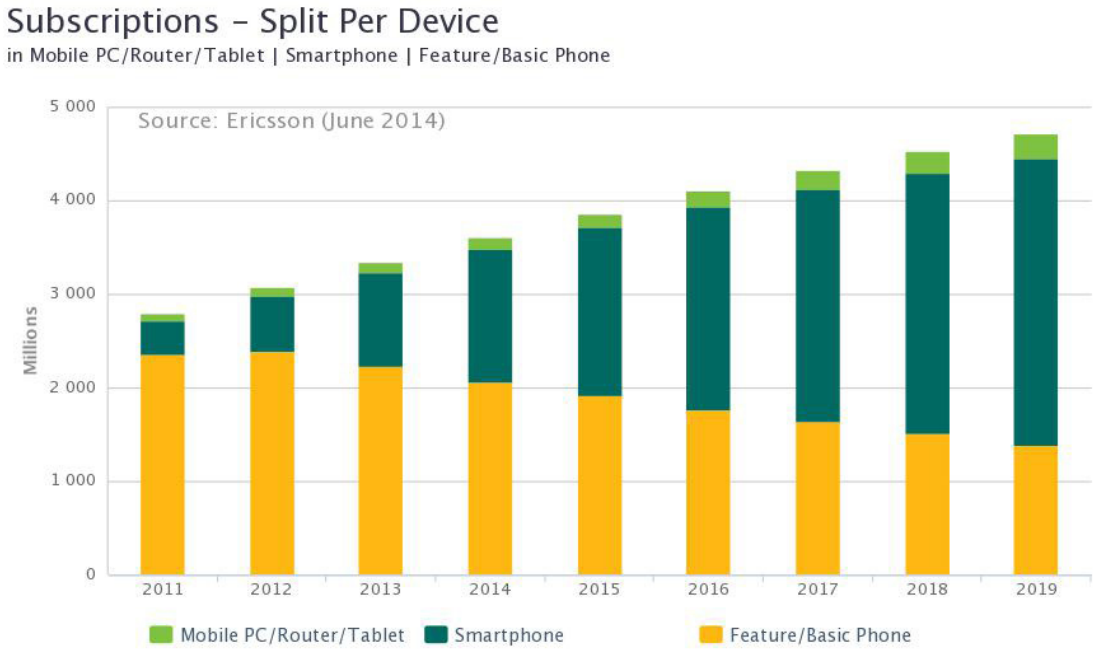
Demand for commercial cellular services has grown rapidly in Bangladesh in recent years. In Bangladesh mobile phones are the primary means of communication for over two thirds of the population. The affordability both in terms of subscription charges and devices is driving the adoption of mobile services. Globally, the total number of mobile connections has exceeded 7 billion[6] and the number continues to rise. In many countries, mobile penetration has already exceeded 100 per cent (e.g., Hong Kong (China) was 236.2 per cent[7] in July 2014, and Singapore was 156 per cent[8] in December 2013). As the demand for mobile services continues to grow, there is also a shift from mobile voice to mobile broadband/data services.

The demand for mobile broadband services is fuelled by the innovation around smart mobile devices (smartphones and media tablets) that are based on the Apple iOS or Android platform. The enhancement of the mobile network – from 3G to HSPA to LTE and now to LTE-A – have also made it compelling for consumers to stay connected anytime, anywhere. More importantly, the concept and the development of the app store have resulted in many apps that are available either at little or no cost. The introduction of media tablets and PC dongles further generates the demand for mobile broadband services. Based on the Ericsson Mobility Report, Figure 2.3 shows that there are already

[6] Source: GSMA Intelligence – mobile connections including M2M
[7] Source: Office of the Communications Authority, Hong Kong
[8] Source: Infocomm Development Authority of Singapore

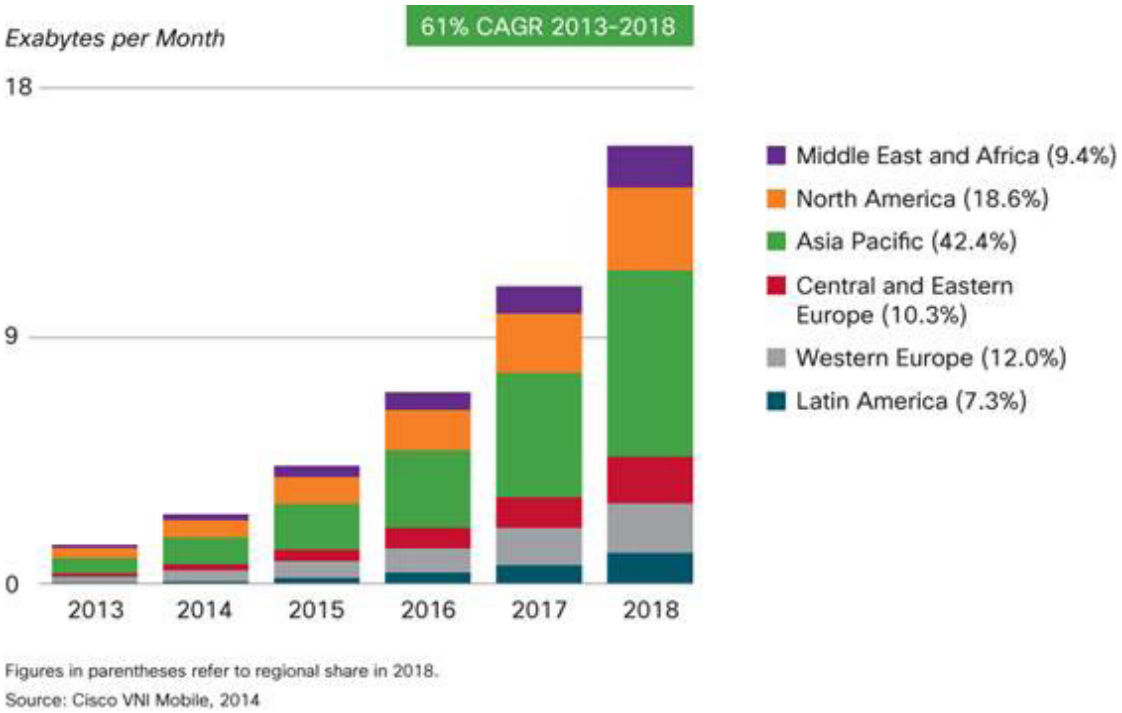
a significant proportion of smart devices users in Asia-Pacific region and the penetration is forecast to grow strongly over the next five years.

Figure 2.3: Rising penetration of smart mobile devices



Source: Ericsson

Figure 2.4: Strong growth in mobile traffic in Asia Pacific



Source: Cisco

As a result, many smartphone users now have multiple apps on their devices and they use mobile data for various activities such as updating social media, watching video, access location-based services, and so on. Based on the Cisco Visual Networking Index (February 2014), mobile data traffic in Asia Pacific is forecast to grow 13-fold from 2013 to 2018 reaching 6.7 Exabytes per month (equivalent to 1 679 million DVDs each month). Figure 2.4 illustrates the strong traffic growth anticipated in Asia Pacific. Mobile data traffic will account for 15 per cent of Asia Pacific network traffic (fixed and mobile) by 2018, up from 3 per cent in 2013. A significant part of the traffic growth will come from video content, which already accounted for over 50 per cent of mobile traffic in 2013. The increasing usage of machine-to-machine (M2M) is also expected to contribute to traffic growth.

The growing demand for mobile broadband however is causing a challenge to mobile operators. Mobile networks need to offer faster and more reliable connections and yet mobile operators do not have unlimited amount of spectrum to offer the services. To meet the growing demand for mobile data, equipment vendors, device makers and mobile operators need to develop technologies to ensure that are spectrally more efficient. Several mobile operators around the world have deployed LTE and a few of them have also signalled the intention to deploy LTE-A. For example, Telstra announced in September 2014 that it had launched LTE-A and by using carrier aggregation, combining 700 MHz and 1800 MHz, the operator was able to achieve speeds over 200 Mbit/s. Telstra has also achieved network speeds of 450 Mbit/s using carrier aggregation by combining 1800 MHz and 2600 MHz spectrum. To help operators maximise their spectrum resources, vendors such as Qualcomm are also developing multimode (TDD and FDD) LTE solutions.

The discussion and development of the next generation (5G) is already underway. Manufacturers are aiming to deliver 5G products in 2020 that will support network speeds of over 1Gbit/s. The demand for mobile broadband services and faster mobile networks are driving greater demand for spectrum. At the international level, work is underway to identify additional spectrum allocations for mobile services. This is covered under WRC 2015 Agenda Item 1.1:

Agenda Item 1.1 – to consider additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for International Mobile Telecommunications (IMT) and related regulatory provisions, to facilitate the development of terrestrial mobile broadband applications, in accordance with Resolution 233 (WRC - 12)

Table 2.1 shows the spectrum requirements in 2020 estimated by ITU-R WP 5D for RATG1 (pre-IMT, IMT-2000) and RATG2 (IMT-Advanced).

Table 2.1: Total spectrum requirements in the year 2020 calculated by ITU-R WP 5D

	Spectrum requirements		Total spectrum requirements
	for RATG 1	for RATG 2	
Lower user density settings	440 MHz	900 MHz	1 340 MHz
Higher user density settings	540 MHz	1 420 MHz	1 960 MHz

Ultimately, the demand for spectrum depends on operators' business models and consumers' consumption pattern. Globally, operators are staying away from unlimited usage to avoid network congestion. In this case, consumers are likely to switch to Wi-Fi at home or in the office to avoid using up their data allowance. Some operators are also deploying hotspots and implementing WiFi-offloading to divert some of the mobile traffic to their fixed network. In Bangladesh, the smartphone penetration remains relatively low and most of the mobile traffic is voice. However, this is expected to change as operators expand their 3G networks and as mobile broadband becomes more affordable. Similar to voice communications, people will start to use mobile broadband as their primary means to access the Internet. With a low fixed broadband penetration however, a high proportion of Internet traffic in Bangladesh will be carried over the mobile networks.

Current utilisation and outlook

Table 2.2 shows the spectrum bands allocated for mobile cellular services and broadband wireless access (BWA) services. The total amount of spectrum allocated to mobile cellular services is 675 MHz.

Table 2.2: Bands allocated for mobile cellular services and broadband wireless access services

Spectrum Band	Total Bandwidth	Spectrum Assigned	Spectrum Available
800 MHz	40 MHz	Mostly assigned to two mobile operators (CDMA and GSM) and PSTN operators	Mostly assigned; but not efficiently used
900 MHz	50 MHz	70MHz assigned to four mobile operators	Fully assigned
1800 MHz	150 MHz	128.8 MHz assigned to five mobile operators, one PSTN operator and one government user	21.2 MHz unassigned (15 MHz to be assigned shortly)
2100 MHz	120 MHz for FDD and 25MHz for TDD	70 MHz assigned to four mobile operators through an auction	50 MHz FDD and 25 MHz TDD spectrum unassigned
2300 MHz	100 MHz	35MHz assigned to one BWA operator through the BWA auction; and 18 MHz assigned to an ISP	47 MHz unassigned
2500 MHz	190 MHz	95 MHz assigned to two BWA operators and one government user	95 MHz unassigned
Total	675 MHz		

There are currently six operators in Bangladesh offering mobile services with over 116 million mobile subscribers. Five of the operators offer 2G GSM services and they have rolled out 3G services after acquiring licences and spectrum through the auction. Table 2.3 summarises the spectrum assigned to mobile operators.

Whilst the total subscriber base is huge, 96.4 per cent are 2G subscribers and only 3.6 per cent are 3G subscribers. This means that the mobile networks are currently carrying large amount of voice minutes while the data traffic remains relatively low by international standard. This is partly because the 3G services are fairly new in Bangladesh since mobile operators secured their 3G spectrum only in September 2013. With a relatively low fixed phone line penetration, mobile has become the main means of communication for most people in Bangladesh. Table 2.4 shows that there are also three BWA operators (Augere, Banglalion, and BIEL) offering wireless broadband using WiMAX technology.

Table 2.3: Spectrum assigned to mobile operators

Operator	Systems	Mobile Spectrum Assigned	Subscriber Base (M)
Grameenphone	GSM, UMTS, HSPA	64 MHz (7.4MHz x 2 of GSM900, 14.6 MHz x 2 of GSM1800 and 10 MHz x2 of 3G)	50.5
Banglalink	GSM, UMTS, HSPA	40 MHz (5MHz x 2 of GSM900, 10MHz x2 of GSM1800 and 5MHz x 2 of 3G)	31.0
RobiAxiata	GSM, UMTS, HSPA	39.6 MHz (7.4MHz x 2 of GSM900, 7.4MHz x2 of GSM1800 and 5MHz x 2 of 3G)	25.2
Airtel	GSM, UMTS, HSPA	40 MHz (5MHz x 2 EGSM, 10MHz x2 of GSM1800 and 5MHz x 2 3G)	9.0
Teletalk	GSM, UMTS, HSPA	50.2 MHz (5.2 MHz x 2 of GSM900, 10MHz x2 of GSM1800 and 10MHz x 2 of 3G)	4.6
PBTL	CDMA	17.64 MHz (8.82 MHz x 2 of CDMA 800)	2.4

Table 2.4: Wireless broadband using WiMAX technology

Operator	Systems	Mobile Spectrum Assigned
Augere	WiMAX	35 MHz of 2.3GHz band
Banglalion	WiMAX	35 MHz of 2.5GHz band
BIEL	WiMAX	40 MHz of 2.5GHz band

BWA auction was carried out in 2008 way ahead of the 3G auction. Despite having a head start in deploying the networks, the total BWA subscriber base remains much smaller (less than 1 million) than the total 3G subscribers. In Bangladesh, the spectrum bands identified for IMT are similar to those in the ITU Radio Regulation (Edition 2012) as shown in Table 2.5.

Table 2.5: Spectrum bands identified for IMT

Band (MHz)	Amount of Spectrum	Footnotes identifying the band for IMT	Spectrum bands identified for IMT in Bangladesh
450-470	20 MHz	5.286AA	Yes
698-960	262 MHz	5.313A, 5.317A	Yes except806 – 824 MHz and 851 – 869 MHz
1 710-2 025	315 MHz	5.384A, 5.388	Yes
2 110-2 200	90 MHz	5.388	Yes
2 300-2 400	100 MHz	5.384A	Yes
2 500-2 690	190 MHz	5.384A	Yes
3 400-3 600	200 MHz	5.430A, 5.432A, 5.432B, 5.433A	Yes

Going forward, BTRC is planning on making more spectrum resources available for IMT services:

- **450 MHz**: 450 MHz band (due its propagation characteristics) is considered ideal for coverage of a large area, but the bandwidth available to BTRC in this band is limited. The 450- 470 MHz band has also been identified for IMT in Bangladesh but there are some legacy assignments in this band. Two PSTN operators were assigned in this band but one of them has been terminated. The second PSTN operator is apparently not using this spectrum as efficiently as it should and therefore BTRC may consider re-farming this spectrum and reserve it for allocation to future IMT services beyond 2016. The regulator recognises that while some equipment manufacturers are developing LTE-450 products, the equipment and devices are not yet readily available at attractive market prices, especially for the users in Bangladesh.
- **700MHz:** BTRC is planning to make the 700MHz band available for mobile services in the near future, potentially in 2015. BTRC is aware of the benefits of 700 MHz in terms of coverage- for larger footprint in rural areas and better building penetration in urban cities. BTRC is considering APT band plan (698MHz to 806 MHz) to ensure that equipment is readily available and to benefit from the global economies of scale. BTRC assigned spectrum (704-710/734-740 MHz) to an ISP in 2006. The ISP is using this spectrum in limited geographical areas serving a small subscriber base. BTRC intends to move the ISP to an alternative band. However, the amount of spectrum available in the 700MHz band is limited and BTRC is working through the policy for allocating the spectrum. Moreover, the 700MHz band may be used for broadcasting services in neighbouring countries and BTRC needs to consider border issues and identify operating conditions at border areas.

It is recommended that BTRC recover the spectrum from the ISP and offer them from another spectrum bands suitable for ISPs. Instead of assigning different spectrum bands to different ISPs (700MHz, 3.5GHz and 5.4GHz), BTRC can consider consolidating all ISP allocation into one band.

- **800 MHz**: CDMA 800 MHz (825 – 845/870 – 890 MHz) spectrum band is assigned to two mobile operators and some PSTN operators. Most of the PSTN operators have only been using their assigned spectrum for a short time. Globally this spectrum band is recognised for IMT services. This spectrum band is important in terms of its larger coverage and capacity. BTRC may consider recovering the spectrum assigned to PSTN operators and reserving it for future IMT services.
- **1800 MHz remaining spectrum**: Globally, the 1800 MHz is one of the most widely used bands for mobile communications. BTRC notes that operators overseas are starting to use 1800 MHz for LTE after moving 2G users to 3G. But similar to other IMT bands, PSTN operators and government users are also partially occupying this band. BTRC is planning to recover the PSTN operator spectrum and release the currently available free spectrum to mobile operators by 2015.

Recommended actions

With a wide global adoption, equipment is readily available and this band is deemed valuable to mobile operators. It is therefore strongly recommended that BTRC recover the spectrum from the PSTN operator immediately. In case of a strategic use of 1800MHz use by the government, BTRC needs to offer some support to find an alternative solution.

It is recommended that BTRC consider assigning another frequency (e.g., 806 – 816 MHz) to the government to switch there network and use part of the proceeds from the spectrum auction of vacated band in 1800 MHZ to compensate the government user.

Recommended actions (cont.)

Alternatively, if the system deployed by the government user is only used occasionally during an emergency situation, an arrangement can be negotiated with a mobile operator for the government user to use part of the spectrum in an area during an emergency situation. In Australia for example, the Queensland Government awarded a contract to Telstra to manage a network for emergency services during the 2014 G20 Leaders' Summit. Telstra is able to (1) turn on dedicated spectrum for the emergency services network and (2) to prioritise traffic if there is an overflow of traffic to public spectrum (to ensure quality of service).

- **1900 MHz**: 1900 -1910 and1980-1990 MHz spectrum bands have been assigned to PSTN operators. The PSTN operators have implemented CDMA-based systems but the subscriber base remains small, largely as a result of competition from mobile operators. BTRC is reviewing the spectrum requirements of PSTN operators and may recover spectrum that is not utilised.
- **2100 MHz remaining spectrum**: BTRC will be making the remaining spectrum available to mobile operators in the immediate future. BTRC will be conducting further consultation with industry on the timing and approach for the allocation of the remaining spectrum to ensure transparency and fairness.

Recommended action

It is crucial to ensure that no operator could hold excessive amounts of spectrum to gain unfair competitive advantages over other competitors. Moreover, BTRC may consider making it clear that the policy is to award all commercial mobile spectrum via auction.

- **2300 MHz and 2500 MHz:** To support medium term expansion of mobile broadband networks, BTRC is considering allocating the remaining spectrum in the 2300 MHz and 2500 MHz bands. 3G/IMT/LTE systems are able to coexist with existing WiMAX systems deployed by BWA operators.

Recommended actions

BTRC has assigned 2300-2318 MHz spectrum to an ISP in 2006. The ISP is using this spectrum in very small geographical areas supporting a small subscriber base. It is recommended that BTRC recover this spectrum by assigning them frequencies from another spectrum band suitable for ISPs. In the longer term, BTRC may need to consider recovering the spectrum from the government user. This band is becoming popular for operators to deploy LTE and LTE-A. BTRC needs to keep the government user aware of the international development and put in place a plan to recover the spectrum when the time comes.

- **WRC 2015:** BTRC supports the identification of additional spectrum for mobile broadband services, under Agenda Item 1.1 of WRC-2015. BTRC will provide an update on the outcome of this agenda item after WRC 2015 and the Bangladesh position on this issue.
- **Neutrality:** In view of the rapidly changing technology landscape, BTRC is considering the adoption of a technology neutral approach. This will give operators greater flexibility when choosing the technology and re-farming existing 2G spectrum for mobile broadband services.

Recommended action: See subsection 2.5.7

2.3.2 Fixed services

Fixed services operate in various radio spectrum bands from very high frequency (VHF) and ultra-high frequency (UHF) to extremely high frequency (EHF). The VHF and UHF bands are typically used for narrowband applications, for point-to-point links between land mobile base stations, or point-to-multipoint in the case of wireless local loop. In some countries, the 2.3GHz, 2.5GHz and 3.5GHz spectrum bands are also used for fixed wireless access (FWA).

Fixed wireless access has over time evolved to BWA and operators are using technologies such as CDMA and WiMAX to compete with fixed Internet providers (xDSL and cable). There are also microwave point-to-point links operating in 6 GHz and above and they are typically used for long haul and high capacity transmission. Fixed services are being deployed by many organisations including government agencies (defence and public safety agencies), telecommunication operators and broadcasters.

Fibre replacing microwave links

Fixed services for telecommunication networks are being replaced by wired infrastructure especially in countries where operators have invested in fibre backbone infrastructure. Fibre networks are taking away some demand for microwave links as fibre connections support higher speed (multiple Gbit/s), provide higher availability (microwave links are susceptible to fading and other propagation characteristics) and are able to carry traffic over longer distances (e.g., inter-city, long haul connectivity). Fibre optic backbone networks are able to cater for various requirements including telephony, data, Internet and broadcasting/content.

Fixed point-to-point links in the lower frequency bands (<6GHz) are also being replaced by fixed line infrastructure as regulators re-allocate spectrum bands for other services. For instance, the 400MHz is increasingly being used for land mobile services and 2.3 GHz and 2.5 GHz bands are allocated for mobile services. However, there remains demand for microwave links where fibre connectivity is not available. Operators are also looking at higher spectrum bands as the lower frequency bands become congested. In particular, mobile operators expect microwave to be a key backhaul option and they are looking at higher frequency bands (e.g., 23 GHz, 28 GHz and 38 GHz) for shorter but higher capacity backhaul links.

Convergence of fixed and mobile services

Some countries have also embarked on national fibre to the home (or curb or node) initiatives (e.g., Australia, Japan, the Republic of Korea, New Zealand, Singapore, and the United Kingdom). Similarly in Bangladesh, the fibre rollout is underway to connect major cities across the country and to provide connectivity to rural areas through telecentres. In places where fibre Internet is available, the demand for BWA and indeed other fixed Internet services has been declining. While fixed wireless services (PSTN and fixed Internet) can have a role to play in rural areas where there is limited fixed line infrastructure, operators are increasingly facing competition from mobile services. The evolution of technology is driving the convergence of services and WLL and FWA are being substituted by mobile broadband services. Globally, the demand for WiMAX is declining and operators are looking to LTE or 4G to offer broadband services since there are more devices in the market supporting these technologies.

Figure 2.5: NTT DOCOMO femtocell

Source: NTT DOCOMO

Backhaul for small cell

The advancement of the mobile broadband technology is driving consumer demand for even faster connections to support a plethora of multimedia applications. To ensure sufficient coverage and capacity, mobile operators need to deploy more base stations and reduce the cell size in densely populated areas. In countries such as Japan and the Republic of Korea, operators are also moving ahead with LTE-A technology and small cell technology to improve customer experience. For example, the NTT DOCOMO femtocell (Figure 2.5) weighs about 0.7 kg and it provides a cost-effective solution for indoor coverage. With the increase in mobile data speed, there is a need for more backhaul options. While fibre or other fixed line connections are ideal for mobile backhaul, they are not always available especially if the small cells are to be installed in public places. Wireless backhaul will be required to support the deployment of small cell technologies and some vendors are touting 42 GHz and 60 GHz as potential spectrum bands for shorter but higher capacity wireless backhaul. These millimetre wave links are highly directional and the same frequency can be reused multiple times in a small area. As such, regulators have generally lowered the fees for operators using these spectrum bands.

Current utilisation and outlook

In Bangladesh, there are about 50 000 fixed links in the BTRC database. The lack of fixed line infrastructure means that wireless links play an important part in delivering telecommunication services to remote areas. PSTN operators have deployed wireless local loop to provide fixed telephony to households. ISPs are also using spectrum in the 800 MHz, 3.5 GHz and 5 GHz to provide Internet access services. However, with the convergence of technology and services, PSTN operators and ISPs are facing strong competition from mobile operators and BWA operators and their subscriber growth has been limited. In many countries, consumers are increasingly relying on their mobile phones for

voice, text and Internet access. The proliferation of smartphones will further erode the demand for fixed phone and fixed wireless Internet access.

Fixed microwave links are expected to be in demand for mobile base station backhaul. However, the rollout of the fibre infrastructure over the next few years will alleviate the demand for fixed microwave links. In addition, there are fixed links that are deployed by broadcasters for TV outside broadcasting that are ad-hoc in nature, and not in fixed locations.

VHF/UHF fixed services and fixed wireless access

Table 2.6 shows the VHF and UHF spectrum bands allocated for fixed services including point-to-point and point-to-multipoint fixed operations.

Table 2.6: VHF and UHF spectrum bands allocated for fixed services

Spectrum Band	Allocation	Utilisation	Major Users
806 – 816 MHz / 851 – 866 MHz	Radio Trunking, Civil fixed and mobile systems	Low	One ISP
1350 – 1375MHz/ 1492 – 1517MHz (NFAP Annex 4D)	Broadcasting fixed links	Medium	RAB and other organisations for point-to-point communications
1375 – 1400MHz/ 1427 – 1452MHz (NFAP Annex 4E)	Broadcasting fixed links	Medium	RAB and other organisations for point-to-point communications
1900 – 1910 MHz / 1980 – 1990 MHz	CDMA (cellular/PSTN operation)	Low	PSTN Operator
2025 – 2070 MHz/ 2200 – 2245MHz (NFAP Annex 4F)	Civil and government fixed/mobile systems	Low	-
2070 – 2110 MHz/ 2245 – 2290MHz (NFAP Annex 4F)	Civil fixed links	Low	-
3400 – 3600 MHz	Fixed links	Low	ISP
4400 – 4800 MHz	Fixed links, ENG/OB, government systems	Medium	Broadcasters, government users
5150 – 5250 MHz	Wireless access, RLAN	Low	-
5250 – 5350 MHz	Government systems, wireless access, RLAN	Low	ISP
5470 – 5725 MHz	Government systems, wireless access, RLAN	Low	ISP

800 MHz: The utilisation of 800 MHz is low and currently occupied by one ISP. BTRC is considering the ISP requirements and may re-farm the band for other services.

1GHz – 3GHz: The systems operating in these bands are typically long haul, low capacity links. These systems are also providing basic telecommunication services to the public or mission critical operations for government agencies. Existing users need to be aware that the 1.9 GHz and 2 GHz spectrum bands have also been identified as candidate bands for 3G/IMT mobile services. Spectrum rights for these bands have been issued in some countries but the operators owning the spectrum have not been using these bands for commercial services. There is a potential need for re-farming if these bands become popular globally for mobile services, and equipment becomes readily available.

3.5 and 5 GHz: There has been a lot of interest for the use of the 3.5GHz (3.4GHz- 3.6GHz) for mobile communications and broadband wireless access. This band is currently assigned to ISPs but the utilisation has been low due to the small subscriber bases. To improve the utilisation of this band, the BTRC will be taking steps to re-farm part of this spectrum band and reallocate this band for other services.

Recommended actions

The utilisation of the 3.5 GHz band is currently very low but the whole band has been assigned to ISPs. The subscriber growth of these ISPs is slow and increasingly, the customers (mostly corporate users in Dhaka) will move to fibre connections for better service quality.

The ISPs will also face greater competition from mobile operators and BWA operators as these players enhance their networks to support faster broadband speeds. BTRC should consider recovering the spectrum from ISPs that are not fully utilised. In particular, X-net has been assigned 120MHz, in 5.4 MHz band, more than other ISPs while also supporting a small customer base. BTRC can make an assessment of ISP requirements by comparing the utilisation (number of subscribers and number of base stations) vs spectrum assigned for each ISP. Since ISPs are not providing nationwide coverage, BTRC should reconsider whether ISPs should be assigned the spectrum exclusively for nationwide use. To encourage ISPs to give up spectrum they are not using, BTRC may consider subjecting the ISPs to the full spectrum fees.

5GHz: At WRC 2003, the 5GHz bands were allocated for wireless access and radio LANs (RLANs). Regulators have allowed unlicensed use of the band subject to technical conditions such as power limitation. BTRC is consider allocating the 5GHz bands for wireless LAN but it will first consider the impact on existing services.

Point-to-point microwave links

Table 2.7 is the list of spectrum bands allocated for point-to-point microwave links.

Below 10 GHz: The spectrum bands below 10GHz offer high capacity, long haul links critical for operators for backbone transmission or backup links. The demand for frequencies in these bands remains strong. BTRC will be reviewing the assignment process and criteria to ensure that new requests for shorter microwave links are assigned higher frequency bands.

Above 10GHz: BTRC will encourage the use of higher frequency bands. There are opportunities for mobile operators to utilise the higher microwave links for backhauling their base station traffic (e.g., unlicensed use of 60GHz band).

Table 2.7: Spectrum bands allocated for point-to-point microwave links

Spectrum Band	Utilisation	Reference
5925 – 6425 MHz	High	ITU-R F.383
6425 – 7125 MHz	High	ITU-R F.384
7110 – 7900 MHz	High	ITU-R F.385
7900 – 8275 MHz	High	ITU-R F.386
8275 – 8500 MHz	High	ITU-R F.386
10.15 – 10.68 GHz	High	ITU-R F.1568
10.70 – 11.70 GHz	High	ITU-R F.387
12.75 – 13.25 GHz	High	ITU-R F.497
14.4 – 15.35 GHz	High	ITU-R F.636
17.7 – 19.7 GHz	High	ITU-R F.595
22.0 – 22.6 GHz / 23.0 – 23.6 GHz	Medium	NFAP Annex 4H
25.0 – 26.5 GHz	Medium	NFAP Annex 4I
27.5 –29.5 GHz	Low	NFAP Annex 4J
31.0 – 31.3 GHz/31.5 – 31.8 GHz	Low	Annex 4K & 4L
37 – 39.5 GHz	Low	ITU-R F.749
48.5 – 50.2 GHz	Low	NFAP Annex 4M
51.4 – 52.6 GHz	Low	NFAP Annex 4N
55.78 – 57 GHz	Low	NFAP Annex 4O
57 – 59 GHz	Low	NFAP Annex 4P

2.3.3 Land mobile services

Organisations deploy land mobile systems for different operation needs including push-to-talk voice communications, paging, telemetry and narrowband data. A land mobile system is crucial for organisations in different industries construction, logistics, manufacturing, energy/mining, tourism, and public safety. A land mobile network can consist of base stations, repeaters and portable units. A basic set up can be a short-range radio between two walkie-talkie units.

Over the years, land mobile systems have moved from analogue to digital, which is more spectrally efficient and allows simple data services such as sending short messages. Digital land mobile equipment operates with 12.5 kHz (or 6.25 kHz) as compared with 25 kHz for analogue equipment.

The demand for land mobile systems has been stable and there has been demand for new consumer oriented land mobile systems such as Family Radio Systems and GMRS (462/467 MHz). However, some of the demand is being replaced by the adoption of mobile phones. For example, paging has been replaced by SMS and some smartphone applications mimic the walkie-talkie capability.

However, land mobile systems continue to play a critical part in public safety and emergency services. Trunked radio networks are crucial for secure, reliable and closed group communications. While commercial mobile services are used by national security agencies, during emergency situations, there is a need for dedicated networks to ensure reliability and to meet other operational requirements. In some countries, different government agencies tend to have their own equipment. By encouraging these agencies to consolidate their networks, there will be efficiency gained, resulting in fewer spectrums requirements.

At the international level, through ITU and APT, administrations are harmonising the spectrum for public protection and disaster relief (PPDR) systems. ITU-R Resolution 646 defines public protection radiocommunication as radio-communications used by responsible agencies and organisations dealing with maintenance of law and order, protection of life and property and emergency situations. Disaster relief radiocommunication refers to radio-communications used by agencies and organisations dealing with serious disruption of the functioning of society, posing a significant widespread threat to human life, health, property or the environment, whether caused by accident, natural phenomena or human activity, whether developing suddenly or as a result of complex, long-term processes.

The harmonisation of spectrum for PPDR enables different agencies (fire, police, ambulance, etc.) to communicate with each other at the disaster site, and to promote interoperability for cross-border operations in emergency situations. In addition, there is a demand for PPDR equipment to have the capability to handle wideband applications such as high-speed data, transmission of high resolution images and real-time video. At WRC 2003, the following spectrum bands have been identified for PPDR in Region 3:

- 406.1 – 430 MHz
- 440 – 470 MHz
- 806 – 824 MHz / 851 – 869 MHz
- 4940 – 4990 MHz
- 5850 – 5925 MHz

Administrations are deliberating the future direction of spectrum needs of PPDR under the WRC 2015 Agenda Item 1.3. Since the identification of spectrum at WRC 2003, there have been new requirements for PPDR, particularly for the need to support mobile video by PPDR organisations.

Current utilisation and outlook

There are currently about 300 land mobile networks in Bangladesh deployed by private as well as government organisations. These land mobile systems are either single frequency or two-frequency, and there are some trunked radio networks as well. The number is expected to grow gradually, similar to the trends in other countries. Whilst traditional land mobile systems support voice communications only, there is now demand for systems that support data transmission.

The spectrum bands in the 400 MHz range (see Table 2.8) are ideal for land mobile systems and internationally, 380 – 400 MHz, 410 – 430 MHz and 470 – 490 MHz are used for trunked radio systems such as TETRA and APCO Project 25. The 800 MHz band also supports trunked radio systems such as iDEN. These trunked radio systems are typically deployed by government agencies. Whilst the radio networks deployed by law enforcement and emergency services agency are only activated during major events and emergency situations, they require dedicated spectrum for certainty that their systems will not be interfered during critical operations.

Table 2.8: Spectrum bands in the 400 MHz range

Spectrum Band	Allocation	Utilisation	Major Users
Below 380 MHz	Private mobile radio	Medium	Private organisations, government organisations except defence and police
380 – 390 MHz / 390 – 400MHz	Trunked radio	Medium	
406.1 – 410 MHz	Private mobile radio	Medium	
410 – 430 MHz	Private mobile radio/ Trunked radio	Medium	
470 – 490 MHz	Private mobile radio	High	
490 – 510 MHz	Private mobile radio	High	
520 – 522 MHz	Private mobile radio	Medium	

To promote greater efficiency of spectrum usage, BTRC will not accept new requests for 25 kHz analogue land mobile equipment. Existing land mobile users are also required to transition to more efficient 12.5 kHz technology. Moreover, BTRC expects more demand for land mobile assignment and there will be congestion in urban areas. BTRC will review the assignment criteria for land mobile services to improve the reuse of spectrum.

In Bangladesh, the spectrum band 4940 – 4990 MHz has been identified for PPDR but there are currently no PPDR systems operating in this band. BTRC believes that this spectrum band is ideal for broadband systems and equipment will become readily available since this band is widely accepted in Region 3 for PPDR. BTRC will be working closely with the related government organisations to develop the national position for WRC 2015 agenda 1.3 and to achieve harmonisation with administrations in Region 3.

2.3.4 Broadcasting services

Digital TV broadcasting trends

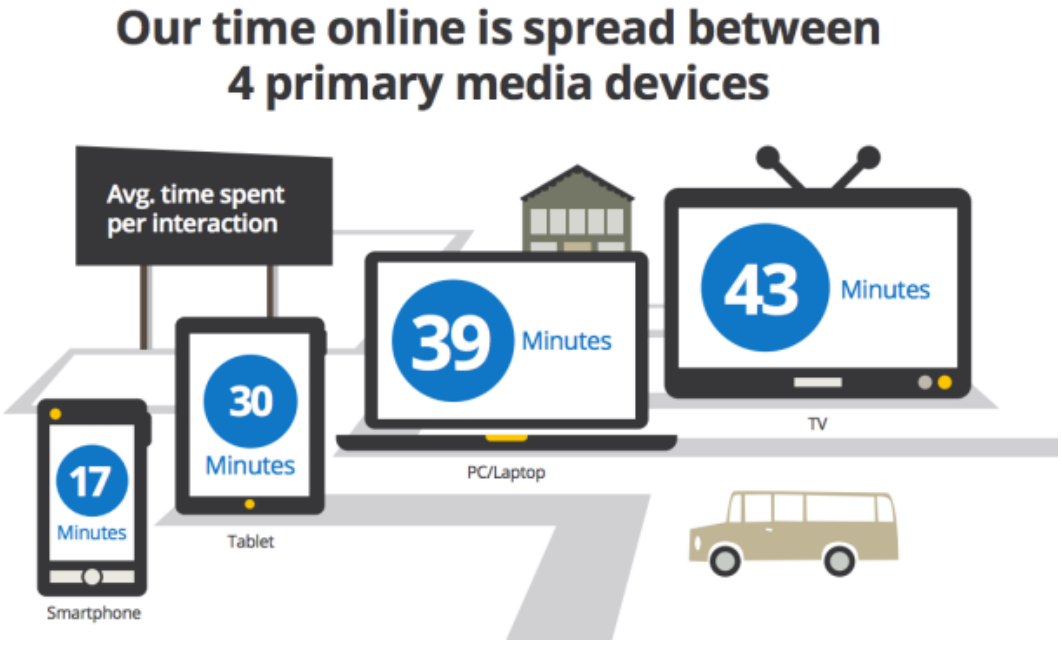
The key driver for the changes in the terrestrial broadcasting services is the transition from analogue broadcasting to digital. Digital broadcasting is spectrally more efficient and the switch-over to digital is freeing up spectrum known as the digital dividend. In Asia, through the Asia-Pacific Telecommunity (APT), administrations have developed a band plan for allocating the digital dividend (698 – 806 MHz) for mobile services. Globally, broadcasters have launched digital broadcasting and some administrations have set an analogue switch-off (ASO) date. In Bangladesh, analogue switch-off is yet to be confirmed.

With more efficient modulation, compression and coding techniques (e.g., DVB-T2), the same 8 MHz UHF TV channel can now carry more high definition content. However, broadcasters are also facing the challenge of retaining viewership as consumers have more options of access entertainment content from satellite networks, fixed networks (cable TV or IPTV via DSL or other broadband access) as well as free content from the Internet. Hence, broadcasters are also contemplating how to fully utilise the capacity of the multiplexer to retain viewership and to tap into new revenue streams.

Some broadcasters are offering catch-up TV, electronic programme guide, 3DTV, and digital signage. Another major trend is for terrestrial broadcasters to implement hybrid TV or interactive TV, which offers broadcasters the ability to provide video-on-demand, interactive advertising, personalisation, voting, social networking and so on. In the multiscreen era, people do not just consume content from the TV unit in the home. Broadcasters are also aware of the need to push content to mobile devices. In November 2011, DVB Steering Board approved the DVB-T2 Lite, which is a subset of the

DVB-T2 specifications for supporting mobile broadcasting. Doordarshan, a broadcaster in India had announced its plans to rollout DVB-T2 Lite by 2015. In addition, mobile operators are also looking at delivering broadcasting content through their LTE networks using the evolved multiple broadcast multiple service (eMBMS) system. China Telecom has already contracted ZTE as its supplier for eMBMS to deliver mobile video services. Other telecom providers such as Verizon, AT&T and Telstra have also shown interest in deploying this technology.

Figure 2.6: Our time online is spread between four primary media devices



Source: Google

Digital TV can also be an important infrastructure for providing information to the public during national emergency situations. For example, when the tsunami hit Japan in 2011, people affected by the natural disaster were able to receive information about the situation through digital TV sent to their mobile devices while electricity and Internet were out.

Digital audio broadcasting trends

While digital audio broadcasting services have been implemented in several countries, the adoption has been lacklustre and no countries have made a decision on when analogue radio transmission will be switched off. Digital radios offer better sound quality but apart from that, there are no compelling reasons for consumers to purchase a digital radio device that costs more than the analogue radio. On the other hand, FM radio services offer extensive coverage and FM receivers are relatively low cost, often integrated to mobile devices. More importantly there is currently no competing demand for the spectrum. Hence, FM radio services are expected to stay in the foreseeable future.

Current utilisation and outlook

In Bangladesh, the main terrestrial broadcasting services are in the FM band and VHF TV bands. There are currently over 20 FM stations including nationwide broadcasters and community broadcasters.

There are also a few radio stations broadcasting in the MF-AM band (526.5–1606.5 kHz) for national and community broadcasting services. However, there is unlikely demand for new assignments since MF-AM radio has poorer audio quality and is more prone to electrical noise than VHF/FM.

BTV is the only free-to-air broadcaster in Bangladesh. Whilst there are other private TV providers, they distribute content through the cable network. The national broadcaster is broadcasting in the VHF band.

Table 2.9: National and community terrestrial broadcasting services

Service	Spectrum Band	Utilisation	Major Users
FM	87 – 108 MHz	Medium	12 nationwide broadcasters and 14 community broadcasters
TV	174 – 230 MHz	Low	BTV
	526 – 694 MHz	Low	

- **88 – 108 MHz:** There are some interests to implement HD Radio in Bangladesh using the FM band. BTRC is evaluating the request with the Ministry of Information and Communications Technology (MOICT) and the assessment will be done through a more holistic review of the plan for digital audio broadcasting for Bangladesh.
- **174 – 230MHz:** MOICT has decided not to issue any licences to private terrestrial broadcasting services. BTV will therefore be the only user of terrestrial TV broadcasting spectrum. BTV currently uses the VHF TV band for analogue TV and it is planning to use the same band for digital TV. BTRC will be working closely with MOICT and BTV to ensure a smooth transition to digital TV broadcasting and spectrum is effective used.
- **Digital audio:** In view of the lack of success in other countries, the MOICT has not firmed up its plans to introduce digital audio broadcasting. BTRC will be working with MOICT and the broadcasters to formulate the plan for digital audio.
- **526 – 694 MHz:** This band is earmarked for digital broadcasting services. BTRC will work closely with MOICT to ensure that the broadcasting spectrum is efficiently utilised and to ensure that sufficient spectrum is set aside for digital broadcasting services.

Recommended actions: See subsection 2.5.8 for recommendations on broadcasting spectrum issues.

2.3.5 Satellite services

Satellite communications remain vital for niche applications particularly for communications across a vast area where other means of communications are not available. For example, maritime, mining, oil and gas exploration industries rely heavily on satellite communications. In addition, satellite is also widely used for broadcasting content over a large geographical area. Internationally, the satellite communications are categorised into the following:

- Mobile satellite service (MSS)
- Fixed satellite service (FSS)
- Broadcasting satellite service (BSS)

Similar to terrestrial communications, satellite operators are also offering broadband access to meet user demand. There has been a growing demand for satellite bandwidth and the WRC 2015 will be looking at additional spectrum allocation for FSS under the following agenda items 1.6 and 1.9.

Agenda 1.6 – to consider possible additional primary allocations:

1.6.1 to the fixed-satellite service (Earth-to-space and space-to-Earth) of 250 MHz in the range between 10 GHz and 17 GHz in Region 1;

1.6.2 to the fixed-satellite service (Earth-to-space) of 250 MHz in Region 2 and 300 MHz in Region 3 within the range 13-17 GHz;

and review the regulatory provisions on the current allocations to the fixed satellite service within each range, taking into account the results of ITU-R studies, in accordance with Resolutions 151 (WRC-12) and 152 (WRC-12), respectively;

Agenda 1.9 – to consider, in accordance with Resolution 758 (WRC-12):

1.9.1 possible new allocations to the fixed-satellite service in the frequency bands 7 150-7 250 MHz (space-to-Earth) and 8 400-8 500 MHz (Earth-to-space), subject to appropriate sharing conditions;

1.9.2 the possibility of allocating the bands 7 375-7 750 MHz and 8 025-8 400 MHz to the maritime-mobile satellite service and additional regulatory measures, depending on the results of appropriate studies.

Current utilisation and outlook

There are currently 29 VSAT users in Bangladesh but the government limits the use of VSAT communications. These users include embassies, corporate offices and bank head offices/branches, and these VSAT systems mainly operate in C-band (5925 – 6425 MHz uplink / 3700 – 4200 MHz downlink). The C-band is also used to receive content from broadcasting satellites.

Bangladeshi satellite

The Bangladesh Government is in the midst of planning to launch a satellite (Bangabandhu Satellite) that is managed by a project team within BTRC. Bangabandu-1 is expected to be launched in late 2017 or early 2018. The satellite will be used to provide direct-to-home (DTH) TV service, VSAT, backup connections and disaster relief applications. The satellite is crucial for providing uninterrupted communication services during natural disaster.

- **Satellite uplink:** Satellite uplink may cause interference to fixed services if not properly coordinated. BTRC will be establishing criteria for the satellite uplink bands to be shared between satellite and fixed services.
- **4500 – 4800 MHz:** This band is currently used for fixed services including government systems and electronic news gathering / outside broadcasting for broadcasters. These fixed services will cause interference to satellite reception in this band if the use of satellite is allowed anywhere in Bangladesh without coordination. BTRC is considering freeing up the band for satellite and will work with existing users to find alternative solutions for their current use.

Table 2.10: Bangabandhu transponders spectrum bands

Spectrum Band	Remarks	Current Use
4500 – 4800 MHz	FSS C-Band downlink – 300 MHz bandwidth	Fixed services by broadcasters and government users
6725 – 7025 MHz	FSS C-Band uplink – 300 MHz bandwidth	Fixed point-to-point services
11.7 – 12.2 GHz	BSS Ku-Band downlink – 473.84 MHz bandwidth	Allocated for BSS
17.3 – 18.1 GHz	BSS Ku-Band uplink – 781.02 MHz bandwidth	17.7 – 18.1 GHz used for fixed point-to-point services
12.2 – 12.5 GHz	BSS Ku-Band downlink – 320.7 MHz bandwidth	Allocated for FSS
14.5 – 14.8 GHz	BSS Ku-Band uplink – 282.34 MHz bandwidth	Fixed point-to-point services

Recommended actions

Sharing of spectrum between satellite downlink and terrestrial fixed services is not recommended. Satellite receivers are highly sensitive and the chance of interference is high if VSAT and DTH services are permitted and deployed everywhere across the country.

It is recommended that BTRC place an embargo on the satellite downlink bands. BTRC should also consider re-farming the 4500 – 4800 MHz band and move existing users out of the band; unless the existing applications are only meant for specific remote areas and a sharing arrangement can be determined.

Satellite planning and coordination takes a long time and the satellite project team has identified the following spectrum bands for future requirements.

Table 2.11: Spectrum bands for future requirements (uplink and downlink)

Uplink Band	Current Use
1626 – 1660.5 MHz	Allocated for mobile satellite and government systems
1980 – 2010 MHz	PSTN operator and identified for IMT
5925 – 6425 MHz	Fixed point-to-point services
7900 – 8395 MHz	Fixed point-to-point services
11.2 – 11.45 GHz	Fixed point-to-point services
12.75 – 13.25 GHz	Fixed point-to-point services
13.75 – 14 GHz	FSS, not in use
14.0 – 14.5 GHz	FSS and fixed services
27.5 – 31 GHz	Fixed point-to-point services

Table 2.11: Spectrum bands for future requirements (uplink and downlink) *(end)*

Downlink Band	Current Use
1525 – 1559 MHz	Allocated for mobile satellite and government systems
2170 – 2200 MHz	Identified for IMT
3700 – 4200 MHz	FSS
7250 – 7745 MHz	Fixed point-to-point services
10.7 – 10.95 GHz	Fixed point-to-point services
10.95 – 11.2 GHz	Fixed point-to-point services
11.45 – 11.7 GHz	Fixed point-to-point services
12.25 – 12.5 GHz	FSS, not in use
17.7 – 21.2 GHz	17.7 – 19.7 GHz allocated for fixed point-to-point services; 19.7 – 21.2 GHz allocated for FSS

There are several overlapping bands between the satellite planned bands and fixed services. While it is crucial to ensure that there is spectrum for future satellite service expansion, BTRC also needs to ensure that the spectrum is efficiently used. BTRC will continue to allow fixed services to operate in these bands but licensees should be aware that these assignments may be withdrawn when there is a need for future satellite use.

Recommended actions

It is recommended that BTRC do not assign mission-critical fixed links and exclusive assignments (e.g., for mobile backhaul) in the overlapping bands between satellite and fixed services. These bands should continue to be made available to backup connectivity, temporary links and other fixed links that will eventually be replaced by fibre.

- **WRC 2015:** BTRC notes that several of the above bands are being considered as candidate bands for additional allocation for IMT under WRC 2015 Agenda Item 1.1. The bands being considered include 1518 – 1559 MHz, 1610 – 1660.5 MHz, 3600 – 4200 MHz GHz, 4500 – 4800 MHz and 5850 – 6725MHz. BTRC is preparing its position for this agenda item and will take into consideration the future satellite requirements.

Recommended actions

There are more administrations within Region 3 opposing the allocation of C-band, particularly 4500 – 4800 MHz for IMT. BTRC should monitor ITU studies on the use of C-band for IMT services.

2.3.6 Short range devices

Short range devices (SRDs) operate with very low power (typically 100mW and below) which limits the communication range to a few hundred meters. SRDs are allowed to operate without the need for a licence but some form of equipment certification or type approval is usually required. SRDs are

used in many areas including remote control, RFID, wireless microphones, health monitoring devices and wireless LAN. Manufacturers are now working through ITU and other standardisation bodies to harmonise the frequency ranges and the technical standards. Bluetooth, ZigBee and Wi-Fi (802.11) are some examples of global standards that are widely used and the economies of scale have driven down the cost of hardware tremendously.

SRDs will continue to be in demand as connected home and Internet of things (IoT) become a reality. Today, wireless LAN has moved from IEEE 802.11b in 2.4GHz offering 11 Mbit/s to IEEE 802.11ac in 5GHz offering over 500 Mbit/s to 1 Gbit/s (using wider bandwidth and techniques such as MIMO and 256 QAM). Wireless LAN is now widely deployed in offices and used in households for sharing the bandwidth with multiple users or devices. In large campuses, such as universities, wireless LAN can help students to get access anywhere within the campus. Household appliances will also become more connected (air conditioners, lighting sensors, garage openers) to enable home automation. As the usage become more bandwidth intensive (video streaming), there is a need for faster wireless LAN hardware, and therefore more bandwidth. Moreover, mobile operators in some countries are already deploying wireless hotspots to offload their mobile data traffic.

The growing demand for wireless LAN has resulted in the identification of three blocks of spectrum in the 5GHz range for radio LAN – 5150 – 5350 MHz, 5470 – 5725 MHz and 5725 – 5875 MHz. Wireless LAN hardware operating in these bands is becoming readily available e.g., 802.11n and 802.11ac. To cater for the growing demand, manufacturers are developing wireless access in higher frequency range (57 – 66 GHz) to support multiple Gbit/s data rate (European standard EN 302 567).

In addition, there is also increasing demand for sensors, RFID and NFC applications. WRC 2015 Agenda Item 1.18 will consider the allocation to the radiolocation service for automotive applications in the 77.5 – 78.0 GHz frequency band (in accordance with Resolution 654).

The demand for short range, high capacity communication has resulted in a lot of interest around the ultra-wideband (UWB) technology. As highlighted in subsection 2.2.4, some countries have allowed the use of UWB by defining the emission mask and setting the operating requirements.

Current utilisation and outlook

Table 2.12: Bands currently available for SRDs in Bangladesh

Spectrum Bands	Applications
9 – 315 kHz	Ultra-low power active medical implants
3155 – 3400 kHz	Hearing aid devices
6765 – 7000 kHz	ISM
7400 – 8815 kHz	Not specified (power limit < 1W)
10.15 – 11.175 MHz	Not specified (power limit < 1W)
13.522 – 13.57 MHz	ISM
26.175 – 27.5 MHz	ISM, model control, CB radio
40.66 – 40.7 MHz	ISM, model control
48.5 – 50.0 MHz	Not specified (power limit < 1W)

Table 2.12: Bands currently available for SRDs in Bangladesh *(end)*

Spectrum Bands	Applications
57.5 – 61 MHz	Services Ancillary to Broadcasting (SAB)
245 – 246 MHz	VHF Citizen Band 245-246 MHz and VHF Short Business Radio 245-246 MHz
433.04 – 434.79 MHz	Not specified (power limit < 1W)
863 – 870 MHz	Analogue voice, radio microphones, alarms, wireless audio
2400 – 2500 MHz	ISM, RLAN, AVI, RFID
5725 – 5875 MHz	ISM, RLAN, AVI, RFID
24.05 – 24.25 GHz	Sensors
61 – 61.5 GHz	Sensors
122.25 – 123 GHz	ISM
241 – 248 GHz	Not specified (power limit < 1W)

- **5 GHz:** The 5150 – 5350 MHz and 5470 – 5725 MHz band are currently used by ISPs. Internationally, these bands are being used for wireless LAN on a shared, licence-exempt basis. BTRC is aware of the availability of wireless LAN equipment operating in these bands. BTRC is consider allocating the 5GHz bands for wireless LAN but it will first consider the impact on existing services.

Recommended actions

Many people have benefited from the wireless LAN technology and Wi-Fi is now used at home, in schools, offices and public areas. BTRC may also face pressure from equipment vendors and dealers to allow the sale of 5GHz-enabled wireless LAN equipment in Bangladesh.

It is recommended that BTRC assess the utilisation of spectrum by the ISPs and recover the spectrum that is not efficiently used. BTRC may also consider the possibility of sharing between licence-exempt wireless LAN and FWA services. In the United States and the United Kingdom for example, FWA is allowed to operate in the 5.8 GHz band on a secondary basis and the band is also used for many licence-exempt applications.

- **60 GHz:** BTRC is monitoring the equipment availability for the 57 – 66 GHz band and the level of interest to use this band. BTRC may consider making this band available for SRD, specifically wireless LAN applications in the future.
- **UWB:** BTRC notes that it is still early days before UWB devices will become pervasive. BTRC will therefore continue to monitor the development of UWB and setting the boundaries for UWB taking into consideration the ITU Recommendations.
- **Guidelines for SRDs:** To provide greater clarity on the import and use of SRDs in Bangladesh, BTRC will develop and publish guidelines for SRDs. These guidelines will provide details such as technical parameters, usage permitted and equipment approval requirements; similar to the document for 2.4 GHz and 5.7 GHz instructions ("Instructions for providing service through 2.4 and 5.7 GHz band in Bangladesh").

2.3.7 Other services

Aeronautical services

Civil and military aviation are key users of spectrum and the radio systems on board aircraft as well as for air-traffic control are generally harmonised globally through international bodies such as ITU and the International Civil Aviation Organization (ICAO). The ICAO in particular facilitates the harmonisation of equipment as well as the spectrum requirements. These systems are used for navigation, communications, and radiolocation.

Table 2.13: Spectrum bands currently utilised for aeronautical services

Spectrum Band	Allocation	Current Users
117.975 – 137.175	Civil and military aviation	47 assignments have been made to Airlines in this RF band

The following WRC 2015 agenda items concern the future spectrum demand for the aviation industry:

- Agenda Item 1.5 – to consider the use of frequency bands allocated to the fixed-satellite service not subject to Appendices 30, 30A and 30B for the control and non-payload communications of unmanned aircraft systems (UAS) in non-segregated airspaces, in accordance with Resolution 153 (WRC-12).
- Agenda Item 1.17 – to consider possible spectrum requirements and regulatory actions, including appropriate aeronautical allocations, to support wireless avionics intra-communications (WAIC), in accordance with Resolution 423 (WRC-12).

Maritime services

The maritime mobile services are used by vessels operating in international waters, coastal areas and inland waterways. Maritime systems are also used in onshore facilities for ensuring safety and security purposes. To ensure safety of life as vessels move across international waters, the maritime systems and frequency requirements are also coordinated internationally through ITU and the International Maritime Organisation (IMO). For example, the Global Maritime Distress and Safety System (GMDSS) and emergency position indicating radio beacons (EPIRBs) are globally harmonised systems.

The following WRC 2015 agenda items pertain to the future spectrum demand for the maritime industry:

- Agenda Item 1.15 – to consider spectrum demands for on-board communication stations in the maritime mobile service in accordance with Resolution 358 (WRC-12);
- Agenda Item 1.16 – to consider regulatory provisions and spectrum allocations to enable possible new Automatic Identification System (AIS) technology applications and possible new applications to improve maritime radiocommunication in accordance with Resolution 360 (WRC-12);

Table 2.14: Spectrum bands currently utilised for aeronautical services

Spectrum Band	Allocation	Current Users
405 - 512 KHz	Ocean going shipping, inland water transport and fishing trawlers	266 licensees are using these spectrum bands
2000 - 2850 KHz		
4000 - 4438 KHz		
6200 - 6525 KHz		
8100 - 8815 KHz		
16360 - 17410 KHz		
18780 - 18900 KHz		
19680 - 19800 KHz		
22000 - 22855 KHz		
25070 - 25210 KHz		
26100 - 26175 KHz		
156 - 162 MHz		

2.4 Spectrum outlook

Table 2.15 is a list of activities in the BTRC work plan over the next five years. These are mainly activities related to spectrum allocation and utilisation.

Table 2.15: BTRC activities related to spectrum allocation and utilisation

Spectrum Band	Description	Priority/Timeline
88 – 108 MHz	BTRC and MOICT are reviewing the feasibility of allowing HD Radio implementation.	2015 – 2016
450 – 470 MHz	BTRC is planning to allocate this band for IMT/mobile services. BTRC is monitoring the demand and equipment availability in this band.	2017 – 2019
174 – 230 MHz	BTRC will work closely with MOICT and BTV to ensure a smooth transition to digital TV broadcasting and spectrum is efficiently utilised.	2015 – 2016
526 – 694 MHz	BTRC will work closely with MOICT to ensure that the broadcasting spectrum is efficiently utilised and to ensure that sufficient spectrum is set aside for digital broadcasting services.	2015 – 2016
698 - 806 MHz	BTRC is planning to make the 700MHz band available for mobile services. BTRC will is working on the allocation framework and it is possible for BTRC to allocate this band in 2015-2016.	2015 – 2016

Table 2.15: BTRC activities related to spectrum allocation and utilisation *(cont.)*

Spectrum Band	Description	Priority/Timeline
806 – 816 MHz / 851 – 866 MHz	BTRC is evaluating the current utilisation of this band and may re-farm the band for other services.	2017 – 2019
825 – 845/ 870 – 890 MHz	BTRC may recover the spectrum assigned to PSTN operators and reserve for future IMT services	2015 – 2016
1710 – 1785 MHz / 1805 – 1880 MHz	BTRC is evaluating the maximum amount of spectrum it can allocate for mobile services. BTRC is also reviewing the services operators can offer using the 1800 MHz band.	2015 – 2016
1900 – 1910 MHz / 1980 – 1990 MHz	The 1900 – 1910 MHz and 1980 – 1990 MHz bands have been identified for IMT globally for TDD and MSS respectively. However, there is limited interest to implement IMT in these bands and BTRC does not expect to make any changes in the near future. However, further use of the band for PSTN is not encouraged and BTRC may recover underutilised spectrum from the PSTN operators.	2020 and beyond
2100 MHz	There is still spectrum leftover from the last 3G auction. BTRC will be making the remaining spectrum available to operators in the immediate future.	2015 – 2016
2300 MHz	There is still spectrum left over from the last BWA auction. BTRC is monitoring the demand for this band and will make the remaining spectrum available for IMT/ mobile broadband services in a timely manner.	2017 – 2019
2500 MHz	There is still spectrum left over from the last BWA auction. BTRC is monitoring the demand for this band and will make the remaining spectrum available for IMT/ mobile broadband services in a timely manner.	2017 – 2019
4500 – 4800 MHz	BTRC plans to allocate this band for satellite downlink.	2015 – 2016

Table 2.15: BTRC activities related to spectrum allocation and utilisation *(end)*

Spectrum Band	Description	Priority/Timeline
5150 – 5350 MHz & 5470 – 5725 MHz	BTRC is consider allocating the 5GHz bands for wireless LAN but it will first consider the impact on existing services.	2015 – 2018
6 GHz and below	WRC 2015 (Agenda 1.1) will deliberate the additional allocation for IMT services. Several bands in 6 GHz and below have been proposed for consideration. BTRC is involved in the WRC discussions and will provide and update after the conference. Any changes as a result of the WRC 2015 will not be implemented immediately since it will take time for equipment to become available and to reach certain scale.	2020 and beyond
57 – 63 GHz	Equipment vendors are developing wireless LAN hardware in this band and BTRC is monitoring the availability and cost of equipment. BTRC may consider opening this band for short-range devices when the equipment becomes available.	2017 – 2019

Table 2.16 describes the BTRC work activities for the next five years. These are activities planned to review existing spectrum policies and spectrum management practices.

Table 2.16: BTRC plans to review existing spectrum policies and spectrum management practices

Project	Description	Priority/Timeline
WRC 2015	ITU WRC 2015 will be held in 2015. BTRC is preparing the Bangladesh positions for WRC 2015. BTRC will provide an update on the Bangladesh positions and the WRC outcomes after the conference.	2017 – 2019
Neutrality	BTRC is considering adopting technology neutrality for commercial mobile services. BTRC will take into consideration licensing and competition issues.	2015 – 2017
Satellite spectrum sharing	BTRC will be formulating the criteria for spectrum sharing between satellite uplink and fixed services.	2015 – 2016
Assignment criteria for fixed point-to-point links	BTRC is reviewing the assignment criteria for fixed microwave links to improve the utilisation of spectrum.	2015 – 2016
Assignment criteria for land mobile services	BTRC is reviewing the assignment criteria for land mobile networks to improve the utilisation of spectrum.	2015 – 2016

Table 2.16: BTRC plans to review existing spectrum policies and spectrum management practices *(end)*

Project	Description	Priority/Timeline
Ultra-Wideband (UWB)	BTRC will be assessing whether to allow the use of UWB devices. BTRC is monitoring the technology development, device availability and emission standards adopted by other countries.	2017 – 2019
Guidelines for short-range devices (SRD)	BTRC will be issuing guidelines for SRDs.	2017 – 2019
TV Whitespace (TVWS)	BTRC is monitoring the development and adoption of LSA and TVWS internationally. BTRC will make provision for the introduction of TVWS devices when the technology and products become more mature.	2017- 2019
Advanced spectrum sharing techniques	BTRC is monitoring international development around spectrum sharing technique. BTRC does not expect these sharing arrangements to be implemented in the next few years but industry feedback will be sought at the right juncture.	2020 and beyond

2.5 Recommendations

BTRC has been making good progress in aligning its spectrum management with international best practices. The telecommunication industry is fast changing and projects such as mobile spectrum auctions, the launching of Bangabandhu satellite and the fibre network rollout all have an impact on the demand of radio frequency spectrum. Whilst there are challenges, BTRC is improving its spectrum management practices and working towards a more structure way of planning spectrum allocation by looking at international best practices. The subsections below provide recommendations on areas that BTRC may consider to further enhance its spectrum management practices.

2.5.1 Providing transparency through the spectrum master plan

BTRC has already taken steps to engage operators in some spectrum management processes such as the development of the NFAP, spectrum auctions and the spectrum pricing framework. However, the general industry sentiment is that more could be done to improve the industry consultation process. For example, after taking feedback from the industry, it is good practice to not just inform the industry about the decision but also to provide detailed explanation on its decisions.

BTRC can also provide greater transparency in spectrum planning and engage the industry in formulating its decision. In particular, operators have requested for the development of a spectrum roadmap to provide greater transparency in spectrum management process and to give operators some certainty in terms of spectrum availability.

Recommended actions

It is recommended that BTRC publish a Spectrum Master Plan document using subsection 2.2, 2.3 and 2.4 of this report as a foundation.

It is also recommended that BTRC invite feedback from the industry and other government users through a public consultation to ensure transparency and to capture any future potential requirements from spectrum users.

Since this document outlines BTRC priorities and work activities, it should be reviewed at certain intervals (in early 2017 and early 2019) to update the plans and any changes to the spectrum demand.

2.5.2 Automating the frequency assignment process

Frequency assignment is currently done manually and the records are not stored in a structured database. The implementation of a database and using frequency evaluation software will help to tighten the reuse of frequencies particularly for land mobile and fixed assignments. The use of the technical analysis software should result in greater spectrum efficiency – allowing each frequency to be assigned more times. It is noted that BTRC has access to ITU Spectrum Management System for Developing Countries (SMS4DC) as well as the TCI Automated Spectrum Management System (ASMS) that comes with the monitoring system.

Recommended actions

It is recommended that BTRC start transferring frequency assignment records into the SMS4DC or ASMS database. The use of technical simulation tools in these systems will help to improve spectrum efficiency and it will also raise the technical knowledge/capability of spectrum management staff.

2.5.3 Assignment criteria and guidelines

BTRC does not publish the frequency assignment process and criteria even though there are internal guidelines on spectrum assignment. It would be beneficial to provide the industry greater clarity in the frequency assignment process and criteria.

Recommended actions

It is recommended that BTRC prepare and publish guidelines to outline the assignment criteria particularly for land mobile and fixed services that are highly in demand by private entities as well as government agencies. Publishing the guidelines will help to reduce the number of frivolous requests – essentially discouraging companies who do not qualify to apply for frequencies from submitting their applications.

BTRC should also consider tightening the assignment criteria for land mobile and fixed services. For example, in some countries, land mobile networks need to have over certain number of mobile/portable units to qualify for a frequency operating at a higher power of 5W (ERP). Or fixed microwave frequencies in the 7 GHz band should be reserved for links greater than 20 km. Similarly for short-range devices (SRDs), BTRC may consider issuing guidelines to provide details such as technical parameters, usage permitted and equipment approval requirements.

2.5.4 Involving stakeholders in international spectrum coordination and harmonisation

Bangladesh shares common borders with India and Myanmar but there are currently no formal frequency coordination activities between Bangladesh and its neighbours. However, as operators are expanding their coverage along the border areas, more interference issues will start to emerge. Coordination also becomes crucial when bordering countries do not have similar spectrum allocation for a particular band. For instance, the use of 700 MHz band for mobile services in Bangladesh will need coordination with neighbouring countries (the band might be used for broadcasting services) to avoid interference issues along the border areas.

There are also considerable efforts at the international level, mainly through APT and ITU to harmonise the usage of spectrum. The ITU and APT discussions provide insights to potential future changes required for spectrum allocations. These are also useful platforms to understand the challenges faced by other regulators and to exchange ideas. However, following the development of various ITU studies and the associated WRC agenda items requires a lot of expertise and manpower. At this point, the level of involvement by BTRC, commercial operators and government agencies is low.

Recommended actions

BTRC is starting to engage its counterpart in India to discuss interference issues along the border areas. BTRC should consider working with its counterparts to formalise the coordination process to allow regular dialogues between the two sides. It is beneficial for BTRC to involve the operators at the coordination forums because some countries have found inter-operator coordination at the border area to be very effective.

For future APT and ITU WRC activities, BTRC may consider encouraging participation of both the public and private sectors. By involving the relevant parties, BTRC can become more effective at these international meetings to present its national positions and to understand the discussions happening within various sub-working groups. This will also help to raise awareness in the proposed changes to spectrum allocation and the challenges faced by other regulators.

2.5.5 Spectrum demand for mobile broadband services

As mobile operators expand their 3G coverage, the demand for mobile broadband will accelerate. Bangladesh still has a relatively low broadband subscriber base of about one million. Mobile broadband is likely to become the main broadband access option for many people in Bangladesh. With the rising number of subscriptions, mobile operators will put in more investments to upgrade and expand their networks. It is inevitable that they will need more spectrum resources to have sufficient capacity to meet customer demand.

Service convergence is blurring the line between mobile operators and BWA operators. The two groups will be targeting the same customers offering wireless Internet access. BWA operators are also expected to deploy LTE technology going forward and they can offer VoLTE to compete with mobile operators. Mobile operators on the other hand will be looking to use 2.3 GHz and 2.5 GHz for implementing LTE or LTE-A in the future.

Recommended actions

The demand for spectrum from mobile services has been strong. BTRC does have additional spectrum to help operators expand their network and to improve their services. BTRC needs to monitor the industry development and make the additional spectrum available in a timely manner.

The convergence of technology and services means that it will become more difficult for BTRC to separate mobile operators from BWA operators. When addressing the spectrum demand for mobile broadband services, BTRC should consider the total spectrum available including those allocated for BWA services. BTRC may consider making the remaining 2.3 GHz and 2.5 GHz available to both mobile operators and BWA operators for mobile broadband services. There is a possibility for the market to see some consolidation and BTRC will have to ensure that no single operator owns significantly more spectrum than other operators to hamper competition.

It is noted that state-owned Teletalk was awarded 3G spectrum prior to the auction. BTRC should also consider treating TeleTalk the same as other mobile operators. The industry expects fair competition and all mobile operators should have the same access to spectrum.

2.5.6 Addressing QoS issues

At over 116 million mobile subscribers, Bangladesh has one of the largest subscriber bases in the world. However, the amount of spectrum assigned to mobile operators is not high compared with other countries. This is partly due to the fact that mobile services are mainly used for voice communications and operators are still expanding their 3G coverage. There is also anecdotal evidence that drop call rate is high in Bangladesh and indoor coverage is generally poor.

Recommended actions

It is recommended that BTRC engage a third party to carry out an independent audit on the network service quality. This can be conducted by a university or any independent firm with the technical capability. BTRC can publish the results and raise greater awareness on the quality of service. This will encourage operators to compete based on quality of service. In some markets, having a better QoS and a brand image often allow a network operator to offer premium services and reduce churn. Operators will have to balance between investing in more base stations or to acquire more spectrum.

2.5.7 Allowing technology neutrality for commercial mobile services

Mobile licences are currently tied to a specific type of mobile technology. As highlighted in subsection 2.2.2, mobile technology is evolving rapidly and mobile operators should be encouraged to migrate their 2G customers to 3G, which is spectrally more efficient, and to re-farm their 2G spectrum for LTE rollout.

Recommended actions

BTRC should consider giving mobile operators more flexibility in using the spectrum assigned to them. This enables operators to invest in spectrally more efficient technology and improve the quality of service. Operators need sufficient lead time to plan their investment and get budget approval – operators may consider leapfrogging to LTE and lower their commitment in 3G and HSPA.

2.5.8 Managing broadcasting spectrum

The migration of analogue broadcasting to digital is currently managed by the MOICT and BTV. The current migration plan suggests that BTV will be using a multi-frequency network (MFN) approach. MOICT and BTV are keen to use the VHF band for digital TV since the cost of implementation is lower (better coverage). Since the band is already in use for analogue TV, MOICT and BTV have therefore decided to adopt the MFN approach. However, this means that the entire VHF TV band (174 – 230 MHz) will still be used to broadcast one BTV programme, which is not efficient. In countries where there are frequencies available for nationwide digital TV coverage, the single-frequency network approach is preferred as this requires only one frequency channel to carry multiple programmes.

At this stage, MOICT has not clearly indicated its plans to use the UHF band. The UHF is a prime band for different services and BTRC needs to ensure that the band is used efficiently. The plan to introduce digital audio broadcasting (DAB) is also unclear while some broadcasters are asking for spectrum to implement HD radio in the FM band.

Recommended actions

While the MOICT is responsible for broadcasting licensing matters, they expect BTRC to be able to provide the necessary spectrum to meet the national broadcasting needs. It is therefore imperative for BTRC to work closely with MOICT to understand their long term plans to ensure spectrum availability.

BTRC should ensure that spectrum is efficiently used in the process of transitioning TV broadcasting to digital. For example, newer standards (e.g., DVB-T2) should be considered since they provide better spectrum efficiency, allowing a higher data rate with the same spectrum.

BTRC may also consider working with MOCIT and BTV to work out a longer term plan to eventually move digital TV to SFN. This will free up spectrum for other applications (e.g. digital audio broadcasting). BTRC also needs to understand the government plans for utilising the UHF band. The UHF is high in demand by commercial applications as well as other government purposes. Moreover, TV white space devices are starting to emerge and there are ways to utilise the spectrum more efficiently.

It may not be possible for the implementation of DAB in the TV band III (174 – 230 MHz) if it is used for digital TV during the simulcast period. MOICT, BTRC, and broadcasters need to work out the plan for DAB before deciding on whether to encourage HD radio in the country. Both DAB in VHF band and HD Radio require consumers to buy new radios to receive the programs and having multiple systems may cause public confusion.

2.5.9 Spectrum sharing

Under the Bangladesh Telecommunication Act, Section 37 states:

"A licence or any right acquired there under, whether wholly or partly, shall not be transferable, and such transfer, if any, shall be void."

This means that spectrum trading and leasing are currently not permitted in Bangladesh. Due to the restriction under Section 37, BTRC currently does not allow any sharing of radio infrastructure (the active components such as radio transceivers and antennas). This limits the ability for mobile operators to share their infrastructure to improve the coverage. In some countries sharing of infrastructure is becoming common to lower the cost and improve coverage. This restriction also limits the ability for broadcasters to share the infrastructure to maximise the spectrum utilisation. For example, in the United Kingdom, and Germany, broadcasting spectrum is assigned to multiplexer operators Arqiva and Media Broadcast respectively. Spectrum efficiency is higher through these multiplexer operators since the same frequency is used to carry programmes from multiple broadcasters.

Going forward, with the development of cognitive radios and software-defined radios, new spectrum sharing methods are being tested out in some countries to maximise the use of spectrum.

Recommended actions

BTRC may consider reviewing its policy on spectrum and radio infrastructure sharing since sharing of these resources can result in more efficient use of spectrum, improvement in quality of service and lower the cost for operators. Spectrum sharing methods such as LSA and DSA (highlighted in section 2.4) are emerging and BTRC should monitor the development internationally and consider whether to adopt these methods.

2.5.10 Recovering spectrum and spectrum re-farming

Spectrum re-farming is an activity that the regulator has to undertake when there is a change in frequency allocation or when there is a need to allow spectrum to be freed up for new technologies that are more spectrally efficient. As BTRC tries to increase the amount of spectrum available to new services, it is inevitable that some spectrum bands have to be re-farmed.

Recommended actions

By planning ahead, BTRC can freeze a band for new assignments and allow existing users to have sufficient to migrate to alternative systems (preferably more than two years). BTRC may also have to provide alternative spectrum so that the affected users can continue their services. In some cases, there may be a need to compensate users for the costs incurred to transition to the new frequencies. BTRC may consider setting up a re-farming fund using the proceeds from spectrum auctions.

2.5.11 Strengthening spectrum management capability

To implement some of the recommendations highlighted in this document, BTRC will need to equip its spectrum managers with the knowledge and skillset to handle the changes. Spectrum managers need to develop expertise in four key functional areas:

- **Spectrum planning** of the future steps required to achieve optimal spectrum use by charting the major trends and developments in technology and considering the needs of current and future users of the radio spectrum.
- **Spectrum engineering** including the evaluation of information, capabilities and technology choices to support decisions affecting the allocation, allotment and assignment of radio spectrum. Identifying solutions to interference problems and technical compatibility among radio systems are key areas of focus.
- **Spectrum authorization/assignment** involves licensing of radiocommunication equipment and the making of frequency assignments.
- **Spectrum monitoring and compliance** activities help by avoiding incompatible frequency usage and through identification of sources of harmful interference.

There is also a need to develop expertise around services including mobile, fixed, broadcasting and satellite.

Recommended actions

BTRC may consider putting in place a structured training programme for spectrum managers. Learning how to use the spectrum management software will equip spectrum managers with radio interference management knowledge. Through attending the international meetings, spectrum managers are also exposed to international trends and future development related to spectrum use.

To develop knowledge around spectrum management practices and policies, BTRC can leverage ITU centres of excellence for spectrum management and request assistance from ITU to run spectrum management related workshops.

Abbreviations

ASO	Analogue Switch-off
CAS	Conditional Access System
NFAP	National Frequency Allocation Table
DSO	Digital Switch Over
DTTB	Digital Terrestrial Television Broadcasting (synonym to DTV)
DTV	Digital Terrestrial Television (synonym to DTTB)
DVB-H	Digital Video Broadcasting – Handheld (MTV standard)
DVB-T2	Digital Video Broadcasting – Terrestrial 2nd generation (DTTB standard)
EPG	Electronic Programme Guide
GE06	Geneva 2006 Agreement (Digital broadcasting plan in VHF and UHF in parts of Region 1 and 3)
ITU	International Telecommunication Union
ITU-R	ITU – Radiocommunication Sector
Mbit/s	Megabits per second
MPEG	Moving Picture Expert Group
MTV	Mobile Television
SDTV	Standard Definition Television
UHDTV	Ultra High Definition Television
UHF	Ultra High Frequencies (300 – 3000 GHz)
WRC	ITU World Radiocommunication Conference

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