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Spectrum Plan for the Accommodation of Broadband Wireless Access Services

Maintenance History		
Date	Change Details	Version
23-03-06	First Draft	1.0

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1 Background

The Government's National Information and Communications Technology (NICT) Strategy (*fastforward* strategy) is founded on the concept that information is critical to knowledge which in turn is crucial to the growth and development of Trinidad and Tobago. This Strategy provides the blueprint for a self-sustaining, knowledge-based society. It will be a major contributor in the country's drive for a prominent position in the global information society, and provide Trinidad and Tobago with a giant stride towards developed country status.

The *fastforward* strategy describes many 'pathfinder' projects which will allow Trinidad and Tobago to realize this NICT vision. One such project is the development of a Broadband Strategy. Such a strategy will aid in achieving the national connectivity agenda, which will:

- Provide all citizens with affordable Internet access;
- Focus on the development of skills for adults and children to ensure a sustainable solution and a vibrant future;
- Promote citizen trust, access, and interaction through good governance; and
- Maximise the potential within all citizens, and accelerate innovation, to develop a knowledge-based society.

In keeping with the *fastforward* initiatives and vision, the Telecommunications Authority of Trinidad and Tobago (hereafter called the Authority) has embarked on the liberalization of the telecommunications sector which will serve to facilitate telecommunications infrastructure growth essential for accessing information and the provision of communications services.

In the area of wireless technologies, this exercise began with the introduction of new Cellular Mobile Operators for the provision of a public domestic mobile telecommunications network and services.

This paper addresses proposed spectrum bands for Wireless Access Technologies and the approach proposed to be adopted by the Authority towards licensing of these bands.

In today's global society, the rapid evolution and deployment of wireless technologies, such as Cellular Mobile and Fixed Wireless Access, has contributed immensely to the growth in infrastructure as it is a more economical and feasible means of expanding public telecommunications networks and offering telecommunications and broadcasting services. This means of rapid roll-out of networks to facilitate access to telecommunications and broadcasting services is bringing countries closer to knowledge-based societies.

Wireless Access Technologies have been instrumental in extending the reach of information and communication to persons who were not able to access a landline (fixed) connection to public telecommunications networks and services. Wireless Access technologies have been increasingly deployed as an alternative last mile solution to the traditional 'wired' local loop access networks. Wireless Access technologies have evolved from offering 'narrowband' services only (i.e. Wireless Local Loop (WLL) services), such as voice telephony or dial-up internet access, to broadband services such as broadband Internet access and subscription television broadcasting services (e.g. wireless cable television). Today, Wireless Access technologies can be categorized as Fixed Wireless Access, Nomadic Wireless Access and Mobile Wireless Access, each category alluding to the level of mobility allowed by the Wireless Access technology. The commonality between them today is the ability to provide high capacity or broadband connectivity, thus allowing services such as broadband Internet and subscription television broadcasting to be offered. Consequently, the term **Broadband Wireless Access (BWA) technologies** shall be used to address any Wireless Access technology in this document, with services utilizing these technologies referred to as **Broadband Wireless Access (BWA) services**.

The Authority commenced the process of expanding the use of BWA technologies with a request for information to parties interested in using such technologies to provide public telecommunications services, in the form of an Expressions of Interest (EOI) for such parties to indicate the public telecommunications services and frequency spectrum of preference. A total of forty-nine (49) parties responded to the request for information and submitted Expressions of Interest. The information collated from this stage of the process was used to inform the BWA technologies, services and frequency spectrum captured in this framework.

2 Objectives

The Objectives of this Spectrum Plan are to:

1. Identify the frequency bands which will be allocated to the provision of BWA services, in accordance with the market and sector interests;
2. Indicate the process for licensing of the allocated frequency bands;
3. Specify the technical operating conditions and specifications to be imposed on the licensed radiocommunication systems in the allocated frequency bands.

3 Review Cycle

This document will be modified periodically to meet changing and unforeseen circumstances. The Authority, any entity in the telecommunications sector, or any appropriate industry forum may identify the need for modification. When a need for modification is identified, the identifying entity will submit the modification issue to the Authority. Modifications shall be made in a manner that is transparent, non-discriminatory and in the public domain.

Questions or concerns regarding the maintenance of this Spectrum Plan may be directed to the Authority.

4 The Consultation Process

The Authority will seek the opinion of stakeholders regarding the proposals made in this document, after which, this document shall be published as a utilized plan.

5 Considerations for the Provision of BWA Services

In addition to the information received from interested parties for the EOI conducted initially, the Authority considered the following:

- The spectrum utilized by the available and prominent BWA technologies;
- The telecommunication and broadcasting services which can be offered using BWA technologies;
- The availability of spectrum in Trinidad and Tobago to accommodate BWA services;
and
- The appropriate licensing process for assigning spectrum to users.

The following BWA technologies and their respective operating frequency ranges were identified from a review of current literature on the subject and also from the EOI stage of the process and are described in the table below.

BWA Technology	Operating Frequency Range
Code Division Multiple Access (CDMA) 450	410 – 490 MHz
Multichannel Video Distribution and IP Services	698 – 746 MHz
Wireless Fidelity (WiFi)	2400 – 2483.5 MHz
Multipoint Multichannel Distribution Service (MMDS), Worldwide Interoperability for Microwave Access (WiMAX)	2495 – 2690 MHz
Worldwide Interoperability for Microwave Access (WiMAX)	3400 – 3800 MHz
Wireless Fidelity (WiFi)	5150 – 5250 MHz
Wireless Fidelity (WiFi)	5470 – 5725 MHz
Wireless Fidelity (WiFi), Worldwide Interoperability for Microwave Access (WiMAX)	5725 – 5850 MHz
Multichannel Video Distribution and Data Services (MVDDS)	12.2 – 12.7 GHz
Local Multipoint Distribution Service (LMDS)	25.35 – 28.35 GHz

Table 1: BWA Technologies and Respective Operating Frequency Ranges

Subsequent to an assessment of the current spectrum occupancy of the operating frequency ranges for the various BWA technologies, the frequency bands which can be made available for licensing at this time were identified, as illustrated in the table below.

BWA Technology	Frequency Range Available for Licensing	Comments
Code Division Multiple Access (CDMA) 450	410 – 430 MHz	The recommended Licensing approach can be implemented at a later date pending verification of status of Licensees.
Multichannel Video Distribution and IP Services	698 – 746 MHz	The recommended Licensing approach can be implemented immediately.
Wireless Fidelity (WiFi)	2400 – 2483.5 MHz	The recommended Licensing approach can be implemented immediately.
Multipoint Multichannel Distribution Service (MMDS), Worldwide Interoperability for Microwave Access (WiMAX)	2495 – 2690 MHz	Discussions will be held with the Licensees in this Band with a view to implement a more efficient use of the band. The recommended Licensing approach can be implemented at a later date.
Worldwide Interoperability for Microwave Access (WiMAX)	3400 – 3800 MHz	Discussions will be held with the Licensees in this Band with a view to implement a more efficient use of the band. The recommended Licensing approach can be implemented at a later date.
Wireless Fidelity (WiFi)	5150 – 5250 MHz	The recommended Licensing approach can be implemented immediately.
Wireless Fidelity (WiFi)	5470 – 5725 MHz	The recommended Licensing approach can be implemented immediately.
Wireless Fidelity (WiFi), Worldwide Interoperability for Microwave Access (WiMAX)	5725 – 5850 MHz	The recommended Licensing approach can be implemented immediately.
Multichannel Video Distribution and Data Services (MVDDS)	12.2 – 12.7 GHz	The recommended Licensing approach can be implemented immediately.
Local Multipoint Distribution Service (LMDS)	25.35 – 28.35 GHz	The recommended Licensing approach can be implemented immediately.

Table 2: BWA Technologies and Spectrum Availability for Licensing

6 Proposed Frequency Band Plans for BWA Services

The various frequency bands allocated for the provision of BWA Services can be further sub-divided in frequency channel or block assignments, predicated on the type(s) of technologies which can be employed using the allocated spectrum. These frequency band plans are aimed at maximizing the efficient use of the allocated spectrum, especially for spectrum that is individually licensed.

The following sub-sections illustrate the various frequency band plans, the recommended licensing process and conditions, and the technical operating conditions and specifications for the radiocommunication systems operating in the stated frequency band.

6.1 400 MHz Band: 410 – 430 MHz

Frequency Band Plan

6.1.1 This frequency band plan is based on the use of CDMA 450 technology. The table below identifies the adopted band plan:

Subclass	Subscriber CPE Transmit Frequency / MHz	Base Station Transmit Frequency / MHz
D	411.675 - 415.850	421.675 - 425.850

Table 3: Frequency Band Plan, BWA Services, 400MHz Band

Recommended Licensing Process and Conditions

6.1.2 A moratorium shall be placed on the licensing of the 400 MHz band for BWA services until such time that spectrum can be made available to new users.

Technical Operating Conditions and Specifications

6.1.3 The technical operating conditions and specifications for radiocommunication systems operating in the 400 MHz band shall be indicated when spectrum can be made available to new users.

6.2 700 MHz Band: 698 MHz – 746 MHz

Frequency Band Plan

6.2.1 This frequency band plan would allow for the deployment of subscription broadcasting services and BWA services. The adopted band plan is identified in the table below and illustrated in the figure 1.

Block	Subscriber CPE Transmit Frequency / MHz	Base Station Transmit Frequency / MHz
A	698 – 704	728 – 734
B	704 – 710	734 – 740
C	710 – 716	740 – 746
D		716 – 722
E		722 – 728

Table 4: Frequency Band Plan, BWA Services, 700MHz Band

Lower 700 MHz Band Channelization



Source: FCC Report and Order 01-364

Figure 1: Typical UHF Band Channel Plan for Subscription Broadcasting and BWA Services

Recommended Licensing Process and Conditions

- 6.2.2 Assignment to a spectrum user shall be via a competitive licensing process.
- 6.2.3 The allocated spectrum in the 700 MHz band shall be licensed as three (3) 6MHz duplex frequency blocks (i.e. blocks A, B and C) and two (2) 6MHz frequency blocks (i.e. blocks D and E).
- 6.2.4 The allocated spectrum in the 700 MHz band shall be used for the provision of public telecommunications networks and services or broadcasting services.

Technical Operating Conditions and Specifications

- 6.2.5 All spectrum users shall adhere to the technical operating condition and specifications identified in the table below, in order to operate radiocommunication equipment in the 700 MHz band.

Parameter	Maximum Value	Comments
Maximum Effective Radiated Power (E.R.P.)	Fixed Station – 1kW Mobile Station – 30 W Portable(handheld) Station – 3W	
Modulation scheme	Digital	Any digital modulation technique e.g. BPSK, QPSK
Standardization	FCC	

Table 5: Technical Operating Specifications, 700 MHz band, BWA Services

6.2.6 Other technical operating conditions shall be specific to the radiocommunication system deployed.

6.3 2.4 GHz Band: 2400 MHz – 2483.5 MHz

Frequency Band Plan

6.3.1 This frequency band plan is based on the use of WiFi technology. The figure below illustrates the adopted band plan.

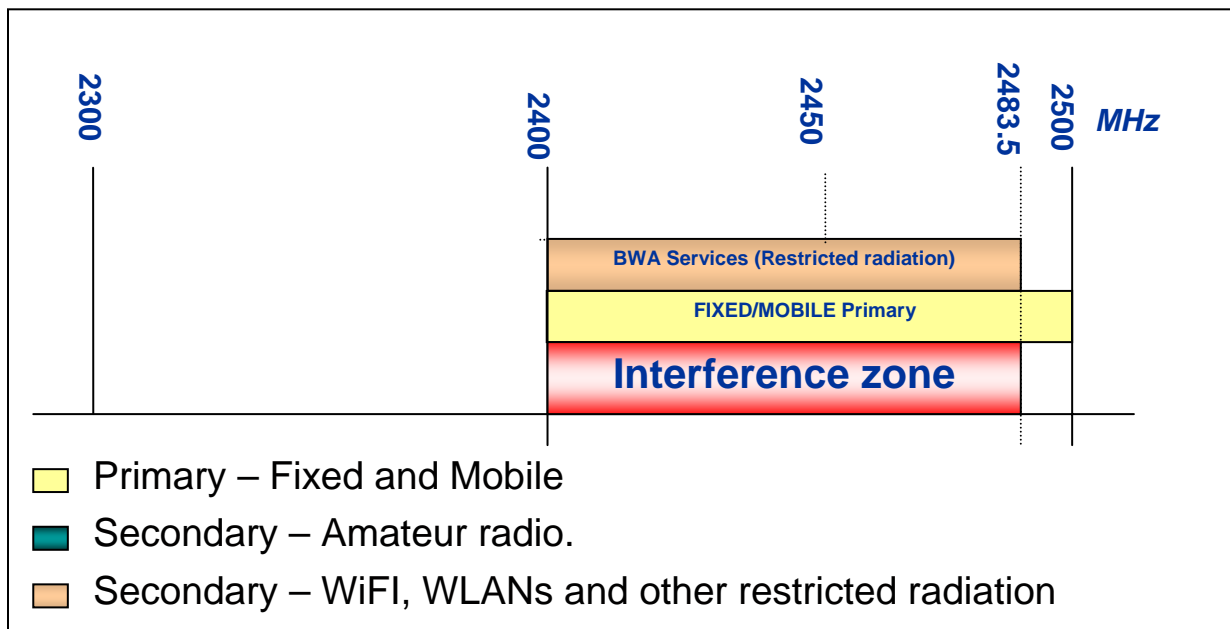


Figure 3: 2.4 GHz Typical Band Plan for BWA Services

6.3.2 The typical Band Plan for BWA technologies in this frequency range will be adopted. Therefore, the Band Plan for BWA services in the 2.4 GHz Band extends from 2400 MHz – 2483.5 MHz.

Recommended Licensing Process and Conditions

6.3.3 The spectrum allocated in the 2.4 GHz band shall be shared amongst spectrum users, via a class licensing process.

6.3.4 Individual or user licences will not be required in order to use radiocommunication equipment in the 2.4 GHz band.

6.3.5 Radiocommunication systems using the 2.4 GHz band can be used for both private or public telecommunications networks and services or broadcasting services.

Technical Operating Conditions and Specifications

6.3.6 All spectrum users shall adhere to the technical operating condition and specifications identified in the table below, in order to operate radiocommunication equipment in the 2.4 GHz band.

Parameter	Maximum Value	Comments
Peak Output power of Intentional Radiator	200mW	
Modulation scheme	Digital	Any digital modulation technique e.g. BPSK, QPSK
Multiple Access technique	Frequency Hopping Spread Spectrum (FHSS) Direct Sequence Spread Spectrum (DSSS)	
Minimum Channel Bandwidth	FHSS (20dB) – 25kHz DSSS (6dB) – 500kHz	FHSS shall use at least 15 well-defined, non-overlapping channels separated by the channel bandwidth. The dwell time per channel shall not exceed 0.4s within a period of 0.4n, where n is the number of channels employed

Parameter	Maximum Value	Comments
Frequency Range	2.4 – 2.4835 GHz	
Narrowband Transmitter spurious emission limits	Operating 30MHz – 1GHz = -36dBm 1GHz to 12.75GHz = -30dBm Standby 30MHz – 1GHz = -57dBm 1GHz to 12.75GHz = -47dBm	
Narrowband Receiver spurious emission limits	30MHz – 1GHz = -57dBm 1GHz to 12.75GHz = -47dBm	
Wideband Transmitter spurious emission limits	Operating 30MHz – 1GHz = -86dBm/Hz 1GHz to 12.75GHz = -80dBm/Hz Standby 30MHz – 1GHz = -107dBm/Hz 1GHz to 12.75GHz = -97dBm/Hz	
Wideband Receiver spurious emission limits	30MHz – 1GHz = -107dBm/Hz 1GHz to 12.75GHz = -97dBm/Hz	
Maximum Spectral Power density	FHSS – 100mW/100kHz DSSS – 10mW/1MHz	
Standardization	FCC	

Table 6: Technical Operating Specifications, 2.4 GHz band, BWA Services

6.4 2.5 GHz Band: 2495 MHz – 2690 MHz

Frequency Band Plan

6.4.1 This frequency band plan is based on the use of MMDS technology. The figure below illustrates the adopted band plan.

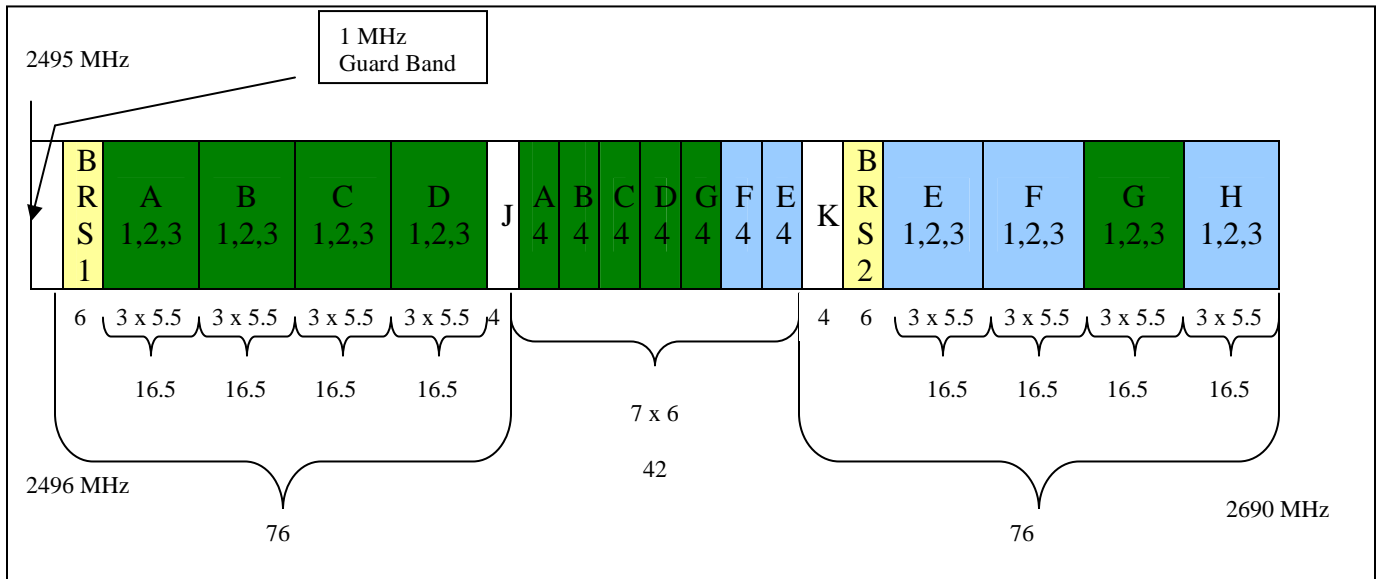


Figure 4: 2.5 GHz Typical Band Plan for BWA Services

6.4.2 The typical Band Plan for BWA technologies in this frequency range will be adopted. Therefore, the Band Plan for BWA services in the 2.5 GHz Band extends from 2495 MHz – 2690 MHz.

Recommended Licensing Process and Conditions

6.4.3 A moratorium shall be placed on the licensing of the 2.5 GHz band for BWA services until such time that spectrum can be made available to new users.

Technical Operating Conditions and Specifications

6.4.4 The technical operating conditions and specifications for radiocommunication systems operating in the 2.5 GHz band shall be indicated when spectrum can be made available to new users.

6.5 3.5 GHz Band: 3.4 GHz – 3.8 GHz

Frequency Band Plan

6.5.1 This frequency band plan is based on the use of MMDS technology. The typical Band Plan for the assignment of spectrum in this frequency range to BWA services is a block assignment Band Plan for the frequency range 3.4 – 3.8 GHz, as illustrated in Figure 5 below.

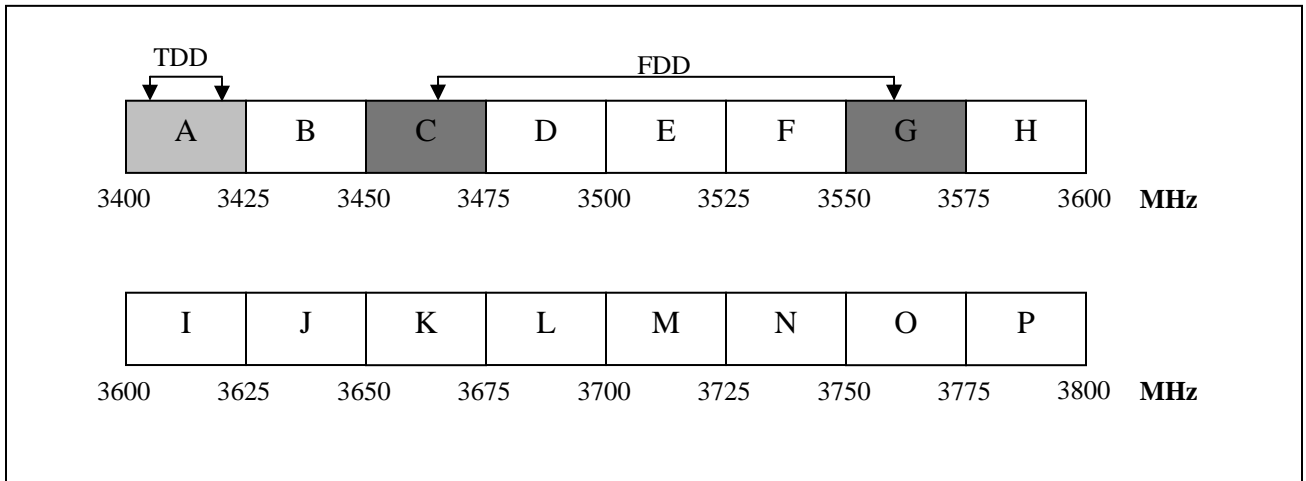


Figure 5: 3.5 GHz Typical Band Plan for BWA Services

6.5.2 The frequency range is divided in frequency blocks of 25MHz each. This arrangement allows the assignment of blocks to facilitate Frequency Division Duplex (FDD) radiocommunications systems, utilizing a frequency duplex

spacing of 100 MHz (e.g. – Block C paired with Block G. Time Division Duplex (TDD) systems or IEEE 802.16 (WiMAX) systems may operate in any 25 MHz block (e.g. Block A).

- 6.5.3 The typical Band Plan for BWA technologies in this frequency range will be adopted. Therefore, the Band Plan for BWA services in the 3.5 GHz Band extends from 3400 MHz – 3800 MHz.

Recommended Licensing Process and Conditions

- 6.5.4 A moratorium shall be placed on the licensing of the 3.5 GHz band for BWA services until such time that spectrum can be made available to new users. Is this applicable?

Technical Operating Conditions and Specifications

- 6.5.5 The technical operating conditions and specifications for radiocommunication systems operating in the 3.5 GHz band shall be indicated when spectrum can be made available to new users. Is this applicable?

6.6 5 GHz Band: 5150 MHz – 5850 MHz

Frequency Band Plan

6.6.1 This frequency band plan is based on the use of WiFi and WiMAX technology. The figure below illustrates the adopted band plan.

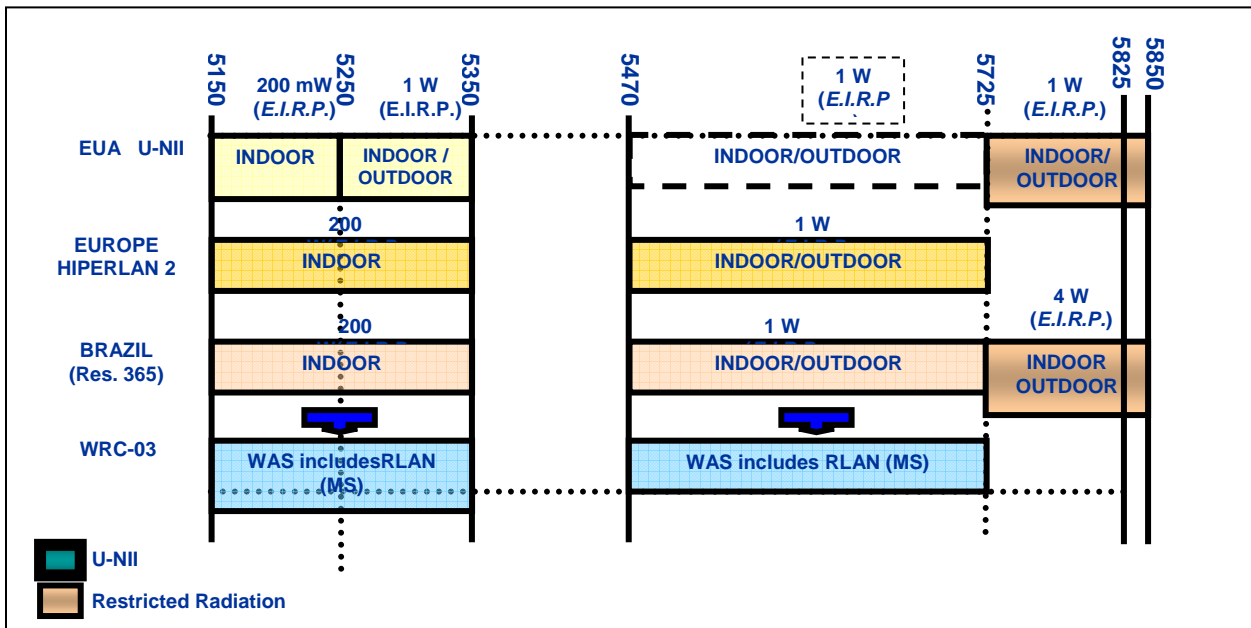


Figure 6: 5 GHz Typical Band Plan

6.6.2 The typical Band Plan for BWA technologies in this frequency range will be adopted. Therefore, the Band Plan for BWA services in the 5 GHz Band comprises the following frequency bands:

- 5150 – 5250 MHz;
- 5250 – 5350 MHz;
- 5470 – 5725 MHz;
- 5725 – 5850 MHz.

Recommended Licensing Process and Conditions

6.6.3 The spectrum allocated in the 5 GHz band shall be shared amongst spectrum users, via a class licensing process.

6.6.4 Individual or user licences will not be required in order to use radiocommunication equipment in the 5 GHz band.

6.6.5 Radiocommunication systems using the 5 GHz band can be used for both private or public telecommunications networks and services or broadcasting services.

Technical Operating Conditions and Specifications

6.6.6 All spectrum users shall adhere to the technical operating condition and specifications identified in the table below, in order to operate radiocommunication equipment in the 5 GHz band.

Parameter	Maximum Value	Comments
Peak Output power of Intentional Radiator	5150 – 5250 MHz – 200 mW 5250 – 5350 MHz – 200 mW 5470 – 5725 MHz – 1 W 5725 – 5850 MHz – 1 W	
Modulation scheme	Digital	Any digital modulation technique e.g. BPSK, QPSK
Multiple Access technique (WiFi and WiMAX Technology)	Frequency Hopping Spread Spectrum (FHSS) Direct Sequence Spread Spectrum (DSSS) Orthogonal Frequency Division Multiplexing (OFDM)	

Parameter	Maximum Value	Comments
Minimum Channel Bandwidth (WiFi and WiMAX Technology)	FHSS (20dB) – 25kHz DSSS (6dB) – 500kHz OFDM (20dB) – 1.25 MHz	FHSS shall use at least 75 well-defined, non-overlapping channels separated by channel bandwidth. The dwell time per channel shall not exceed 0.4s within a period of 30s
Operating Frequency Range (WiFi and WiMAX Technology)	5150 – 5250 MHz 5250 – 5350 MHz 5470 – 5725 MHz 5725 – 5850 MHz	
Narrowband Transmitter mask (WiFi technology)	Un-modulated $F_{tx} \pm 3 \text{ to } 14\text{MHz} = -49\text{dBm}$ Modulated $F_{tx} \pm 3 \text{ to } 8\text{MHz} = -32\text{dBm}$ $F_{tx} \pm 2 \text{ to } 14\text{MHz} = -35\text{dBm}$	
Transmitter Spectral Mask (WiMAX technology)	20 MHz Channelization: $F_{tx} \pm 9.5 \text{ MHz} = 0\text{dBm}$ $F_{tx} \pm 10.9 \text{ MHz} = -25\text{dBm}$ $F_{tx} \pm 19.5\text{MHz} = -32\text{dBm}$ $F_{tx} \pm 29.5\text{MHz} = -50\text{dBm}$ 10 MHz Channelization: $F_{tx} \pm 4.75 \text{ MHz} = 0\text{dBm}$ $F_{tx} \pm 5.45 \text{ MHz} = -25\text{dBm}$ $F_{tx} \pm 9.75\text{MHz} = -32\text{dBm}$ $F_{tx} \pm 14.75\text{MHz} = -50\text{dBm}$	
Transmitter spurious emission limits (WiFi Technology)	Operating 25MHz – 1GHz = -69dBm 1GHz to 40GHz = -63dBm Standby 25MHz – 1GHz = -90dBm 1GHz to 40GHz = -80dBm	

Parameter	Maximum Value	Comments
Receiver spurious emission limits (WiFi Technology)	25MHz – 1GHz = -90dBm 1GHz to 40GHz = -80dBm	
Maximum Spectral Power density (WiFi Technology)	FHSS – 1W/100kHz DSSS – 10mW/3kHz	
Standardization	FCC ETSI	

Table 7: Technical Operating Specifications, 5 GHz band, BWA Services

6.7 12 GHz Band: 12.2 GHz – 12.7 GHz

Frequency Band Plan

6.7.1 The typical Band Plan for the assignment of spectrum in this frequency range to BWA services is a block assignment Band Plan for the frequency range 12.2 – 12.7 GHz, as illustrated in Figure 7 below:

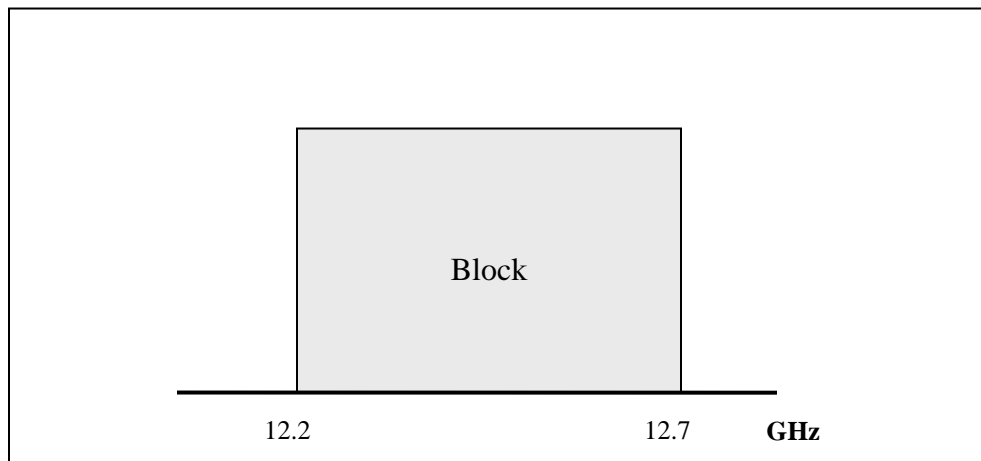


Figure 7: 12 GHz Typical Band Plan

6.7.2 The typical Band Plan for BWA technologies in this frequency range will be adopted. Therefore, the Band Plan for BWA services in the 12 GHz Band extends from 12.2 GHz – 12.7 GHz.

Recommended Licensing Process and Conditions

- 6.7.3 Assignment to a spectrum user shall be via a competitive licensing process.
- 6.7.4 The allocated spectrum in the 12 GHz band shall be licensed as one(1) 500MHz frequency block.
- 6.7.5 The allocated spectrum in the 12 GHz band shall be used for the provision of public telecommunications networks and services or broadcasting services.

Technical Operating Conditions and Specifications

6.7.6 All spectrum users shall adhere to the technical operating condition and specifications identified in the table below, in order to operate radiocommunication equipment in the 12 GHz band.

Parameter	Maximum Value	Comments
Maximum Effective Isotropically Radiated Power (E.I.R.P.)	-16dBW per 24 MHz	
Modulation scheme	Digital	Any digital modulation technique e.g. BPSK, QPSK
Standardization	FCC ETSI	

Table 8: Technical Operating Specifications, 12 GHz band, BWA Services

6.7.7 Other technical operating conditions shall be specific to the radiocommunication system deployed.

6.7.8 The frequency range 12.2 – 12.7 GHz is shared on a co-primary basis between terrestrial and satellite services, therefore, coordination of radiocommunication system for BWA services and satellite services will be required in accordance with the ITU-R Radio Regulations.

6.7.9 MVDDS fixed stations shall exist on a co-primary basis with non-geostationary satellite orbit fixed satellite services and direct broadcast satellite service in the frequency range 12.2 – 12.7 GHz. The necessary interference protection criteria shall be determined once a co-primary accommodation exists.

6.8 28 GHz Band: 25.35 GHz – 28.35 GHz

Frequency Band Plan

6.8.1 Due to the availability of spectrum in the frequency bands above 20 GHz in Trinidad and Tobago, the frequency range 25.35 GHz – 28.35 GHz can be allocated to LMDS. The following block assignment Band Plan will be utilized for two-way BWA services.

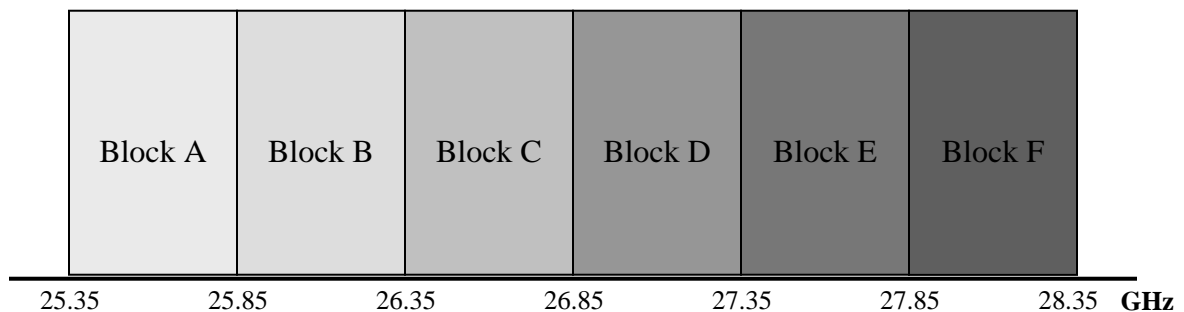


Figure 8: 28 GHz Typical Band Plan

6.8.2 The frequency range is divided in frequency blocks of 500MHz each, thus allowing for an estimated 100 channels per block, as identified below:

Block A:	25.35 - 25.85 GHz
Block B:	25.85 - 26.35 GHz
Block C:	26.35 - 26.85 GHz
Block D:	26.85 - 27.35 GHz
Block E:	27.35 - 27.85 GHz
Block F:	27.85 - 28.35 GHz

6.8.3 The typical Band Plan for BWA technologies in this frequency range will be adopted. Therefore, the Band Plan for BWA services in the 28 GHz Band extends from 25.35 GHz - 28.35 GHz.

Recommended Licensing Process and Conditions

6.8.4 Assignment to a spectrum user shall be via a competitive licensing process.

6.8.5 The allocated spectrum in the 28 GHz band shall be licensed as six(6) 500MHz frequency blocks (i.e. blocks A, B, C, D, E and F).

6.8.6 The allocated spectrum in the 28 GHz band shall be used for the provision of public telecommunications networks and services or broadcasting services.

Technical Operating Conditions and Specifications

6.8.7 All spectrum users shall adhere to the technical operating condition and specifications identified in the table below, in order to operate radiocommunication equipment in the 28 GHz band.

Parameter	Maximum Value	Comments
Maximum Effective Isotropically Radiated Power (E.I.R.P.) Density	Base Station: +55 dBW per carrier frequency Subscriber (CPE) Station: +30 dBW/MHz	
Minimum Height of Intentional Radiator (Antenna) above ground	30 metres	
Modulation scheme	Digital	Any digital modulation technique e.g. BPSK, QPSK
Standardization	FCC ETSI	

Table 9: Technical Operating Specifications, 28 GHz band, BWA Services

6.8.8 Other technical operating conditions shall be specific to the radiocommunication system deployed.

6.8.9 The frequency range 25.35 GHz - 28.35 GHz is shared on a co-primary basis between terrestrial and satellite services, therefore, coordination of radiocommunication system for BWA services and satellite services will be required in accordance with the ITU-R Radio Regulations.