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BHUTAN INFOCOMM AND MEDIA AUTHORITY

ROYAL GOVERNMENT OF BHUTAN

REGULATORY FRAMEWORK FOR 5G DEPLOYMENT IN BHUTAN

NOVEMBER, 2019

FOREWORD

In accordance with the Information, Communications and Media Act of Bhutan 2018 and the National Radio Rules and Regulations, the **"Regulatory Framework for 5G Deployment in Bhutan"** is hereby adopted as of 15th November, 2019.

(Chairperson)

BHUTAN INFOCOMM AND MEDIA AUTHORITY

1. INTRODUCTION

With the new demand of people in mobile technology such as more traffic volume, many more devices with diverse service requirements, better Quality of Experience (QoE) and better affordability by further reducing costs, will require an increasing number of innovative solutions. In order to cater new demand of people in mobile tehchnology, in 2015, the International Telecommunication Union – Radiocommunication sector ("**ITU-R**") officially adopted the term International Mobile Telecommunication beyond 2020 ("**IMT-2020**") as the vision for fifth generation ("**5G**") mobile networks and finalised the projected timeline towards IMT-2020. To meet the defined targets of 5G by ITU, 3GPP has structured the development work for 5G into two phases (i.e Release 15 and 16). Both Release 15 and 16 were initially targeted for completion by 2020.

Most of the developed countries have already launched 5G network or are in final stage of 5G trials. To align ourselves with the information technological development pace of other countries, it is necessary to prepare ourself for the deployment of 5G in Bhutan. We must learn from the experiences of overseas markets and take advantage of the increasingly mature 5G mobile ecosystem so that we would be able to reap the economies of scale from commercially available 5G equipment.

2. OBJECTIVES

The key objective for the deployment of 5G in Bhutan is to have national digital connectivity, where every citizen is connected with faster, reliable, innovative and efficient mobile broadband services at affordable prices in keeping with principles of Gross National Happiness(GNH). With the deployment of 5G, the following outcomes are expected:

i. Faster and reliable mobile broadband connectivity for every citizen of country at affordable price;
ii. Enhance the government to citizen digital services;
iii. Promote innovation for smart manufacturing, transport, efficient energy system and digital bussiness;
iv. Facilitate efficient allocation of scarce resources such as spectrum;
v. Support the growth of a vibrant ICT sector in Bhutan;

vi. Employment generation in ICT sector.

The 5G is the next generation of mobile technology and it is expected to deliver better and faster mobile broadband services with more devices connected to the network. More than higher speeds, 5G paves the way for new innovative applications that LTE (long term evolution) technology cannot support. The 5G network architecture will provide platform for service providers to customise their services to meet the demands of different end-users, thereby promoting the innovative services and applications. This will further drive the Bhutan's digital economy for the socio economic prosperity of the country.

3. 5G TECHNOLOGY OVERVIEW AND ITS SCOPE

IMT-2020(5G) is envisaged to expand and support diverse usage scenarios and applications that will continue beyond the current IMT. Furthermore, a broad variety of capabilities would be tightly coupled with these intended different usage scenarios and applications for IMT-2020 and beyond. The usage scenarios for IMT 2020 and beyond include:

i. enhanced Mobile Broadband ("**eMBB**");

5G is envisioned for able to deliver relatively high data rates (gigibits in second) where a 4K ultra high-definition ("UHD") movie could be downloaded in merely a few seconds, games could be played in the cloud with streaming delay of few milliseconds.

ii. ultra-Reliable and Low Latency Communications ("**uRLLC**");

Several scenarios require the support of very low latency and very high communications service availability. These are driven by the new services such as industrial automation. For instance, in the context of remote control for process automation, a reliability of 99.9999% is expected, with a user experienced data rate up to 100 Mbps and an end-to-end latency of 50 ms.

iii. massive Machine Type Communications ("**mMTC**") or massive Internet of Things (**mIoT**);

5G would enable more devices to be connected to internet with higher throughput, lower lantency, better reliability and better network flexilibity. With more devices connected to internet, wide deployment of IPV6 has become vital.

In order to support these usage scenarios, 5G will need to deliver superior, secure and resilient performance as compared to its predecessors. ITU has also defined eight key targets for 5G to meet and improve upon, as shown in Figure 1.

The following eight parameters are considered to be key capabilities of IMT-2020:

i. Peak data rate under ideal condition per user /device (in Gbit/s);
ii. User experienced data rate across the coverage area to a mobile user/device (in Mbit/s or Gbit/s);
iii. Latency (in ms);
iv. Mobility(in Km/h);
v. Connection density;

Total number of connected and/or accessible devices per unit area (per km^2).

vi. Energy efficiency;

Energy efficiency has two aspects:

- On the network side, energy efficiency refers to the quantity of information bits transmitted to/ received from users, per unit of energy consumption of the radio access network (RAN)(in bit/Joule);
- In the device side, energy efficiency refers to quantity of information bits per unit of energy consumption of the communication module (in bit/Joule).

vii. Spectrum efficiency;

Average data throughput per unit of spectrum resource and per cell3 (bit/s/Hz).

viii. Area traffic capacity;

Total traffic throughput served per geographic area (in Mbit/s/m^2).

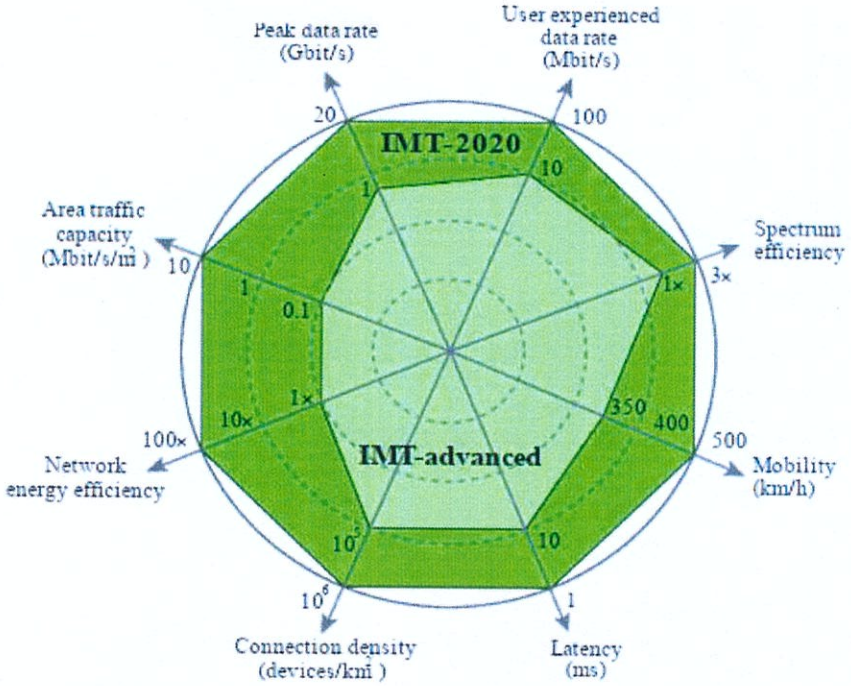


Figure 1: Enhancement of key capabilities from IMT-Advanced to IMT-2020 [1].

Some of the technologies that are expected to play a vital part in 5G include Software-defined Networks ("**SDN**"), Network Functional Virtualisation ("**NFV**"), network slicing, Multiple-Input Multiple-Output ("**MIMO**"), scalable Transmission Time Interval ("**TTI**"), 3D beamforming and small cells. There will be a new radio airinterface termed as the 5G New Radio ("**NR**"), and a cloud-native, Service-based Architecture ("**SBA**") core network.

[1] Recommendation ITU-R M.2083-0 (09/2015), IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond.

4. NON-STAND ALONE (NSA) VERSUS STAND-ALONE (SA) ARCHITECTURES

Based on 3GPP technical report TR 21.915 V1.0.0 (2019-03) for release 15, Non-standalone archintecture (NSA) and Stand-alone architecture (SA) are defined as follows:

i. Non-standalone architecture (NSA);

5G network architecture where the 5G Radio Access Network (AN), also called New Radio (NR) is used in conjunction with the existing LTE and EPC infrastructure Core Network (respectively 4G Radio and 4G Core), thus making the new 5G-based radio technology available without network replacement.

5G NSA will enable the provision of eMBB services through the use of large bandwidths and hardware improvements at the edge networks (e.g. using massive MIMO and advanced antenna techniques), but also leverages existing 4G network for connectivity.

ii. Stand-alone architecture (SA);

Network architecture, where the NR(New Radio) is connected to the 5G core network. 5G SA will bring about a brand new end-to-end network architecture and will deliver the full capabilities and performance of 5G such as network virtualisation, intelligence at network edges, and dynamic provisioning of differentiated services for different use-cases.

3.1 Network Slicing

A network slicing is where a single physical network infrastucture is segmented into multiple virtual ntworks. There can be a differrent network slice for differrent application like network slice for IoT/sensors, mobile data, video streaming and mission critical. This can enable the operators to customise the services to meet the demands of their customers and the operators will be able to provide diverse use-cases with different performance requirements as shown in figure 2. The different slices can be used simultaneously.

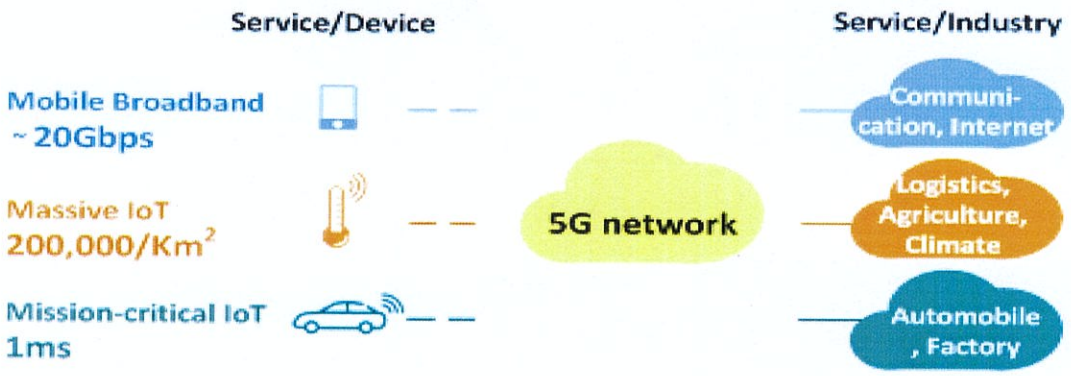


Figure 2: Network slicing (source : google)

5. THE DEVELOPMENT OF 5G IN INTERNATIONAL LEVEL

The vision and capabilities of 5G have been defined by the International Telecommunications Union (ITU) in its 'IMT-2020' specification. The 3GPP (3rd Generation Partnership Project), an industry driven standardisation body, is currently developing standards for 5G to reflect the ITU requirements. The 3GPP uses a system of parallel "Releases", with each Release describing a firm set of features and specifications which provides developers with a stable platform for the implementation of features at a given point in time and allows the addition of new functionality in subsequent Releases.

i. To meet the defined targets of 5G by ITU, 3GPP has structured the development work for 5G into two phases (i.e Release 15 and 16) . Both Release 15 and 16 were initially targeted for completion by 2020. However, in December 2018, 3GPP delayed Release 15 till March 2019 and Release 16 till March 2020 to ensure better stability and compatibility for future Releases. Development of 5G is expected to continue beyond Release 16 so that any enahancemets to be made can be incorporated in subsequent Releases.

ii. Even though the full 5G standards have yet to be finalised, some operators of third countries like Canada,China,France,Germany,Japan,Russia ,Singapore,South korea, UK and US have already carried out trials on 5G or launched 5G services.

6. TIMELINE FOR 5G DEPLOYMENT IN BHUTAN

Bhutan being developing country, doesnot have domestic network equipment vendors, chipset manufacturers and device vendors. Therefore, the early deployment of 5G will not be feasible at this stage and we may consider deploying 5G only after 2020 to reap the benefit from the globally and regionally harmonised spectrum outcomes of the 2019 World Radiocommunication Conference ("WRC-19"). Deployment after 2020 would also allow Bhutan to learn from the experiences of overseas markets and take advantage of the increasingly mature 5G mobile ecosystem so that we would be able to reap the economies of scale from commercially available 5G equipment.

Making radio frequency spectrum avialable for 5G is the first step towards enabling the deployment of 5G networks and the provision of 5G services in Bhutan. Besides commercial readiness of 5G technology, the Authority will address issues such as harmnoisation of 5G spectrum with neighbouring countries, Spectrum refarming for 5G use, regional and international spectrum harmonisation when allocating the spectrum for 5G.

Taking considersation of 5G development at international level, projection for the deployment of 5G in Bhutan would be in around 2022 with wider scale deployment from 2024/2025 onwards.

7. REGULATORY MECHANISM FOR NURTURING 5G ECOSYSTEM IN BHUTAN

The following regulatory mechanism shall be adopted to nurture the 5G ecosystem in Bhutan:

i. Facilitate the deployment of 5G in Bhutan as per the international best practices and standards;
ii. Facilitate sustainable competition among the Telecom Service Providers(TSPs);
iii. Impose regulatory requirements to ensure 5G networks remain resilient and trusted;
iv. Provide platform for the growth of innovation and expertise (and quality) of the workforce in 5G and future of networks.

i. Facilitate the deployment of 5G in Bhutan as per the international best practices and standards.

The Authority seeks to facilitate the commencement of 5G network rollout from 2020 onwards, after the finalisation of spectrums for 5G during WRC-2019 and finalisation of 5G standards by 3GPP. At a same time , the Authrotiy would like to ensure that the deployment of 5G in Bhutan can be followed by learning from the experiences of overseas markets and take advantage of the increasingly mature 5G mobile ecosystem so that we would be able to reap the economies of scale from commercially available 5G equipment. The Authority will facilitate in buidling efficient and resilient 5G Infrastructure and will also encourange the infrastructure sharing and network sharing.

ii. Facilitate sustainable competition among the Telecom Service Providers(TSPs).

The Authority believes that sustainable competition between the services provider will provide better choice to customer with the innovative, reliable and better quality of services at a affordable prices. While promoting the competition between the TSPs, the Authority beleives that the financial sustainability of TSPs and the available Spectrum resource of 5G must be taken into due consideration.

iii. Impose regulatory requirements to ensure 5G networks remain resilient and trusted.

The Authority will come up with certain baseline regulatory requirements for compliance to ensure that 5G networks are trusted and resilient.

iv. Provide platform for the growth of innovation and expertise (and quality) of the workforce in 5G and future of networks.

The Authority shall provide platform for the growth of innovation and expertise of the workforce in 5G and future of networks by waiving off the Licenese spectrum fee for 5G trials and demonstrations. Further ,the Authority encouranges the research on 5G technology by making an easy access in getting perimit for reasearch on 5G technology. Such regulatory licensing mechanism will enhance in promoting innovation and workforce in 5G and future of networks.

8. SPECTRUM ALLOCATION FOR 5G

Our one of the main objective for coming up with this framework is to ensure that spectrum is made available in the most appropriate and timely way to enable investments, innovation and competition in the development of 5G services to benefit consumers and businesses.

Unlike our current mobile network, 5G is projected to operate in a mix of frequency bands with different propagation characteristics as shown in Table 1. The different spectrum band at low, mid and high frequencies has been identified as Spectrum band for 5G technology which have different characteristics and can be used to deliver different benefits. This spectrum mix includes radio frequencies below 1 GHz to support massive IoT applications, frequencies from 1 to 6 GHz for enhanced mobile broadband and mission control, and high frequencies above 6 GHz for dense networks (commonly known as the millimetre wave or mmWave band). The low frequencies have better propagation properties, and are ideal for wide geographical coverage and good in-building penetration with fewer cells. The above-1 GHz spectrum is typically used for capacity enhancements.

Table 1 : Overview of spectrum bands identified for 5G services in Bhutan

Sl. No		Spectrum band	Frequency range	Duplex Mode	Amount of Spectrum available	Remarks
1	Low band(below 1 GHz)	700 MHz	UL:703MHz–748 MHz DL:758MHz–803 MHz	FDD	90 MHz	-curently allocated for 4G mobile services; -band plan as per 3GPP n28.
2	Miduim band (1 GHz to 6 GHz)	2.1 GHz	UL:1920MHz–1980MHz DL:2110MHz–2170MHz	FDD	120 MHz	-currently allocated for mobile service; -band plan as per 3GPP n1.

		2.6 GHz	UL:2500MHz–2570MHz DL:2620MHz–2690MHz	FDD	140 MHz	-currently allocated to mobile, fixed statellite and broadcasting satellite; -band plan as per 3GPP n7.
			2496 MHz – 2690 MHz	TDD	194 MHz 110 MHz As of now.	-currently allocated to mobile, fixed statellite and broadcasting satellite; - band plan as per 3GPP n41.
		3.5 GHz	3400 MHz – 3700 MHz	TDD	200 MHz	-currently allocated for radiolocation, fixed satellite,fixed and mobile; -band plan as per 3GPP n78.
		4.5 GHz	4400 MHz – 5000 MHz	TDD	600 MHz	-currently allocated forfixed,fixed satellite and mobile; -band plan as per 3GPP n79.

3	High band (above 6 GHz)	26GHz	24300MHz–26700 MHz	TDD	2400 MHz	-currently allocated for Radionavigation, fixed,mobile,fixed satellite and inter-satelllite; -band plan as per 3GPP n258.

8.1 Low Band (frequency below 1 GHz)

Sub-700 MHz band

The ecossytem of mobile service in sub-700 MHz is still not matured enough and the allocation of sub-700 MHz band for 5G would not be feasable at this juncture. However, 700 MHz has been identified by the European Commission for 5G and over the last few years, there have been a number of auctions in the 700 MHz band carried out in Europe. In view of the above, the Authority will continue to monitor international trends and developments in the sub-700 MHz band and consider further re-farming in this band when the environment is more ready.

8.2 Meduim band (freqeuncy range from 1 GHz – 6 GHz)

2.1 GHz band

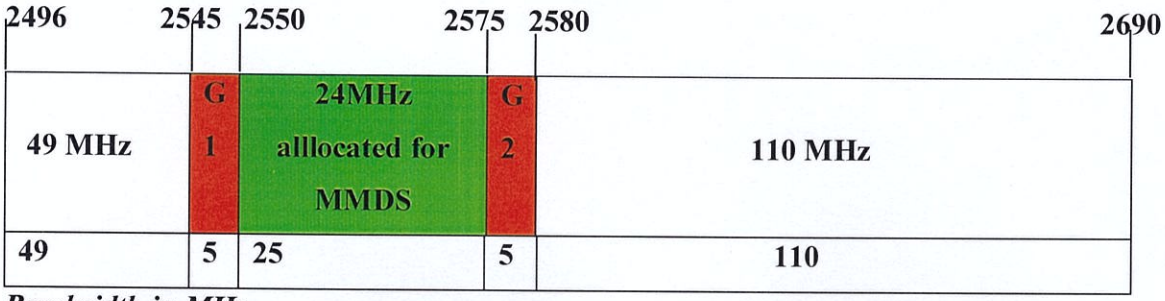
At present, the 2.1 GHz band is primarily used for 3G mobile services in Bhutan and the 2.1 GHz band i.e 3GPP Band 1 has already been adopted as a 5G NR band. The Authority has identified 2.1 GHz band as a candidate band for 5G deployment in Bhutan but the 5G deployment in this band will be feasible only after 2020 since the Authority is of view that the band is required for continued provisioning of 3G services until 2025 and beyond.

2.6 GHz band

The Authroity has also identified 3GPP band7 (2500 –2560 / 2620 –2680 MHz) and 3GPP band41(2496 –2690 MHz) as candidate bands for deployment of 5G services in Bhutan. However, the portion of 2.6 GHz TDD is currently allocated for Wireless Broadband Access (WBA) and MMDS(Multichannel Multipoint Distribution Service) in Bhutan. However, the Authority will review and further refarm the 2.6 GHz band in future when the demand in 2.6 GHz for 5G network increases .

Proposed 2.6 GHz TDD Band Plan

Frequency in MHz

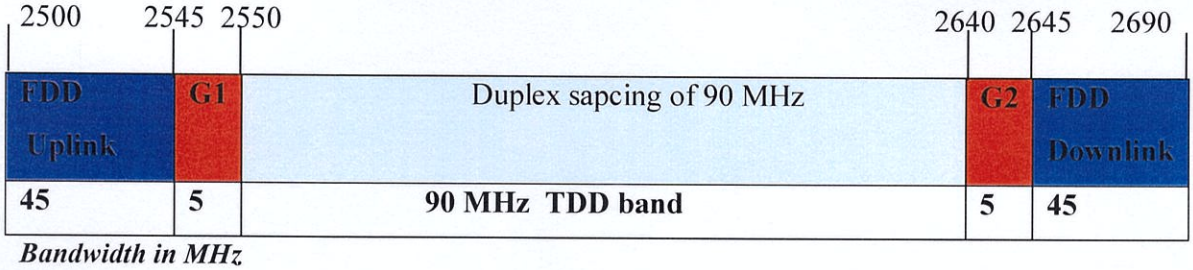


Bandwidth in MHz

G1 and G2 are 5MHz Guard bands, which separate the MMDS from other TDD services.

Proposed 2.6 GHz FDD band plan

Frequeny in MHz



Bandwidth in MHz

G1 and G2 are 5MHz Guard bands, which separate the MMDS from FDD Uplink and Downlink frequency.

3.5 GHz band

The 3.5 GHz band is the current frontrunner 5G band which has a mixed advantages of both capacity and coverage over low and high band. It is predicted that the spectrum holding of less than 40 MHz would not give throughput speeds that are noticeably different from 4G today. As per the 3GPP TR 21.915 V1.1.0 (2019-03), the maximum single carrier size for the 3.5 GHz band is 100 MHz, which will allow a peak downlink throughput of 1750 Mbps per user per cell. However, due to limited spectrum in 3.5GHz, lower carrier size of 50 MHz can considered which would be able to deliver theoretical peak downlink throughput of 850 Mbps. The throughput of 50 MHz carrier size in 3.5 GHz can be improved with the implementation of higher order antennas (e.g., 64 receive,64 transmit antenna which is also known as 64T64R) as illustrated in the table given below:

Table 2: Theoretical Throughput for 50 MHz and 100 MHz based on 16T16R, 32T32R and 64T64R Antennas.(Based on figure 4 of consultation paper issued by the Info-Communications Media Development Authority,Singapore);

Channel bandwidth	3.5 GHz throughput per cells (Mbps)		
	16T16R	32T32R	64T64R
50 MHz	850	1700 (850 per user)	3400 (850 per user)
100 MHz	1750	3500 (1750 per user)	7000 (1750 per user)

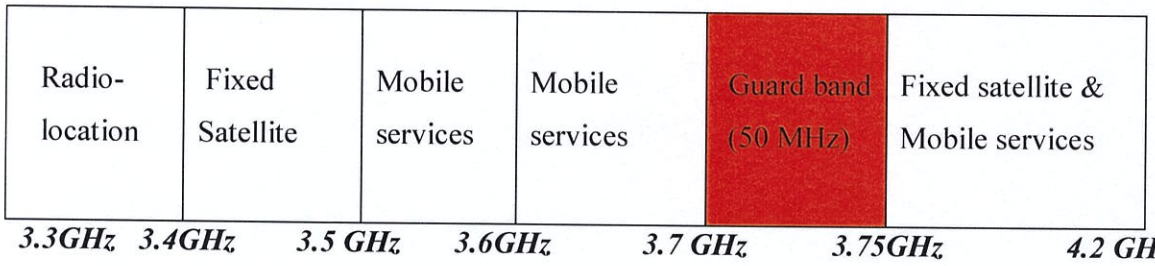
3.5 Band Plan

Current Allocation

Radiolocation	Fixed satellite	Fixed satellite & Mobile services	Fixed satellite & Mobile services	Fixed satellite & Mobile services

3.3GHz 3.4GHz 3.5 GHz 3.6GHz 3.7 GHz 4.2 GHz

Proposed Band Plan



4.5 GHz band

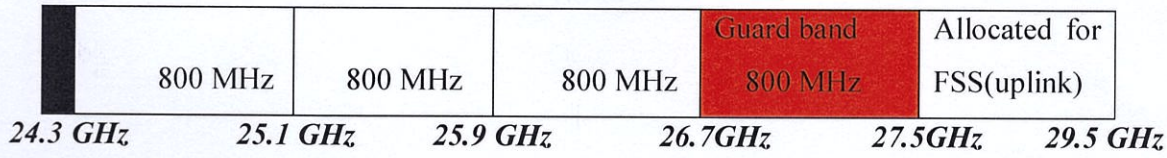
The 4.5 GHz band has potential for long term 5G development and the 3GPP has identified NR operating band "n79" (i.e., 4.4 – 5.0 GHz)as 5G NR candidate in 3GPP Release 15 specification which will be used in TDD mode. Currently frequencies within this band are allocated for fixed, fixed satellite and mobile services. The Spectrum in 4.5 GHz band for 5G services will be avialable only after cross border- coordination and migration of curent users. Therefore, the availability of spectrums in the 4.5 GHz band for 5G deployment may take at least 2 – 4 years.

8.3 High frequencies (frequency above 6 GHz)

The Milllimeter Wave (mmWave) bands provides extremely high data rate and capacity, complementing the sub-6 GHz bands that deliver coverage and service continuity. However, due to propagation charatceristic of mm wave, there is need for wider deployment of small cells. The millimeter wave band of 26GHz has been identified for 5G deployment in Bhutan.

Proposed Band Plan in 26 GHz

The 3GPP has adopted a component carrier bandwidth of 400 MHz in the mmWave bands for 5G NR which can be aggregated to provide even larger contiguous bandwidths. Therefore, the Authority plans to make atleast 2400 MHz in 26 GHz available for 5G deployment.



9. REGULATORY REQUIREMENT

The following regulatory requirement shall be adopted during the deployment of 5G in Bhutan:

a. 5G networks based on best practices and technical specifications from relevant standards bodies and forums, such as 3GPP,IETF, ETSI, and IEEE and comply the Authrotiy's regulatory requirements.
b. The Authority reserves right to impose the Quality of service (QoS) requirement when there is greater certainty on 5G demand.
c. The EMF exposure levels for 5G network shall be one tenth of the international exposure limits set by the International Commission on Non-Ionising Radiation Protection ("ICNIRP") and IEEE.

10. SPECTRUM FOR 5G TRIALS

The 5G development around the world is gaining momentum and most developing countries are in trail phase of 5G at this juncture. With this trend , the Authority would like to support the 5G trials in our country by making the following spectrums available for 5G trials in Bhutan. The Spectrum fees for 5G trials will be waived off to facilitate the growth of innovation and expertise (and quality) of the workforce in 5G and future of networks.

The Spectrums considered for 5G trials are as follows:

i. 2.6 GHz

The frequencies range from 2580 MHz to 2690 MHz.

ii. 3.5 GHz

The frequencies range from 3500 MHz to 3700 MHz.

- Recommended carrier channel width of 50 MHz or 100 MHz.

iii. 26 GHz

The freqeuncies range for 26 GHz: 24.3 GHz to 26.7 GHz.

-Recommended carrier channel width of 400 MHz .