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BHUTAN INFOCOMM AND MEDIA AUTHORITY

ROYAL GOVERNMENT OF BHUTAN

Identification of mmWave Frequency Spectrum Band in 26GHz for International Mobile Telecommunication (IMT) Services in Bhutan

October 2023

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1. Background

With the increase in the demand for mobile broadband services, issues of degrading Quality of Service (QoS) delivered to the subscribers are increasing. The telecom operators have been working with the Bhutan InfoComm and Media Authority to address the network QoS issues and to provide better services to the subscribers. The Authority facilitates the telecom operators to provide better QoS to the subscriber through numerous ways. The network densification, through deploying more mobile network infrastructure is one of the solutions to enhancing the mobile broadband QoS. However, owing to the limited land space and Right of Ways issues, especially in the urban areas, has significantly posed challenges to the telecom operators in expanding their mobile broadband networks and ensuring the mobile QoS.

The other solution to solving such issues is through enhancing the network capacity by making available the frequency spectrum and issuing more frequency spectrum to the telecom operators. The telecom operators in Bhutan have deployed mid 3.5GHz (n78) for 5G Non-Standalone (NSA) and may require additional spectrum in near future for the expansion of 5G services and enhancing its QoS. Globally, most of the regulators have released the spectrum to deploy 5G and they have released spectrum mostly in mid 3.5GHz, 700MHz and mmWave frequency bands. The spectrum in 26GHz (n258 band) which is generally a part of the mmWave frequencies, is also considered suitable for deploying the 5G services globally. Being able to deploy 5G in the n258 band may enhance the network capacity of mobile broadband services in the country. However, in order to deploy the n258 band for IMT services especially for 5G services, there is a requirement to formulate the frequency band plan, the methods of assignment and limitations if applicable.

In this regard, the Authority has identified a spectrum band in mmWave frequency for potential use for the IMT services, in particular, the 5G services.

2. Legal Basis

This frequency band plan is prepared as per the:

a. Section 165 and 166 of the Information, Communication and Media Act of Bhutan 2018, which requires the Authority, from time to time, prepare a frequency band plan in respect of any part of radio frequency spectrum,

b. Subsection 1.2(a) of the chapter I of the National Radio Rules and Regulations 2021 (NRRR 2021) which requires the Authority to prepare frequency band plans.

This band plan shall be the part of Schedule A of National Radio Rules and Regulations (NRRR 2021).

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3. Title and Commencement

This band plan shall come into force on the …………………, corresponding to the ……… day of the ……. Month of Bhutanese ……… Year.

4. Scope of Application

This band plan shall apply to:

a. Any individuals, entity and organizations involved in the use and management of radio frequencies in Bhutan, and

b. All matters by any individuals, entities and organizations related to the radiocommunication within or from the territory of Bhutan, its atmosphere and its outer space, to stations and devices using radio spectrum.

And shall be read in conjunction with all other existing codes of practice, Rules and Regulations established by the Authority.

5. mmWave

Millimeter wave (mmWave), also known as millimeter band, is the band of spectrum whose wavelength ranges between 10 millimeters and 1 millimeter. In terms of frequency, the spectrum band ranges from 30 GHz to 300 GHz. However for cellular mobile networks, mmWave's frequency spectrum is considered to be ranging from 24 GHz to 100 GHz.

mmWave delivers large quantities of spectrum and capacity over the shortest distances. Spectrum allocations for mmWave are often extremely wide, with most recommending 800 MHz or more frequencies per service provider. This enables the provision of high capacity delivery and improved handling of peak data rates. Wide radio carriers are defined for the high band to be used within wide spectrum allocations. These wide carriers enable shorter transmission time intervals and lower radio-interface latency to facilitate the introduction of and support for low-latency-sensitive applications.

The expected capabilities of deploying 5G in mmWave are as follows[1]:

a. Peak throughput per sector is of the order of 5 Gbit/s,

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1 https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2017/Spectrum%20Management/Simoni%20-%20Future%20use%20of%20millimetre%20waves%20in%205G%20v1.1.pdf

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b. Single user peak throughput of the order of 2-3 Gbit/s,

c. Average throughput per sector is expected of the order of 1 Gbit/s,

d. These throughput can be reached with Carrier Aggregation of multiple bandwidths,

e. 8 x 100 MHz contiguous channels to get 5 Gbit/s,

f. Such channel bandwidths can be reached only in mmWave bands,

g. High modulation schemes both in upload and download.

6. WRC-19 Decision on mmWave Allocations

Under the Agenda Item 1.13 of the World Radiocommunication Conference 2019 (WRC-19), the allocation of n258 band to IMT has been thoroughly discussed. The 5G spectrum in mmWave bands above 24 GHz was one of the most important agenda item of WRC-19 (1.13)[2].

WRC-19 identified additional globally harmonized (mmWave) frequency bands for IMT, including IMT-2020 (otherwise known as 5G mobile), facilitating diverse usage scenarios for enhanced mobile broadband, massive machine-type communications and ultra-reliable and low-latency. The WRC-19 had identified the following bands for IMT:

a. 24.25 - 27.5 GHz (26 GHz)

b. 37 - 43.5 GHz (40 GHz)

c. 45.5 - 47 GHz & 47.2 - 48.2 (50 GHz)

d. 66 - 71 GHz for IMT (70 GHz)

However, the key issue at the WRC-19 was to decide the power limits and other conditions to protect satellites in the same and adjacent bands. The main issue for 5G spectrum in 26 GHz band (24.25-27.5 GHz) at WRC-19 was the Protection of Earth Exploration Satellites (EESS) in adjacent band (23.6- 24 GHz) and Fixed Satellites (FSS) in band (24.25-27.5 GHz). During the discussions leading up to the WRC-19, divisions stemmed from polarized views on how to protect the EESS operating in the adjacent 24 GHz band – providing scientific services such as data collection for predictive weather warning systems – from harmful interference by 5G base stations.

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[2]https://www.itu.int/en/mediacentre/Pages/2019-PR24.aspx#:~:text=WRC%2D19%20identified%20additional%20globally,and%20ultra%2Dreliable%20and%20low%2D

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After four weeks of intense negotiations (and months of debate beforehand), WRC-19 delegates came up with a compromise that balances the interests of the EESS and 5G sectors. Under a new time-delay approach – dubbed "grandfather backwards" at WRC-19 – the out-of-band emission limit for 5G base stations will be set at -33 dBW/200 MHz until September 2027, while base stations deployed thereafter (after September 2027) will have to comply with tougher restrictions (-39 dBW/200 MHz). This phased approach mitigates against the growing risk of aggregate interference that will come as 5G deployments increase.

The compromise reached at WRC-19 shows how dearly delegates valued the prize of achieving globally harmonized conditions for IMT in the 26 GHz band – as opposed to the likely alternative of regional fragmentation. The outcome shall foster a vibrant global ecosystem for 26 GHz equipment, paving the way for widespread 5G deployment using this frequency. Significantly, the time-delay approach means there will be no need to replace early 5G equipment in the 26 GHz band as 5G networks become more densely deployed.[3]

The protection was also accorded to the Earth exploration-satellite (EESS) service with the possibility of providing worldwide primary allocation in the frequency band 22.55-23.15 GHz in order to allow its use for satellite tracking, telemetry and control.

7. mmWave Spectrum Allocation as per National Frequency Allocation Table

The spectrum for the n258 band ranges from 24.25 GHz to 27.50 GHz. Likewise, the National Radio Frequency Allocation Plan of Bhutan 2021 also allows the spectrum for 24.25 GHz to 27.50 GHz to be used for IMT considering that following conditions are applied[4]:

a. Existing EESS, SRS and FSS earth stations functioning in the band shall not be disturbed,

b. Take practical measures to ensure the transmitting antennas of outdoor base stations are normally pointing below the horizon, when deploying IMT base stations within the frequency band 24.25-27.5 GHz; the mechanical pointing needs to be at or below the horizon,

c. As far as practicable, sites for IMT base stations within the frequency band 24.45-27.5 GHz employing the values of e.i.r.p. per beam exceeding 30 dB (W/200 MHz) should be selected so that the direction of maximum radiation of any antenna will be separated from the geostationary-satellite orbit, within line-of-sight of the IMT base station, by ±7.5 degrees,

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[3] https://www.policytracker.com/blog/the-implications-of-wrc-19-for-5g/
[4] https://www.itu.int/dms_pub/itu-r/oth/0C/0A/R0C0A00000F0080PDFE.pdf

d. That protection of EESS/space research service (SRS) earth stations in the frequency band 25.5-27 GHz and radio astronomy service (RAS) stations in the frequency band 23.6-24 GHz and coexistence between FSS earth stations in the frequency bands 24.65-25.25 GHz and 27-27.5 GHz and IMT stations shall be facilitated through bilateral agreements for cross-border coordination as necessary,

e. That the operation of IMT within the frequency band 24.25-27.5 GHz shall protect existing and future EESS (passive) systems in the frequency band 23.6-24 GHz,

f. The antenna pattern of IMT base stations within the limits of the approximation envelope according to Recommendation ITU-R M.2101,

g. The spurious emission limits of Recommendation ITU-R SM.329 Category B for the frequency bands 50.2-50.4 GHz and 52.6-54.25 GHz shall be applied for the 24.25-27.5 GHz band;

The table below shows the allocation of frequency spectrum for Bhutan and the rest of the world (3 Regions) in the n258 band.

24.25-24.45 FIXED MOBILE except aeronautical mobile 5.338A 5.532AB	**24.25-24.45** FIXED 5.532AA MOBILE except aeronautical mobile 5.338A 5.532AB	**24.25-24.45** FIXED MOBILE 5.338A 5.532AB RADIONAVIGATION	**24.25-24.45** FIXED MOBILE 5.338A 5.532AB RADIONAVIGATION

24.45-24.65 FIXED INTER-SATELLITE MOBILE except aeronautical mobile 5.338A 5.532AB	**24.45-24.65** FIXED 5.532AA INTER-SATELLITE MOBILE except aeronautical mobile 5.338A 5.532AB RADIONAVIGATION 5.533	**24.45-24.65** FIXED INTER-SATELLITE MOBILE RADIONAVIGATION 5.533	**24.45-24.65** FIXED INTER-SATELLITE MOBILE RADIONAVIGATION 5.533
24.65-24.75 FIXED FIXED-SATELLITE (Earth-to-space) 5.532B INTER-SATELLITE MOBILE except aeronautical mobile 5.338A 5.532AB	**24.65-24.75** FIXED 5.532AA INTER-SATELLITE MOBILE except aeronautical mobile 5.338A 5.532AB RADIOLOCATION SATELLITE (Earth-to-space)	**24.65-24.75** FIXED FIXED-SATELLITE (Earth-to-space) 5.532B INTER-SATELLITE MOBILE 5.338A 5.532AB	**24.65-24.75** FIXED FIXED-SATELLITE (Earth-to-space) 5.532B INTER-SATELLITE MOBILE 5.338A 5.532AB

Region 1	Region 2	Region 3	Bhutan
24.75-25.25 FIXED FIXED-SATELLITE (Earth-to-space) 5.532B MOBILE except aeronautical mobile 5.338A 5.532AB	**24.75-25.25** FIXED-SATELLITE (Earth-to-space) 5.535 MOBILE except aeronautical mobile 5.338A 5.532AB	**24.75-25.25** FIXED FIXED-SATELLITE (Earth-to-space) 5.535 MOBILE 5.338A 5.532AB	**24.75-25.25** FIXED FIXED-SATELLITE (Earth-to-space) 5.535 MOBILE 5.338A 5.532AB
25.25-25.5	FIXED 5.534A INTER-SATELLITE 5.536 MOBILE 5.338A 5.532AB Standard frequency and time signal-satellite (Earth-to-space)		**25.25-25.5** FIXED 5.534A INTER-SATELLITE 5.536 MOBILE 5.338A 5.532AB Standard frequency and time signal-satellite (Earth-to-space)
25.25-25.5	EARTH EXPLORATION-SATELLIT(space-to Earth) 5.536B FIXED 5.534A INTER-SATELLITE 5.536 MOBILE 5.338A 5.532AB SPACE RESEARCH (space-to-Earth) 5.536C Standard frequency and time signal-satellite (Earth-to-space) 5.536A		**25.5-27** EARTH EXPLORATION-SATELLITE (space to Earth) 5.536B FIXED 5.534A INTER-SATELLITE 5.536 MOBILE 5.338A 5.532AB SPACE RESEARCH (space-to-Earth) 5.536C Standard frequency and time signal-satellite (Earth-to-space) 5.536A

27-27.5 FIXED INTER-SATELLITE 5.536 MOBILE 5.338A 5.532AB	**27-27.5** FIXED FIXED-SATELLITE (Earth-to-space) INTER-SATELLITE 5.536 5.537 MOBILE 5.338A 5.532AB	**27-27.5** FIXED FIXED-SATELLITE (Earth-to-space) INTER-SATELLITE 5.536 5.537 MOBILE 5.338A 5.532AB

8. Implementation of mmWave Globally

There have been numerous countries which have deployed 5G in the mmWave spectrum. Some of the countries which have released or deployed the mmWave for IMT implementation are as mentioned below:

Countries	Frequency Bands	Bandwidth assigned to operators
Australia	n258	600 MHz, 1000 MHz and 600 Mhz[5]
Brazil	n258	1000 MHz, 400 MHz, 200 - 600 MHz and 600 MHz[6]
Chile	n258	400 MHz[7]
Croatia	n258	400 MHz
Denmark	n257 and n258	1250 MHz, 1000 MHz and 600 MHz[8]
Estonia	n258	400 MHz
Finland	n258	800 MHz
Hong kong	n257	400 MHz
India	n258	800 MHz and 1000 MHz
Indonesia	n257	-
Italy	n258	200 MHz

5 https://www.acma.gov.au/26-ghz-band-auction-results

6 https://www.gsma.com/spectrum/brazil-multi-band-auction-one-of-the-largest-in-mobile-history/

7 https://5gobservatory.eu/chile-completes-first-5g-spectrum-auction-in-latin-america/#:~:text=By%20player%2C%20the%20results%20of,50MHz%20in%20the%203500MHz%20band

8 https://specure.com/denmark-awards-5g-frequency-bands/#:~:text=In%20the%2026%20GHz%20band,will%20pay%20DKK%20540.5m.

Japan	n257	400 MHz
Malaysia	n257	1600 MHz
Norway	n258	400 MHz
Russia	n258	-
San Marino	n258	-
Singapore	n257	800 MHz
Spain	n258	400 MHz and 1000 MHz
Taiwan	n257	200 MHz, 400 MHz and 600 MHz
Thailand	n258	800 MHz and 1200 MHz
United Arab Emirates	n258	400 MHz
United States of America	n258	100 - 400 MHz
US Virgin Islands	n258	100 MHz, 100-200 MHz, 200-500 MHz, 100-500 MHz, 100-300 MHz and 100-400 MHz
Uruguay	n257	800 MHz
Vietnam	n257	400-1000 MHz

9. mmWave and its Wide Applications Vertical and Horizontal

mmWave have disadvantages such as higher attenuation, susceptibility to shadowing by obstacles, limited line of sight transmission and limited penetration. However, it turns out that these characteristics/disadvantages can also be exploited as benefits in certain applications. Despite the disadvantages, there are more advantages which justifies the use of mmWave technology. The advantages of mmWave technology include wide bandwidths, high data rates, low latency, small antennas, limited range, limited reflection, limited penetration, and increased resolution.

The above mentioned advantages/disadvantages can be exploited in the following applications:

a. Radar

For many years, aerospace radar applications were the primary application of millimeter wave technology. The wide bandwidths are ideal for determining the distance to an object, for resolving between two distant objects that are close together and measuring the relative velocity to the target.

The ability to use smaller multi-element antennas and adaptive beamforming also make millimeter waves ideal for radar applications. For the same reasons that millimeter wave radar is desirable for aerospace applications, it is widely being adopted for automated vehicle applications including emergency braking, adaptive cruise control (ACC), and blind-spot detection.

b. ***Telecommunications***

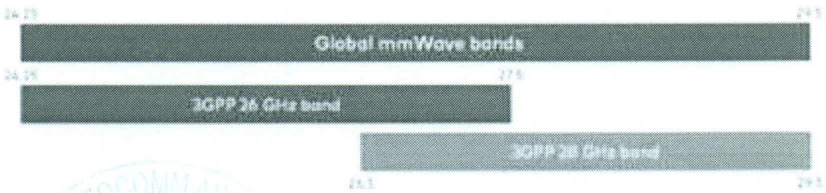
Satellite systems have long used millimeter waves for their communications due to the wide bandwidths, low latency, small antennas, and multi-antenna array beamforming. These same features are driving many terrestrial telecommunication networks to employ millimeter waves. For example, because of the increased bandwidth, millimeter waves can support the wireless transmission of ultra high definition (UHD) video. In addition, the smaller antennas support integration into devices like smartphones, digital set top boxes, game stations, and more. Particularly in indoor and urban environments, spatial reuse and adaptive beamforming of millimeter waves will enable the delivery of high bandwidth communications to a large number of users.

c. ***Security Scanners***

Millimeter waves are also employed for human body security scanners. Thousands of transmit and receive antennas work together to scan with high precision.These systems transmit at a frequency range between 70 GHz to 80 GHz and emit only about 1 mW of power. The millimeter waves pass through most clothing and reflect off the skin and other surfaces back to the receiving antennas. The received signal can be used to create a detailed image of the individual and reveal articles hidden under the clothing. The low power and limited penetration depth of millimeter waves provide improved safety.

10. mmWave Frequency band plan in n258 in other countries

The global mmWave bands and the 3GPP 26GHz band is as shown in the figure below.



In Australia, the Australian Communications and Media Authority made the determination in November 2020 that frequency range 26 GHz (25.1 – 27.5 GHz) band for spectrum licensing in 29 cities and regional centres[9].

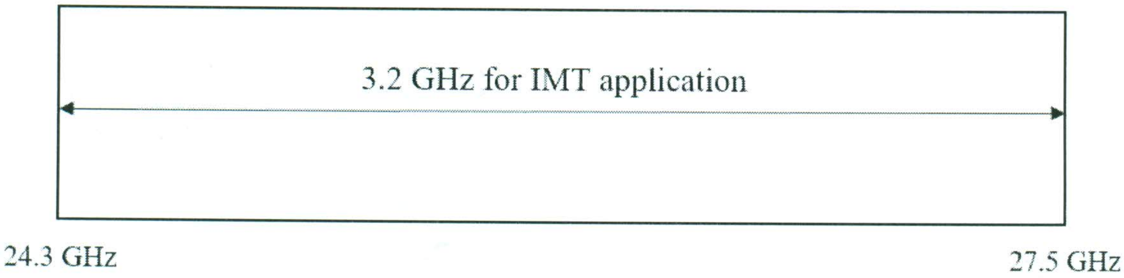
In India, the frequencies in 26GHz were assigned to the service providers during the 5G spectrum auction carried out in September 2022. The 26 GHz frequency ranges from 24.25 - 27.5GHz for India.

11. 26GHz Frequency band identified for IMT in Bhutan

n258 band is commonly used for deploying 5G in high bands/mmWave bands and the band planning is done by taking into consideration that, on both upper and lower end of the n258 band, there are frequencies allocated for the use of satellite/stations. From the total bandwidth of 3.2 GHz, the frequency bandwidth allocated to the telcos shall be as per their demand or on an auction basis.

The proposed band plan for n258 is as shown as follows where the total bandwidth of 3200MHz shall be allocated to the IMT services in Bhutan.

The starting frequency for 26GHz is considered as 24.3GHz instead of 24.25GHz, unlike the 3GPP 26GHz band plan, with an objective to keep the bandwidth separation from the 24GHz ESSS services.



12. Restrictions for IMT Infrastructures in 26GHz

The IMT services which use the n258 mmWave frequency spectrum shall be subject to comply with the following power limitations and other conditions;

[9] https://www.legislation.gov.au/Details/F2020L01453

a. To limit the out-of-band emission from base stations to the maximum of -39 dBW/200 MHz,

b. Existing EESS, SRS and FSS earth stations functioning in the band shall not be disturbed,

c. Take practical measures to ensure the transmitting antennas of outdoor base stations are normally pointing below the horizon, when deploying IMT base stations within the frequency band 24.3-27.5 GHz; the mechanical pointing needs to be at or below the horizon,

d. That the operation of IMT within the frequency band 24.3-27.5 GHz shall protect existing and future EESS (passive) systems in the frequency band 23.6-24 GHz,

13. Proposed Method of Frequency Assignment

The method of allocations will be based on the provisions of the ICM Act 2018 and the National Radio Rules and Regulations 2021.

Many countries have started auctioning the spectrum in mmWave frequency band. These frequencies have numerous applications to different radiocommunication and telecommunication services including the private captive networks and thus are auctioned.

Similarly, the Authority may also explore the feasibility of auctioning the mmWave band for 5G implementation with a certain initial starting reserve price. The participation in the auction will be allowed even to non-telecom companies in Bhutan which may be interested in providing or utilizing the private captive networks.

The blocks of frequency will be designed for the auction if feasible and applicable.

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