Consultation Paper No. 21/2023

भारतीय दूरसंचार विनियामक प्राधिकरण

Telecom Regulatory Authority of India

Consultation Paper on

Open and De-licensed use of Unused or Limited Used Spectrum Bands for Demand Generation for Limited Period in Tera Hertz Range

New Delhi, India

27.09.2023

Mahanagar Doorsanchar Bhawan, Jawahar Lal Nehru Marg, New Delhi – 110 002

Written Comments on the Consultation Paper are invited from stakeholders by 25.10.2023 and counter-comments by 08.11.2023. Comments and counter-comments will be posted on TRAI's website. Comments and counter-comments may be sent, preferably in electronic form, to Shri Akhilesh Kumar Trivedi, Advisor (Networks, Spectrum and Licensing), TRAI, on the email ID: advmn@trai.gov.in.

For any clarification/ information, Shri Akhilesh Kumar Trivedi, Advisor (Networks, Spectrum and Licensing), TRAI, may be contacted on Telephone No. +91-11-23210481.

CONTENTS

ANNEXURE

CHAPTER I:

INTRODUCTION AND BACKGROUND

A. DoT's Reference Dated 08.12.2022

1.1 Through a reference dated 08.12.2022 (**Annexure-I**), the Department of Telecommunications (DoT) requested the Authority to submit recommendations under Section 11(1)(a) of TRAI Act, 1997 (as amended) on 'Open and De-Licensed use of Unused or Limited Used Spectrum Bands for Demand Generation for Limited Period in Tera Hertz Range'. The said reference is reproduced below:

"In various parts of the world, administrations, with a view to encourage technology development, have come up with regulations allowing conduct of experiments in the spectrum bands beyond 95 GHz. Accordingly, it has been decided to encourage the development of new communications technologies and new services in the country in the spectrum ranges above 95 GHz.

2. In view of the above, a Committee was constituted under the Chairmanship of Wireless Adviser to give its recommendations on the issue. The Committee has submitted its report (copy enclosed for ready reference). The summary of recommendations of the Committee is given below:

a. The spectrum beyond 95 GHz and upto 3 THz may be opened for experiments under 'Spectrum-Terahertz Applications License'. There shall not be any restriction on technical condition for designing and conducting experiments and tests provided they should not cause harmful interference to existing services including secondary services.

b. The frequency bands, 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz may be opened for unlicensed use. Initially FCC's Technical specifications may be adopted. After study in Indian environment, technical parameters may be revised.

c. The frequency band 77-81 GHz band may also be delicensed for automotive radar applications in line with international practice.

3. However, with a view to come up with a well-rounded regulatory regime on the subject matter, it was considered appropriate to seek TRAI recommendation as well. Therefore, under the terms of clause ii (1)(a) of TRAI Act, 1997 as amended by TRAI Amendment Act 2000, TRAI is requested to provide recommendations on the following:

(a) Terms and Conditions for opening of spectrum beyond 95 GHz and upto 3 THz for experiments under a regime which may be named as 'Spectrum-Terahertz Applications License' for Experiment' and 'Demonstration' of equipment designed to operate on any frequency above 95 GHz while protecting any "Passive" services in these frequency ranges. The licensees may also be permitted to market such experimental devices via direct sale. The regime may be opened for a defined period.

(b) Terms and conditions including technical parameters for permitting licensed-exempt operations in 116-123 0Hz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz frequency ranges, while protecting both passive and active services in and around these frequency ranges

(c) Terms and conditions including technical parameters for permitting licensed-exempt operations in 77-81 GHz band for automotive radar applications in line with international practice.

(d) Any other techno-regulatory recommendations relevant to the issue."

B. Tera Hertz Band

1.2 Section 3 of Indian Telegraph Act, 1885 defines the term 'telegraph' as follows:

"3. Definitions. – in this Act, unless there is something repugnant in the subject or context, -

'Telegraph' means any appliance, instrument, material or apparatus used or capable of use for transmission or reception of signs, signals, writing, images and sounds or intelligence of any nature by wire, visual or other electro-magnetic emissions, Radio waves or Hertzian waves, galvanic, electric or magnetic means.

'Radio waves' or 'Hertzian waves' means electro-magnetic waves of frequencies lower than 3,000 giga-cycles per second propagated in space without artificial guide."

1.3 Terahertz (THz) radiation is generally defined as the region of the electromagnetic spectrum in the range of 100 GHz to 10 THz, which is between the millimeter and infrared frequencies. The THz band has differing nomenclatures, such as sub-millimeter, far-infrared, and near-millimeters wave. The THz band in the electromagnetic spectrum is shown in the following figure.

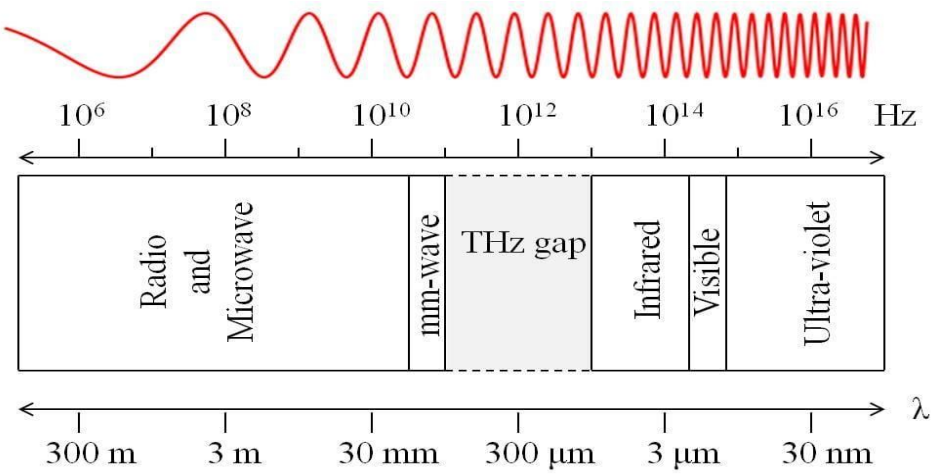

Figure 1.1. Schematic diagram showing the location of THz band in the electromagnetic spectrum[1]

[1] Source: https://www.allaboutcircuits.com/technical-articles/introduction-to-terahertz/

1.4 Tera Hertz Band lies in the cusp of electronics and photonics. It is easy to produce effective radiation with the help of oscillating circuits made of high-speed transistors at low microwave frequencies while, at high frequencies of visible spectrum, it is easy to produce radiation effectively with semiconductor lasers. Conventionally, electronics (i.e. transistors and other electronic devices) have a limit of about 300 GHz while photonics (semiconductor lasers and light emitting diodes) have a limit of about 30 THz. There is a region on the frequency spectrum where these technologies do not meet each other. This is called the Terahertz gap (0.3 to 30 THz). The following figure depicts the Terahertz gap between electronics and photonics.

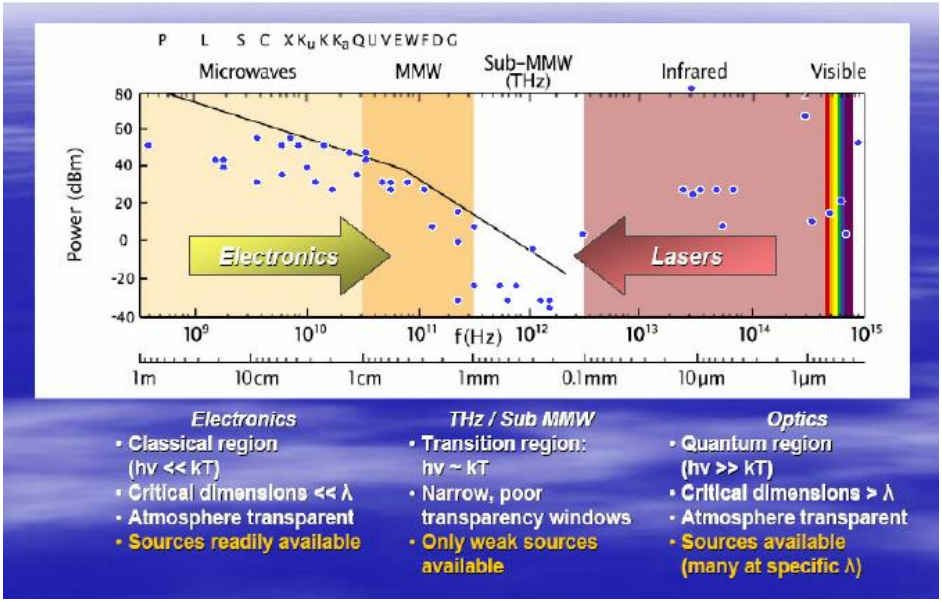

Figure 1.2: Tera Hertz Gap between electronics and photonics [2]

1.5 The term 'THz gap' is used to explain the infancy of this band as compared to well-developed neighboring spectral regions. This has led researchers from disciplines such as physics, material science, electronics, optics, and chemistry to investigate the various unexplored or less-explored aspects of THz waves.

[2] Source: https://www.researchgate.net/figure/Illustration-of-the-THz-gap_fig1_234944264

C. Properties of the Frequency Spectrum in Terahertz Band

1.6 Although interest in the THz band dates back to the 1920s, extensive studies have been devoted to this region only within the past three decades. A key motivation for this renewed interest is the exceptional wave properties and vast possible applications in the THz frequency range. The properties of THz band can be summarized as follows:

(a) Penetration: The wavelength of THz radiation is longer than the infrared wavelength. Hence THz waves have less scattering and better penetration depths (in the range of cm) compared to infrared (in the range of μm). Therefore, dry, and non-metallic materials are transparent in this range but are opaque in the visible spectrum.

(b) Resolution: THz waves have shorter wavelengths in comparison to the microwave ones. This gives a better spatial imaging resolution.

(c) Safety: The photon energies in the THz band are much lower than X-rays. Therefore, THz radiation is non-ionizing.

D. Challenges in Developing the THz Band

1.7 Although the THz band has several fascinating characteristics, one of the reasons for the under-development of THz technologies as compared to the neighboring bands is the lack of efficient, coherent, and compact THz sources and detectors. On the other hand, common microwave-frequency sources such as transistors or RF/ MW antennas and devices working in the visible and infrared range like semiconductor laser diodes exhibit these characteristics. It is not possible, however, to adopt these technologies for operation in the THz region without a significant reduction in power and efficiency.

1.8 One of the other challenges in the THz band is the high losses. THz waves have high atmospheric absorption as depicted in the following figure.

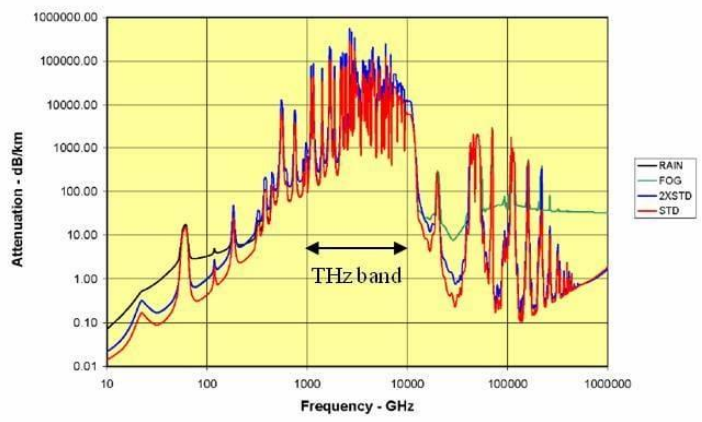

Figure 1.3. Attenuation at sea level for different atmospheric situations[3]

1.9 The signal degradation in the THz range is considerably more than the microwave and infrared bands. This is partly because the water molecules resonate in this range. The adverse atmospheric characteristics of THz waves makes them a suitable frequency range for applications such as space-based communication and short-range applications, as described below:

(a) Space based communication: In space, the ambient is near-vacuum so signal absorption and attenuation due to water molecules is not a problem. Therefore, existing services such as Earth exploration-satellite service (EESS), radio astronomy service, space research service, inter-satellite service and fixed and mobile services operate in the THz Band. The EESS services includes the use of passive sensors to receive and measure natural emissions produced by the Earth's surface and its atmosphere thereby helping us to monitor weather and climate change.

(b) Short-range applications: For short-range applications, atmospheric attenuation is negligible, especially at frequencies with high absorption. Therefore, THz technology is a very resourceful tool for fundamental investigations in various disciplines such as physics and chemistry. It is also an attractive option for short-range wireless communication with high data rates.

[3] Source: Image from M. C. Kemp via IEEE Xplore

E. Applications of Terahertz Radiation

1.10 THz radiation can be used in many potential applications, including terahertz imaging, spectroscopy, and wireless communication. A few applications are listed below:

(a) Biomedical imaging: It is one of the sub-categories of THz imaging. THz waves can penetrate up to a few hundred micrometers in human tissues; so THz medical imaging can be applied for body surface diagnoses such as skin, mouth, and breast cancer detection, and dental imaging.

(b) Security applications: THz systems have a potential market for security applications, solid explosive material detection, and mail screening.

(c) Applications in biochemical and material sciences: THz spectroscopy is a very powerful technique to characterize material properties and understand their signature in this band. THz spectroscopy also has applications in biochemical science such as analysis of DNA signatures and protein structures.

(d) Wireless Communication: Another rising research field is THz wireless communication. This is particularly in demand because it allows high-speed wireless communications for 5G and beyond.

G. Present Consultation Paper

1.11 In this background, the present consultation paper is being released for soliciting comments of stakeholders on the subject. This consultation paper is divided into six chapters. Chapter I provides a background of the subject. Chapter II outlines the Radio Regulations of ITU, and studies being conducted in ITU-R on Tera Hertz. Chapter III provides international best practices on the subject. Chapter IV provides a brief description of the recommendations of the DoT's committee on the subject. Chapter V provides a brief description of the

present experimental licensing regime in India. Chapter VI lists out the issues for consultation.

CHAPTER II:

ALLOCATION OF SPECTRUM IN TERA HERTZ BANDS IN THE ITU-RR, AND STUDIES ON TERA HERTZ BANDS IN ITU-R

A. Allocation of Tera Hertz Bands in ITU-RR

2.1 The International Telecommunication Union (ITU) is the United Nations specialized agency for information and communication technologies (ICTs). ITU promotes the shared global use of the radio spectrum, facilitates international cooperation in assigning satellite orbits, assists in developing and coordinating worldwide technical standards, and works to improve telecommunication infrastructure in the developing world.

2.2 Radio Regulations (RR) is a basic document of the ITU that regulates the utilization of radio frequencies. The ITU-RR regulates the part of the allocated radio frequency spectrum from 9 kHz to 300 GHz. As per the ITU-RR, radio frequency spectrum beyond 100 GHz is allocated largely to Radio Astronomy Service (RAS) and Satellite based services such as Earth Exploration Satellite Service (EESS), Space Research, Amateur Satellite Radio Navigation Satellite and Mobile Satellite etc. on primary basis. There is no allocation beyond 275 GHz in the ITU-RR. Besides Satellite and Radio Astronomy, allocation has also been made in ITU-RR for Fixed and Mobile Services on primary services in 12 frequency bands with about 100 GHz spectrum between 100 GHz to 275 GHz, which accounts for more than 55% of total frequency spectrum available between 100 GHz to 275 GHz. The percentage of allocation of frequency spectrum in the 100-275 GHz frequency range to different services is given in the following table:

Sl. No.	Service	Allocated Bandwidth* (In GHz)	Allocation (in %)
1.	Fixed	97.20	55.54
2.	Mobile	97.20	55.54
3.	Earth Exploration Satellite	58.80	33.6
4.	Space Research	70.75	40.43
5.	Inter Satellite	35.23	20.13
6.	Fixed Satellite	35.00	20
7.	Mobile Satellite	33.71	19.26
8.	Amateur	4.01	2.29
9.	Amateur Satellite	4.01	2.29
10.	Radio Astronomy	107.80	61.6
11.	Radiolocation	21.51	12.29
12.	Radionavigation	30.21	17.26
13.	Radionavigation Satellite	30.21	17.26

* More than one services shared the same band.

Table 2.1: Allocation of spectrum in the 100-275 GHz frequency range to different services

B. Footnotes on Tera Hertz Spectrum in ITU-RR and the Studies Being Carried out in ITU-R

2.3 There is no allocation of spectrum beyond 275 GHz in the ITU-RR. However, there are two footnotes in the ITU-RR viz. Footnote 5.564A and Footnote 5.565 in respect of the spectrum in 275-3000 GHz frequency range. The Footnote 5.564A provides for the operation of fixed and land mobile service applications

in 275-450 GHz frequency range. Footnote 5.565 provides for the coexistence of passive services like RAS and EESS with active and passive services in the frequency range 275-1000 GHz. Studies are also being carried out in ITU-Radiocommunication (ITU-R) sector on certain aspects related to the Tera Hertz band.

2.4 A brief description of the footnotes 5.564A and footnote 5.565 as well as Question ITU-R 256-1/5 (WP 5A) and Question ITU-R 257-1/5 (WP 5C) related to the spectrum in THz band is given below.

(1) Footnote 5.564A

2.5 Footnote 5.564A was introduced in WRC-19 for the operation of fixed and land mobile service applications in frequency bands in the range 275-450 GHz. The said footnote is reproduced below:

"5.564A For the operation of fixed and land mobile service applications in frequency bands in the range 275-450 GHz:

The frequency bands 275-296 GHz, 306-3 13 GHz, 318-333 GHz and 356-450 GHz are identified for use by administrations for the implementation of land mobile and fixed service applications, where no specific conditions are necessary to protect Earth exploration-satellite service (passive) applications.

The frequency bands 296-306 GHz, 313-318 GHz and 333-356 GHz may only be used by fixed and land mobile service applications when specific conditions to ensure the protection of Earth exploration-satellite service (passive) applications are determined in accordance with Resolution 731 (Rev. WRC 19).

In those portions of the frequency range 275-450 GHz where radio astronomy applications are used, specific conditions (e.g., minimum separation distances and/or avoidance angles) may be necessary to ensure protection of radio astronomy sites from land mobile and/or fixed service applications, on a case-by-case basis in accordance with Resolution 731 (Rev.WRC-19).

The use of the above-mentioned frequency bands by land mobile and fixed service applications does not preclude use by, and does not establish priority over, any other applications of radio services in the range of 2 75-450 GHz. (WRC-19)."

(2) Footnote 5.565

2.6 The Footnote 5.565 was introduced in WRC-12 to allow the coexistence of passive services like RAS and EESS with active and passive services in the frequency range 275-1000 GHz. The said footnote is reproduced below:

"5.565 The following frequency bands in the range 275-1000 GHz are identified for use by administrations for passive service applications:

- radio astronomy service: 2 75-323 GHz, 327-371 GHz, 388-424 GHz, 426- 442 GHz, 453-510 GHz, 623-711 GHz, 795-909 GHz and 926-945 GHz;

- Earth exploration-satellite service (passive) and space research service (passive): 2 75-286 GHz, 296-306 GHz, 3 13-356 GHz, 361-365 GHz, 369-392 GHz, 397-399 GHz, 409-411 GHz, 416-434 GHz, 439-467 GHz, 477-502 GHz, 523-52 7 GHz, 538-581 GHz, 611-630 GHz, 634-654 GHz, 657-692 GHz, 713-718 GHz, 729-733 GHz, 750-754 GHz, 771-776 GHz, 823-846 GHz, 850-854 GHz, 85 7-862 GHz, 866-882 GHz, 905-928 GHz, 951-956 GHz, 968-9 73 GHz and 985-990 GHz.

The use of the range 275-1000 GHz by the passive services does not preclude use of this range by active services. Administrations wishing to make frequencies in the 275-1000 GHz range available for active service applications are urged to take all practicable steps to protect these passive services from harmful interference until the date when the Table of Frequency Allocations is established in the above-mentioned 2 75-1000 GHz frequency range.

All frequencies in the range 1000-3000 GHz may be used by both active and passive services. (WRC-12)"

(3) Question ITU-R 256-1/5

2.7 The ITU Radiocommunication (ITU-R) Assembly considered *inter alia* the following:

(i) There is a growing demand for high speed and large capacity radiocommunications having data rates of several tens of Gbit/s to over 100 Gbit/s for land mobile service applications.

(ii) Due to progress in the recent terahertz technologies, the integrated devices and circuits operating above 275 GHz can achieve various sophisticated applications.

(iii) Broadband contiguous bandwidths larger than 50 GHz for the land mobile service are not available in the frequency range below 275 GHz.

(iv) Certain parts of the frequency range 275-1 000 GHz are identified in Radio Regulations No. 5.565 for use by administrations for passive service applications.

2.8 In this background, ITU-R decided to study the following question:

"Question ITU-R 256-1/5 The technical and operational characteristics of the land mobile service in the frequency range 275-1000 GHz under which sharing studies between the land mobile and passive services, as well as the land mobile and other active services should be carried out."

(4) Question ITU-R 257-1/5 (WP 5C)

2.9 The ITU Radiocommunication (ITU-R) Assembly considered *inter alia* the following:

(i) Due to the progress in the recent terahertz technologies, the integrated devices and circuits operating above 275 GHz can achieve various sophisticated applications.

(ii) The fact that these devices and circuits will be able to provide such high speed and large capacity radiocommunications for fixed service systems.

(iii) The traffic demands for backhaul and fronthaul for mobile systems are increasing due to mobile broadband communications such as IMT-Advanced, IMT-2020 and future IMT.

2.10 In this background, ITU-R decided to study the following question:

"QUESTION ITU-R 257-1/5 Technical and operational characteristics of the fixed service in the frequency range 275-1000 GHz under which sharing studies between the fixed and other active services should be carried out."

2.11 The studies are being undertaken by the Working Party 5A and 5C for Question 256-1/5 and Question 257-1/5, respectively. These studies are being undertaken during the two study cycles i.e., 2015 to 2019 and 2019 to 2023 and responses will be discussed during the WRC-23. The results of these studies will be in form of ITU's Recommendations, Reports or Handbooks.

2.12 In addition to these two studies being carried out under ITU-R, a document is also being prepared in WP-5D to include the following:

(a) Propagation models for radio waves above 100 GHz for various scenarios including indoor/ outdoor including information on propagation environment and channel models.

(b) Newly developed technology enablers such as active and passive components, antenna techniques, deployment architectures.

(c) Results of simulations and performance tests.

2.13 The following chapter outlines international best practices on the subject.

CHAPTER III:

INTENATIONAL EXPERIENCE

A. International Experience on Allocations in the THz Band

(1) FCC

3.1 Federal Communications Commission (FCC), United States of America vide its First report and Order dated 21.03.2019[4] provided a background to the interest of the administration in Tera Hertz communication, as below:

"3. *Both industry and academia have expressed interest in the bands above 95 GHz, as evidenced by the wide range of ongoing research and experimentation. Institutions such as Brown University and the New York University Tandon School are conducting propagation measurements at frequencies as high as 400 GHz. Companies such as Boeing and Raytheon have undertaken testing of antennas and radar receivers at frequencies near 100 GHz.*

Frequencies above 95 GHz have also been identified as optimal for instantaneous temporary data links that can enable the transmission of large bandwidth uncompressed high-definition (HD) video signals and other high-speed data for other types of applications. For example, in 2008, Japan's NTT used wireless links in the 120 GHz band to provide live TV coverage of the 2008 Beijing Olympics.

Further, the shorter wavelengths associated with frequencies above 95 GHz may be particularly well-suited for non-communication sensing applications such as spectroscopy and imaging, including detection of drugs and explosives, detection of cancerous tissue, as well as materials analysis and quality control. The Commission has recognized the budding interest in developing new technologies and services that could operate in the frequency bands between 95 GHz and 3 THz, while at the same time acknowledging the need for

[2] https://docs.fcc.gov/public/attachments/FCC-19-19A1.pdf

continued use of passive services in these frequency bands for scientific research, including the radio astronomy service (RAS), the Earth exploration-satellite service (EESS), and the space research service (SRS).

Passive sensing is based on detection of electromagnetic energy generated by natural sources, such as the surface of the Earth and its atmosphere. The EESS includes passive radio sensing operations that have many applications in agriculture, weather forecasting, and the study of global changes of the Earth and its environment. Similarly, the RAS is a passive service in which U.S.-based astronomers operate several large single dish telescopes and interferometers, either by themselves or as part of an array, to receive radio waves of cosmic origin in order to try to gain a better understanding of the universe.

Frequencies above 95 GHz are particularly well-suited for studies of star formation, the properties of the interstellar medium, the chemical evolution of the universe, detection of extra-solar planets and many other phenomena. In addition to the passive services, there are allocations between 95 GHz and 275 GHz for the fixed satellite, mobile satellite, fixed, mobile, radiolocation, radionavigation, radionavigation-satellite, and inter-satellite services….

… We cannot predict what technologies may ultimately develop for operations in these frequency bands. The result was a suite of proposals to:

(1) make 15.2 gigahertz of spectrum available for unlicensed use;

(2) create a new category of experimental licenses to increase opportunities for entities to develop new services and technologies from 95 GHz to 3 THz with no limits on technology; and

(3) introduce limited licensing for fixed point-to-point operations.

These flexible options were driven by a singular objective—to provide incentives and opportunities for investment to spur development of innovative new technologies and services while accounting for and protecting the already extensive and planned passive uses of these bands. While we withhold action on our proposal for licensed fixed point-to-point operations, we find that it is

appropriate to move forward with our unlicensed and experimental proposals at this time."

3.2 Through the afore-mentioned 'First report and Order' dated 21.03.2019[5], FCC instituted a new experimental radio license viz. 'Spectrum Horizon Radio License' that will be available for experiments and demonstrations of equipment designed to operate exclusively on any frequency between 95 GHz and 3 THz. An extract of the 'First report and Order' dated 21.03.2019 relating to Spectrum Horizons Experimental Radio Licenses is reproduced below:

"A. Spectrum Horizon Radio License

8. To accelerate the development of new technologies in the spectrum range between 95 GHz and 3 THz, we adopt a new subpart to the existing Part 5 Experimental Radio Service (ERS) rules for a new and unique license type - the Spectrum Horizons Experimental Radio license (or "Spectrum Horizons License"). With their low barriers to entry and minimal costs to obtain, experimental licenses provide an engine for innovation and offer extraordinary flexibility in system design and technical specifications (such as frequency range, power, and emissions) while ensuring that no harmful interference is caused to existing authorized users. The experimental licensing program, which has played a key role throughout the years in the creation of many of the products and services that are now integral parts of the modern communications environment, is a core component of our plan to promote the responsible commercial development of this frequency range.

We expect the new Spectrum Horizons Licenses to make experimentation in these bands more attractive, resulting in a greater number of thoughtful and innovative experiments. Such experiments are vital for the development of new applications and services suited for the unique properties of the bands above 95 GHz. These applications and services, in turn, will generate additional interest in these bands and can ultimately provide a basis for the further expansion of permissible uses throughout the frequency range. The Spectrum

[2] https://docs.fcc.gov/public/attachments/FCC-19-19A1.pdf

Horizons License rules will incorporate the proposals that the Commission made in the Notice. Specifically, the Spectrum Horizons License will be available for experiments and demonstrations of equipment designed to operate exclusively on any frequency above 95 GHz. Broad license eligibility rules, along with an extended ten-year license term (the longest of any experimental license), should encourage innovation from the widest variety of stakeholders and produce solid data to support future Commission decisions concerning these bands. Additionally, licensees will be able to request the area(s) of operation for their experiment and will be able to market experimental equipment more widely than currently permitted under the Commission's experimental market trial rules.19 Collectively, these Spectrum Horizons License features should promote a more rapid development of new products and services that will reach a larger number and wider variety of users than would be possible under the existing experimental licensing rules."

3.3 Further, FCC vide its First report and Order dated 21.03.2019 provided details on 'terms and conditions' for the 'Spectrum Horizon Radio License'. A summary of the terms and conditions is given below:

(a) The spectrum Horizon License will be available for experiments and demonstrations of equipment designed to operate exclusively on any frequency between 95 GHz and 3 THz.

(b) The spectrum Horizon License aims to promote a more rapid development of new products and services that will reach a larger number and wider variety of users than are possible under the existing experimental licensing rules.

(c) The spectrum Horizon License would be broadly available to person(s) qualified to conduct the types of operations described in existing experimental radio service rules.

(d) Applicants for passive use(s) must provide an explanation as to why nearby bands with non-passive allocations are not appropriate or adequate for the experiment and also acknowledge that they intend to transition any potential long-term use to a band with appropriate allocations.

(e) The spectrum Horizon License will give innovators the flexibility to conduct experiments lasting up to 10 years without further renewal.

(f) The Spectrum Horizons License may be authorized over any geographic area.

(g) There will be no restriction on technical conditions for designing and conducting experiments and tests.

(h) The Spectrum Horizons Licensee will be required to show how the experimental operations (and any related devices) will be controlled so that they do not cause harmful interference to other services.

(i) The Spectrum Horizons License will not be entitled to exclusive use, not be protected from harmful interference from allocated services and prohibited from causing harmful interference to authorized services, including secondary services.

(j) Spectrum Horizons Licensees must ensure that trial devices are either rendered inoperable or retrieved at the conclusion of the trial. Additionally, each device sold under this program must be labeled as "Authorized Under an Experimental License and May be Subject to Further Conditions Including Termination of Operation" and carry with it a licensee-assigned equipment ID number.

(k) Spectrum Horizons Licensees will be permitted to market experimental devices designed to operate in the bands above 95 GHz via direct sale.

(l) Spectrum Horizons Licensees will submit an interim report on the progress of the experiment no later than five years from the date of grant of license.

3.4 FCC vide its First report and Order dated 21.03.2019 also provided details on "Unlicensed Operations" in the THz band as given below:

"B. Unlicensed Operations

27. Following our evaluation of the record, we free up 21.2 gigahertz of the Spectrum Horizons bands for unlicensed use: the 116-123 GHz band, the 174.8-182 GHz band, the 185-190 GHz band, and the 244-246 GHz band.

"28. The bands made available for unlicensed devices are summarized in the table below. These devices would operate on a non-interference basis while protecting both passive and active services. Most notably, several bands contain or are adjacent to passive Earth exploration-satellite service and radio astronomy service allocations. We recognize that these services require stringent protection levels and are the primary focus of the discussion below.

The space research service is also passive, but as explained more fully below, because stations in this service are space-based and looking away from Earth, there is no risk of harmful interference from unlicensed devices.

There are also a number of active service allocations in the bands we are identifying for unlicensed use. Some, such as the fixed service, the mobile service and the radiolocation and radionavigation services cannot be deployed because there are no service rules in place. Thus, protection criteria need not be adopted at this time.

The inter-satellite service also does not have service rules in place but has been permitted to operate on a case-by-case basis. Like the space research service, the inter-satellite service operates solely between satellites in space and therefore there is no significant risk of harmful interference from relatively low power unlicensed devices operating on the Earth, even if terrestrial operations were to occur in high volumes.

In addition, the amateur radio service is permitted to operate in the 122.5-123 GHz band, and as discussed below is unlikely to receive interference from unlicensed operations in that band.

Finally, the 122-123 GHz and 244-246 GHz bands are also allocated for ISM equipment. As such, all authorized services (regardless of whether they are active or passive) operating inside those bands cannot claim protection from ISM emissions. Further, the rules do not limit the emissions levels from ISM equipment in these bands. Therefore, radio astronomy and other passive services cannot reasonably expect a lack of emissions in these bands. Thus, for the 122-123 GHz and 244-246 GHz bands, lower power unlicensed devices

should have no significant impact on these passive operations as long as their emissions are confined within those bands."

3.5 Further, FCC vide its First report and Order dated 21.03.2019 provided details of the 'technical parameters' for unlicensed operations in the THz band. A summary of the technical parameters for unlicensed operations in the THz band is given below:

Technical Parameters	Limit
Maximum EIRP (Indoor)	40 dBm (average) and 43 dBm (peak)
Maximum EIRP (Outdoor)	82 dBm (average) and 85 dBm (peak)
Min Antenna gain	51 dBi (with 2 dB reduction in the maximum permissible EIRP for each dB the antenna gain falls below 51 dBi)
Out-of-band emission limit	90 picowatts per square centimeter at a distance of three meters

3.6 FCC vide its First report and Order dated 21.03.2019 also provided details on the 'terms and conditions' for unlicensed operations in the THz band. A summary of the terms and conditions for unlicensed operations in the THz band is given below:

(a) These devices would operate on a non-interference basis while protecting both passive and active services.

(b) These devices would not be permitted to operate upon satellites or onboard aircraft.

(c) Equipment operating in the 174.8-182 GHz and 185-190 GHz bands should not be designed to operate in the 182-185 GHz band.

(2) ETSI

3.7 European Telecommunications Standards Institute (ETSI) released Report No. ETSI GR mWT 018 V1.1.1 (2019-08) titled 'Analysis of Spectrum, License Schemes and Network Scenarios in the W-band' in September 2018[6]. The said report deals with point-to-point links in frequency ranges 92-114.25 GHz and 130-174.8 GHz, referred to as the W-band and D-band respectively. The report provides information, considerations and application use cases and discusses the flexible and efficient use of these bands.

3.8 The European Union (EU) has already adopted harmonized standards ETSI EN 305 550-1[7] and ETSI EN 305 550-2[8], which allow short range devices (SRDs) to operate between 40 GHz and 246 GHz includes provisions for such devices at 122.0-122.25 GHz and 244-246 GHz. The maximum EIRP permitted to SRDs is given below:

Technical Parameters for SRDs	Limit
Maximum EIRP in 122-122.25 GHz band	10 dBm
Maximum EIRP in 122.25-123 GHz band and 244-246 GHz band	20 dBm

(3) Office of Communications (Ofcom), UK

3.9 To support research, innovation and the development and use of new products and applications in Extremely High Frequency (EHF) bands, the Office of Communications (Ofcom), United Kingdom in December 2021[9], introduced a new 'Spectrum Access: EHF License' to enable simple, flexible access to over 32 GHz of radio spectrum across the following four bands:

[3] https://www.etsi.org/deliver/etsi_gr/mWT/001_099/018/01.01.01_60/gr_mwt018v010101p.pdf
[4] https://www.etsi.org/deliver/etsi_en/305500_305599/30555001/01.02.01_60/en_30555001v010201p.pdf
[5] https://www.etsi.org/deliver/etsi_en/305500_305599/30555002/01.02.01_60/en_30555002v010201p.pdf
[6] https://www.ofcom.org.uk/__data/assets/pdf_file/0025/203767/spectrum-access-ehf-licence-guidance.pdf

(a) 57-71 GHz

(b) 116-122 GHz

(c) 174.8-182 GHz

(d) 185-190 GHz

3.10 Under the Spectrum Access: EHF License, a licensee is allowed to access one of these bands across the UK on a shared, uncoordinated basis. The licensees may use multiple devices within the licence band, provided that these meet the licence technical conditions. Devices must not be used airborne, which means that they cannot be used onboard or attached to an aircraft, drone or balloon. Each licence costs £75, which is payable every five years.

3.11 The spectrum Access: EHF License is intended to provide flexible access to the spectrum on a technology-neutral basis and has an indefinite duration. Certain technical parameters for devices in Spectrum Access: (EHF) License are summarized below:

Technical Parameters	**Limit**
Maximum Permitted EIRP	55 dBm
Main beam elevation angle	<20 degrees above horizontal (Outdoor use) No restrictions (indoor use)
Out of band emissions	Limited to -10 dBm/ MHz EIRP

3.12 For outdoor use of 100-200 GHz equipment only, there are additional power limits on EIRP at angles relative to the main beam in the elevation plane.

(4) Ministry of Internal Affairs and Communications (MIC), Japan

3.13 In 2018, MIC Japan made 18 GHz of frequency spectrum in 116-134 GHz band available for "Commercial Telecommunication Service" subject to the provision that "all practical steps shall be taken to protect the radio astronomy service from harmful interference" in parts of the band.

B. International Experience on Allocations in the 77-81 GHz Band for Automotive RADARs

3.14 Federal Communications Commission (FCC), USA and Ministry of Internal Affairs & Communications (MIC), Japan have designated the frequency spectrum in 76-77 GHz band for automotive radar. MIC, Japan has also recommended introduction of high-resolution radar in 77-81 GHz band for safety related applications.

3.15 CEPT has designated the band 77-81 GHz for automotive radars. ETSI has adopted the harmonized standard in the frequency band 77-81 GHz for the applications of short-range radars. FCC has also allowed 77-81 GHz band for vehicular radar operations aligning with rest of the world.

3.16 Some of the countries in the Asia Pacific Region have also designated 76-77 GHz and 77-81 GHz bands for short range automotive radar application.

3.17 The next chapter provides a brief description of the recommendations of the DoT's Committee on Open and De-Licensed Unused or Limited Used Spectrum Bands for Demand Generation for Limited Including THz Band.

CHAPTER IV:

RECOMMENDATIONS OF THE DOT'S COMMITTEE

ON TERA HERTZ SPECTRUM

4.1 Department of Telecommunications (DoT), Government of India constituted a Committee to give its recommendations for Open and De-license unused or limited used Spectrum bands for demand generation for limited period including THz band. A summary of recommendations of the DoT's Committee is given below:

"The spectrum beyond 95 GHz and upto 3 THz may be opened for experiments under 'Spectrum-Terahertz Applications License'. There shall not be any restriction on technical conditions for designing and conducting experiments and tests provided they should not cause harmful interference to existing services including secondary services.

The frequency bands, 116-123 GHz, 174.8-182 0Hz, 185-190 GHz, and 244-246 0Hz may be opened for unlicensed use. Initially FCC's Technical specifications may be adopted. After study in Indian environment, technical parameters may be revised.

The frequency band 77-81 GHz band may also be delicensed for automotive radar applications in line with international practice."

4.2 The following sections provide an overview of the recommendations of the DoT's Committee.

A. 'Spectrum-Terahertz Applications License (STAL)' Proposed by the DoT's Committee

4.3 Considering the requirements of emerging new radiocommunications technologies, to promote R&D activities, indoor/ outdoor testing/

experimentation in the field of wireless radiocommunications and also to promote Make in India in wireless products, and international practices, the DoT's Committee recommended that a new experimental radio license category 'Spectrum-Terahertz Applications License (STAL)' may be created that will be applicable for 'Experiment' and 'Demonstration' of equipment designed to operate exclusively on any frequency above 95 GHz.

4.4 The DoT's Committee noted that there are very few assignments above 95 GHz and the spectrum beyond 95 GHz is considered to be vacant, and therefore, recommended to open the spectrum between 95 GHz to 3 THz for experiments under 'Spectrum-Terahertz Applications License (STAL)'. The following table summarizes the terms and conditions of STAL proposed by the DoT's Committee:

Item	**Proposed conditions for [Spectrum - Tera Hertz Applications License (STAL)]**
Purpose	To promote R&D activities, indoor/outdoor testing/ experimentation in the field of wireless radiocommunications and also to promote Make in India in wireless products, and international practices
Period	Initially for five years and further extendable for periods of five years at a time with an interim report to be submitted at the time of each renewal
License Fee	Rs.1000/- towards spectrum charges for 5 years There should not be any restriction on geographical areas for STAL. The user may be allowed to request operations over any area, except restricted areas, that they deem appropriate for their experiment.
Technical Conditions	There shall not be any restriction on technical condition for designing and conducting experiments and tests provided they

Item	Proposed conditions for [Spectrum - Tera Hertz Applications License (STAL)]
	should not cause harmful interference to existing services including secondary services.
Terms & Conditions	May be permitted to market experimental devices designed to operate in the bands above 95 GHz via direct sale
	Licensees who take advantage of these marketing provisions must uniquely identify each device (e.g., through a serial number) in a manner that will enable them to easily track each one. Finally, at the time of sale, the licensee is required to provide trial participants with a written disclosure that clearly states that the equipment being purchased is part of an experiment that may be terminated at any time by the licensee or the licensor, and the device will be surrendered or rendered inoperable at the conclusion of the experiment.
	However, the licensees shall ensure that trial devices are either rendered inoperable or retrievable at the conclusion of the trial. Additionally, each device sold under this program must be labelled as "Authorized Under STAL and may be subject to further conditions including Termination of Operation" and carry with it a licensee assigned equipment ID number to be issued by WPC, DoT.
	Government may prescribe any test/ measurement etc. from health safety/ environment safety/ EMI/ EMC etc. as per international practice, if case application wants to market experimental devices.
	No exclusive assignment should be given under 'STAL'. The assignment will be given on 'Non-interference basis and Non-protection Basis' (NIB/ NPB). The operations under the license

Item	Proposed conditions for [Spectrum - Tera Hertz Applications License (STAL)]
	would also not claim any protection from allocated services or incumbent users.
	The spectrum assignment is subject to the condition that such spectrum, if subsequently assigned for regular (commercial, strategic, etc.) use will entail termination/ modification/ relocation of any test or experimentation being carried out in the said spectrum band. In the event, user will be offered alternative spectrum band. If alternative spectrum band is not feasible, the user will be allowed to continue experiment till the completion of license period in coordination with the licensed assignees.

B. Delicensed Bands Proposed by the DoT's Committee

4.5 The DoT's Committee also proposed that the bands 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz may be opened for unlicensed use in India. The present allocation of the proposed bands for 'unlicensed use' in the National Frequency Allocation Plan (NFAP), 2022 is given below:

Band (GHz)	Current Allocation
116 – 122.25	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)
122.25 – 123	FIXED INTER-SATELLITE MOBILE Amateur

Band (GHz)	Current Allocation
174.8 – 182	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)
185 – 190	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)
244 – 246	RADIO ASIRONOMY RADIOLOCATION Amateur Amateur Satellite

Note: Frequency band 122-123 GHz and 244-246 GHz are ISM bands and are regulated in accordance with provision 5.138 of ITU-RR.

4.6 The DoT's Committee recommended that the devices in the unlicensed bands would operate on no-interference and non-protection basis while protecting both passive and active services running in these bands and adjacent bands.

4.7 The DoT's Committee also proposed technical parameters for the unlicensed bands. A summary of the main technical parameters proposed by DoT's Committee is given below:

Technical Parameters	Limit
Maximum EIRP	40 dBm (average) and 43 dBm (peak)
	82 dBm (average) and 85 dBm (peak) for outdoor fixed point-to-point devices

Technical Parameters	Limit
	Minimum antenna gain: 51 dBi (with 2 dB reduction in the maximum permissible EIRP for each dB the
Out-of-Band emission limit	90 picowatts per cm^2 at a distance of 3 meters
Peak radiated power	Transmitters with an emission bandwidth of less than 100 MHz must limit their peak radiated power to the product of the maximum permissible radiated power (in milliwatts) times their emission bandwidth divided by 100 MHz.
Technical conditions	FCC's technical parameters may be adopted initially and after conducting intensive research in Indian environment, technical parameters may be modified at later stage.
Other terms and conditions	No equipment should be permitted to operate on satellites or onboard aircraft.
	Experiment operating in the 174.8-182 GHz and 185-190 GHz bands should not be designed to operate in the 182-185 GHz band.

C. Delicencing of the 77-81 GHz Band for Automotive Radars Proposed by the DoT's Committee

4.8 The DoT's Committee made the following observations in its report:

(a) The frequency band 76-77 GHz frequency range has already been licensed vide G.S.R. 699 (E) dated 16.09.2015 for the purpose of very low power radio frequency devices or equipment for short range radar systems.

(b) DoT has constituted a committee for implementation of V2X in the country. Frequency bands 76-77 GHz and 77-81 GHz are being used for long range radar and short & medium range radars respectively for V2X application.

(c) FCC, USA and MIC, Japan have designated 76-77 GHz for automotive radars. MIC, Japan has also recommended introduction of high resolution radar in 77-81 GHz band for safety related applications. ETSI has adopted the harmonized standard in the frequency band 77-81 GHz for the application of short range radars. FCC, USA has allowed 77-81 GHz band for vehicular radar operations aligning with rest of the world. Many countries in Asia Pacific Region have also designated 77-77 GHz and 77-81 GHz bands for short range automotive radar applications for ITS. Therefore, the frequency band 77-78 GHZ and 77-821 GHz band are globally harmonized bands for short range radar applications.

4.9 Keeping the above observations in mind, the DoT's Committee recommended that 77-81 GHz band may also be delicensed for automotive radar applications in line with international practice.

D. Summary of Recommendations of the DoT's Committee

4.10 A summary of recommendations of the DoT's Committee is given below:

(a) The spectrum beyond 95 GHz and upto 3 THz may be opened for experiments under 'Spectrum-Terahertz Applications License'. There shall not be any restriction on technical conditions for designing and conducting experiments and tests provided they should not cause harmful interference to existing services including secondary services.

(b) The frequency bands, 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz may be opened for unlicensed use. Initially FCC's Technical

specifications may be adopted. After study in Indian environment, technical parameters may be revised.

(c) The frequency band 77-81 GHz band may also be delicensed for automotive radar applications in line with international practice.

E. Examination of Issues Related to the recommendations of the DoT's Committee

4.11 The matter related to 'Spectrum Terahertz Application License (STAL)' will be examined separately in Chapter V of this consultation paper. At this stage, the Authority solicits views of stakeholders on the following questions related to (a) Delicensing of bands in THz range, and (b) Delicensing of 77-81 GHz band for Automotive radars:

Issues for consultation:

Q1. Whether there is a need for permitting license-exempt operations in 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz frequency ranges? Please provide a detailed response with justification.

Q2. In case it is decided to permit license-exempt operations in 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz frequency ranges, what should be the terms and conditions including technical parameters for permitting license-exempt operations in these bands, while protecting both passive and active services in and around these frequency ranges? Please provide a detailed response with justification.

Q3. Whether there is a need for permitting license-exempt operations in any other bands in the 95 GHz to 3 THz frequency range? Please provide a detailed response with justification.

Q4. Whether there is a need for permitting license-exempt operation in 77-81 GHz band for automotive radar applications? Please provide a detailed response with justification.

Q5. In case it is decided to permit license-exempt operations in the 77-81 GHz band for automotive radar applications, what should be the terms and conditions including technical parameters for permitting licensed-exempt operations in this frequency band? Please provide detailed response with justification.

4.12 The following chapter examines the experimental licensing regime in the country.

CHAPTER V:

EXPERIMENTAL LICENSING REGIME

A. Present experimental Licensing regime in India

5.1 Presently the Government of India follows the Unified Licensing Regime. However, considering the requirements for emerging radio communication technologies and to promote R&D activities in the field of wireless radiocommunications, specifically 5G technologies, the Government vide its OM dated 23.07.2019[10] issued a notification for regulating the Experimental and Technology Trial licenses, Manufacturing and Testing licenses and Demonstration licenses.

5.2 The Experimental licenses are available to Indian entities involved in R&D, incubation, manufacturing, telecommunication service providers (TSPs), and public access testbeds. The Technology Trial licenses are available to Indian entities viz. TSPs, companies, organizations, academia involved in services, R&D experimentation, manufacturing of digital communication technologies (DCTs). These licenses are open for all bands including new, unallocated, unallotted, unassigned, unsold, unused bands and others as may be feasible enabling international market access opportunities for Indian entities. However, they are granted for shorter time frames of a year (extendable on a case-to-case basis), and they do not permit provision of commercial services.

5.3 In this regard, as a sample, the terms and conditions under the existing licenses of 'Technology trials (Radiating) other than 5G' trials were compared with the terms and conditions in the 'Spectrum Terahertz Applications License (STAL)' proposed by the DoT's Committee. The main differences between the two licenses are outlined below:

[7] https://dot.gov.in/sites/default/files/OM%20dated%2023rd%20July%202019_0.pdf

Item	Existing Conditions under the 'License for Technology Trials (Radiating) Other Than 5G trials' (DoT's OM dated 23.07.2019)	Proposed conditions for the 'Spectrum - Tera Hertz Applications License (STAL)' proposed by the DoT's Committee
Purpose	Technology and Capability demonstration, Product stabilization, usage case and ecosystem development etc., in standalone or non-standalone modes. Technology trials for special projects of DoT/USOF will also be undertaken under this category.	To promote R&D activities, indoor/outdoor testing/ experimentation in the field of wireless radiocommunications and also to promote Make in India in wireless products, and international practices
Period	3 months for site preparation which may include deployment, Testing, logistics, imports (as may necessary) and One year for trial. Further extendable by one more year (by paying Rs. 5000 towards license fee) based on review by a DoT Expert committee. The period is subject to truncation to prevent interference to licensed operations. Restricted power levels, coordination, relocation of the test site may be tried to complete the test.	The license can be initially granted for five years and can be extended for an additional five-year at a time. Interim reports are required at the time of each renewal.

Item	Existing Conditions under the 'License for Technology Trials (Radiating) Other Than 5G trials' (DoT's OM dated 23.07.2019)	Proposed conditions for the 'Spectrum - Tera Hertz Applications License (STAL)' proposed by the DoT's Committee
	For Special Projects of DoT, the time period will be as per the period defined in DoT /USOF projects for which the trials are required to be conducted.	
License Fee	Rs. 5000/- (one time) per License covering defined geographical areas in one Licensed Service Area (LSA). All devices under trial are included under one license.	Rs.1000/- towards spectrum charges for 5 years
Technical Conditions	Restricted power levels coordination relocation of the test site may be tried to complete the test	No restriction on technical conditions for designing and conducting experiments and tests provided they should not cause harmful interference to existing services
Terms & Conditions	No commercial services	Direct sale of experimental devices designed to operate in the bands above 95 GHz Government may prescribe any test/ measurement etc. from

Item	Existing Conditions under the 'License for Technology Trials (Radiating) Other Than 5G trials' (DoT's OM dated 23.07.2019)	Proposed conditions for the 'Spectrum - Tera Hertz Applications License (STAL)' proposed by the DoT's Committee
		health safety/ environment safety/ EMI/ EMC etc. as per international practice, if case application wants to market experimental devices.
	Review by an Expert Committee appointed by DoT on Quarterly basis to monitor and ascertain effective usage of spectrum	The spectrum assignment is subject to the condition that such spectrum, if subsequently assigned for regular (commercial, strategic, etc.) use will entail termination/ modification/ relocation of any test or experimentation being carried out in the said spectrum band. In the event, user will be offered alternative spectrum band. If alternative bands aren't available, users can continue experiment until license period ends.
	Non protection and Non-interference basis	Non protection and Non-interference basis. The operations under the license would also not claim any

Item	Existing Conditions under the 'License for Technology Trials (Radiating) Other Than 5G trials' (DoT's OM dated 23.07.2019)	Proposed conditions for the 'Spectrum - Tera Hertz Applications License (STAL)' proposed by the DoT's Committee
		protection from allocated services or incumbent users.
	The entities are also permitted for demo of their products developed/ under development in other locations (other than trial area) in indoor environment (for a maximum period of one month at one place) on non-interference and non-protection basis without a separate demo license.	No restriction on geographical areas for STAL (except restricted areas)
	The license includes the necessary permissions for importing wireless products/ assemblies/ modules and associated accessories including antennae operating in both licensed and license-exempt bands. Such imported products shall not be for commercial use/ sale.	The licensees shall ensure that trial devices are either rendered inoperable or retrievable at the conclusion of the trial and each device sold under this program may be labeled as "Authorized Under STAL and may be subject to further conditions including Termination of Operation" and carry with it a licensee assigned equipment ID number to be issued by WPC, DOT.

5.4 In this background, the Authority solicits views of stakeholders on the following set of questions:

Issues for consultation

Q6. Whether there is a need to open the frequency spectrum between 95 GHz to 3 THz for experiment and demonstration of equipment designed to operate on any frequency above 95 GHz through a separate experimental license? Please provide a detailed response with justification.

Q7. In case it is decided to open the frequency spectrum between 95 GHz to 3 THz for experiment and demonstration of equipment designed to operate on any frequency above 95 GHz through a separate experimental license -

(a) what should be the terms and conditions under such a license? Kindly provide inputs in respect of, *inter alia,* the following aspects for the proposed separate experimental license:

i. Purpose of the license;

ii. Scope of the license;

iii. Eligibility conditions for entities seeking to acquire the license;

iv. Mode of applying for the license;

v. Duration of the license;

vi. Obligation under the license;

vii. Financial conditions including the license fees;

viii. Technical conditions and other terms and conditions for operations under the license;

ix. Mechanism to ensure protection to passive services in the frequency range between 95 GHz to 3 THz; and

x. Any other (please specify).

(b) whether the licensees should be permitted to market experimental devices designed to operate in the frequency range between 95 GHz to 3 THz via direct sale? If yes, what should be the associated terms and conditions?

Please provide a detailed response with justification.

Q8. Whether there are any other issues or inputs in respect of the frequency spectrum in Tera Hertz bands? If yes, please provide detailed comments with justification.

5.5 The following chapter lists the issues for consultation.

CHAPTER VI:

ISSUES FOR CONSULTATION

Stakeholders are requested to provide responses to the following questions with detailed justifications:

Q1. Whether there is a need for permitting license-exempt operations in 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz frequency ranges? Please provide a detailed response with justification.

Q2. In case it is decided to permit license-exempt operations in 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz frequency ranges, what should be the terms and conditions including technical parameters for permitting license-exempt operations in these bands, while protecting both passive and active services in and around these frequency ranges? Please provide a detailed response with justification.

Q3. Whether there is a need for permitting license-exempt operations in any other bands in the 95 GHz to 3 THz frequency range? Please provide a detailed response with justification.

Q4. Whether there is a need for permitting license-exempt operation in 77-81 GHz band for automotive radar applications? Please provide a detailed response with justification.

Q5. In case it is decided to permit license-exempt operations in the 77-81 GHz band for automotive radar applications, what should be the terms and conditions including technical parameters for permitting licensed-exempt operations in this frequency band? Please provide detailed response with justification.

Q6. Whether there is a need to open the frequency spectrum between 95 GHz to 3 THz for experiment and demonstration of equipment designed to operate on any frequency above 95 GHz through a separate experimental license? Please provide a detailed response with justification.

Q7. In case it is decided to open the frequency spectrum between 95 GHz to 3 THz for experiment and demonstration of equipment designed to operate on any frequency above 95 GHz through a separate experimental license -

(a) what should be the terms and conditions under such a license? Kindly provide inputs in respect of, *inter alia,* the following aspects for the proposed separate experimental license:

i. Purpose of the license;

ii. Scope of the license;

iii. Eligibility conditions for entities seeking to acquire the license;

iv. Mode of applying for the license;

v. Duration of the license;

vi. Obligation under the license;

vii. Financial conditions including the license fees;

viii. Technical conditions and other terms and conditions for operations under the license;

ix. Mechanism to ensure protection to passive services in the frequency range between 95 GHz to 3 THz; and

x. Any other (please specify).

(b) whether the licensees should be permitted to market experimental devices designed to operate in the frequency range between 95 GHz to 3 THz via direct sale? If yes, what should be the associated terms and conditions?

Please provide a detailed response with justification.

Q8. Whether there are any other issues or inputs in respect of the frequency spectrum in Tera Hertz bands? If yes, please provide detailed comments with justification.

ANNEXURE – I

DoT's reference dated 23.01.2022

R-14019/01/2022-SG

I/3073157/2022

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning & Coordination (WPC) Wing

6th floor, Sanchar Bhawan,
20, Ashoka Road, New Delhi – 110001.

No.: R-14019/01/2022-SG Date: 08.12.2022

To,

The Secretary
Telecom Regulatory Authority of India
Mahanagar Doorsanchar Bhawan
Jawahar Lal Nehru Marg (Old Minto Road)
New Delhi-110002.

Subject: Seeking TRAI recommendations on Open and De-licensed use of unused or limited used Spectrum bands for demand generation for limited period in Tera Hertz range.

Sir,

In various parts of the world, administrations, with a view to encourage technology development, have come up with regulations allowing conduct of experiments in the spectrum bands beyond 95 GHz. Accordingly, it has been decided to encourage the development of new communications technologies and new services in the country in the spectrum ranges above 95 GHz.

2. In view of the above, a Committee was constituted under the Chairmanship of Wireless Adviser to give its recommendations on the issue. The Committee has submitted its report (copy enclosed for ready reference) . The summary of recommendations of the Committee is given below:

a. The spectrum beyond 95 GHz and upto 3 THz may be opened for experiments under 'Spectrum-Terahertz Applications License'. There shall not be any restriction on technical condition for designing and conducting experiments and tests provided they should not cause harmful interference to existing services including secondary services.
b. The frequency bands, 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz may be opened for unlicensed use. Initially FCC's Technical specifications may be adopted. After study in Indian environment, technical parameters may be revised.
c. The frequency band 77-81 GHz band may also be delicensed for automotive radar applications in line with international practice.

3. However, with a view to come up with a well-rounded regulatory regime on the subject matter, it was considered appropriate to seek TRAI recommendation as well. Therefore, under the terms of clause 11 (1)(a) of TRAI Act, 1997 as amended by TRAI Amendment Act 2000, TRAI is requested to provide recommendations on the following:

(a) Terms and Conditions for opening of spectrum beyond 95 GHz and upto 3 THz for experiments under a regime which may be named as *'Spectrum-Terahertz Applications License'* for 'Experiment' and 'Demonstration' of equipment designed to operate on any frequency above 95 GHz while protecting any *"Passive"* services in these frequency ranges. The licensees may also be permitted to market such experimental devices via direct sale. The regime may be opened for a defined period.

(b) Terms and conditions including technical parameters for permitting licensed-exempt operations in 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz frequency ranges, while protecting both passive and active services in and around these frequency ranges

(c) Terms and conditions including technical parameters for permitting licensed-exempt operations in 77-81 GHz band for automotive radar applications in line with international practice.

भारतीय दूरसंचार विनियामक प्राधिकरण
महानगर दूरसंचार भवन, नई दिल्ली-०२
पंजीकरण सं. 15406
09 DEC 2022
ई आफिस सं.

I/3073157/2022

(d) Any other techno-regulatory recommendations relevant to the issue.

4. This issues with the approval of the competent authority.

(Gulab Chand)
Joint Wireless Adviser

Encl: As above (Report of the Committee)

Report of the Committee on Open and De-License Unused or Limited Used Spectrum Bands for Demand Generation for Limited Period Including THz Band

Table of Contents

1. Introduction

1.1 Radio spectrum is lifeline for wireless communication. Innovation in wireless technology makes possible to use of those frequency bands which were thought of unusable in past. Radio frequency is considered upto 3 THz, which often viewed as the transition point from radio technology to infrared technology. Presently, radio spectrum upto 95 GHz is in use and radio spectrum beyond 95 GHz is yet to put in use. There are substantial opportunities for innovation in these frequencies, especially for high-bandwidth applications as well as imaging and sensing operations.

1.2 Advancements in research and technology development have allowed for the inception of new products and applications using spectrum in higher frequency bands. The frequency beyond 95 GHz are characterized by short propagation distances and small wavelengths, and availability of large contiguous bandwidths, which make them suited for a range of applications. The propagation characteristics of frequency above 95 GHz permits least interference to the existing services such as Earth exploration-satellite service, radio astronomy service, space research service, inter-satellite service and fixed and mobile services, which make suitable for coexistence of numerous short range applications.

1.3 To encourage the development of new communications technologies and expedite the deployment of new services in the spectrum above 95 GHz, worldwide various administrations have made regulations to conduct experiment in the spectrum band beyond 95 GHz. Accordingly, Indian administration has also desired to open radio spectrum beyond 95 GHz for experiment.

1.4 A Committee with the following composition has been constituted to give its recommendations for Open and De-license unused or limited used Spectrum bands for demand generation for limited including THz band in view of Post-budget webinar on "Technology enabled Development" held on 02.03.2022 "Breakaway session 1: Building a strong 5G ecosystem for Service Delivery" organized by the Government.

1. Shri R.K. Saxena, Wireless Advisor -Chairman
2. Prof. Abhay Karindkar, Director, IIT Kanpur – Co Chair
3. Shri YGSC Kishore Babu, DDG (SRI) – Member
4. Shri V.J. Christopher, Director WMO – Member
5. Shri M.K. Pattanaik, Sr. DWA (Sat)- Member
6. Shri. P.S.M. Tripathi, DWA (Security)- Member Convener

1.5 The Term of Reference (TOR) of the above committee is under:

To give its recommendations for Open and De-license unused or limited used Spectrum bands for demand generation for limited period including THz band.

1.6 The Committee met several times and provided valuable inputs for the report. The summary of recommendations of the Committee is given below:

- The spectrum beyond 95 GHz and upto 3 THz may be opened for experiments under 'Spectrum-Terahertz Applications License'. There shall not be any restriction on technical condition for designing and conducting experiments and tests provided they should not cause harmful interference to existing services including secondary services.

- The frequency bands, 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz may be opened for unlicensed use. Initially FCC's Technical specifications may be adopted. After study in Indian environment, technical parameters may be revised.

- The frequency band 77-81 GHz band may also be delicensed for automotive radar applications in line with international practice.

2. Terahertz (THz) Radio Spectrum

2.1 The terahertz (THz) band is the part of the electromagnetic waves in the frequency between 100 GHz–30 THz i.e. between microwaves and infrared waves. It is also called the sub-millimetre band. The THz band offers a much larger bandwidth, which ranges from tens of GHz up to several THz and suitable for Nano cell. THz communication system is highly directional, more energy efficient, less latency, less susceptible to free space diffraction and able to address the capacity limitations of current wireless systems. At 100 GHz the wavelength is 3 mm, halving to 1.5 mm at 200 GHz, etc. This means that modest size antennas can have dimensions that are many wavelengths so their beams can have well focused mean beams.

2.2 According to Friis Law, free space propagation loss is directly proportional to square of frequency. Therefore, high propagation loss drastically reduces the coverage with THz communication system. Besides free space loss, atmospheric absorptions (e.g., oxygen and water molecule absorptions) resulting in additional path loss. This atmospheric absorption varies with frequency, humidity and altitude, generally increasing in frequency and decreasing with altitude although at certain frequencies with strong molecular resonances. However, atmospheric absorption has not any fixed pattern. In general, atmospheric absorption increases with frequency but exhibit high absorption at some of the frequency. The absorption peaks create spectral windows, which drastically change with the variation of the distance.

2.3 As per Radio Regulation, allocation of radio spectrum beyond 100 GHz are allocated largely to Radio Astronomy and Satellite based services such as Earth Exploration Satellite, Space Research, Amateur Satellite, Radio Navigation Satellite and Mobile Satellite etc. on primary basis. Besides Satellite and Radio Astronomy, allocation has also been made for Fixed and Mobile services as Primary services in 12 frequency bands with about 100 GHz spectrum between 100-275 GHz, which accounts more than 55% of total

spectrum available between 100-275 GHz. The percentage of allocation to different services in the frequency band 100-275 GHz is given in Table.

S. No.	Service	Allocated Bandwidth* (in GHz)	Allocation (in %)
1	Fixed	97.20	55.54
2	Mobile	97.20	55.54
3	Earth Exploration Satellite	58.80	33.6
4	Space Research	70.75	40.43
5	Inter Satellite	35.23	20.13
6	Fixed Satellite	35.00	20
7	Mobile Satellite	33.71	19.26
8	Amateur	4.01	2.29
9	Amateur Satellite	4.01	2.29
10	Radio Astronomy	107.80	61.6
11	Radiolocation	21.51	12.29
12	Radionavigation	30.21	17.26
13	Radionavigation Satellite	30.21	17.26

* More than one services shared the same band

2.4 The initial allocations above 100 GHz were made at WARC-79 and most of the present allocations, include a large number of passive allocations were made at WRC-2000. Most of the passive allocations are included in Radio Regulation 5.340 (RR5.340).

2.5 The passive allocations above 100 GHz appear to have a major impact on the potential of other radio services in this area where demand and technology are now developing. This was anticipated at WRC-2000 and included as an integral part of the decision for these allocation ITU-R studies under Resolution 731. to explore the feasibility of sharing subject to explicit quantitative protection goals.

2.6 There is no allocation beyond 275 GHz in Radio Regulation. However, WRC-19 introduced a footnote 5.564A for making allocation for frequency

band 275-450 GHz for land mobile and fixed services, allow the coexistence of fixed and land mobile services with active and passive services in the frequency band 275-1000 GHz. Specifically, the radioastronomy service occupies 275-450 GHz, while the earth exploration-satellite and space research services operates in 296-306 GHz, 313-318 GHz and 333-356 GHz bands. The footnote also allows the frequency bands 275-296 GHz, 306-313 GHz, 318-333 GHz and 356-450 GHz for the implementation of land mobile and fixed service applications without protection to Earth exploration-satellite service (passive) applications. Further, frequency bands in the range 275-1 000 GHz are identified for use by administrations for passive service applications vide footnote 5.565. These two footnotes are stated as below:

> *5.564A For the operation of fixed and land mobile service applications in frequency bands in the range 275-450 GHz:*
>
> *The frequency bands 275-296 GHz, 306-313 GHz, 318-333 GHz and 356-450 GHz are identified for use by administrations for the implementation of land mobile and fixed service applications, where no specific conditions are necessary to protect Earth exploration-satellite service (passive) applications.*
>
> *The frequency bands 296-306 GHz, 313-318 GHz and 333-356 GHz may only be used by fixed and land mobile service applications when specific conditions to ensure the protection of Earth exploration-satellite service (passive) applications are determined in accordance with Resolution* **731 (Rev.WRC-19)**.
>
> *In those portions of the frequency range 275-450 GHz where radio astronomy applications are used, specific conditions (e.g. minimum separation distances and/or avoidance angles) may be necessary to ensure protection of radio astronomy sites from land mobile and/or fixed service applications, on a case-by-case basis in accordance with Resolution* 731 **(Rev.WRC-19)**.
>
> *The use of the above-mentioned frequency bands by land mobile and fixed service applications does not preclude use by, and does not establish priority over, any other applications of radio services in the range of 275-450 GHz. (WRC-19).*

5.565 The following frequency bands in the range 275-1 000 GHz are identified for use by administrations for passive service applications:

– radio astronomy service: 275-323 GHz, 327-371 GHz, 388-424 GHz, 426-442 GHz, 453-510 GHz, 623-711 GHz, 795-909 GHz and 926-945 GHz;

– Earth exploration-satellite service (passive) and space research service (passive): 275-286 GHz, 296-306 GHz, 313-356 GHz, 361-365 GHz, 369-392 GHz, 397-399 GHz, 409-411 GHz, 416-434 GHz, 439-467 GHz, 477-502 GHz, 523-527 GHz, 538-581 GHz, 611-630 GHz, 634-654 GHz, 657-692 GHz, 713-718 GHz, 729-733 GHz, 750-754 GHz, 771-776 GHz, 823-846 GHz, 850-854 GHz, 857-862 GHz, 866-882 GHz, 905-928 GHz, 951-956 GHz, 968-973 GHz and 985-990 GHz.

The use of the range 275-1 000 GHz by the passive services does not preclude use of this range by active services. Administrations wishing to make frequencies in the 275-1 000 GHz range available for active service applications are urged to take all practicable steps to protect these passive services from harmful interference until the date when the Table of Frequency Allocations is established in the above-mentioned 275-1 000 GHz frequency range.

All frequencies in the range 1 000-3 000 GHz may be used by both active and passive services. (WRC-12)

2.7 WRC-15/19 has framed the following two study questions:

QUESTION ITU-R 256-1/5 on Technical and operational characteristics of the land mobile service in the frequency range 275-1 000 GHz under which sharing studies between the land mobile and passive services, as well as the land mobile and other active services should be carried out.

QUESTION ITU-R 257-1/5 on Technical and operational characteristics of the fixed service in the frequency range 275-1 000 GHz under which sharing studies between the fixed and other active services should be carried out.

2.8 The study is being undertaken by Working Party 5A and 5C for Question 256-1/5 and 257-1/5 respectively. Study will be undertaken during the two study cycles i.e. 2015 to 2019 and 2019 to 2023 and responses will be

discussed during the WRC-23. The results of these studies shall be in form of ITU's Recommendations, Reports or Handbooks. The above questions are given at Annexure-I.

2.9 Further, WP 5D is also preparing a document on propagation models for the radio waves above 100 GHz for various scenarios including indoor/outdoor in the form of Report. The proposed report would include information on propagation environment and channel models, as well as newly developed technology enablers such as active and passive components, antenna techniques, deployment architectures, and the results of simulations and performance tests.

2.10 The applications of THz frequencies include (shown in figure); high data-rate communications and applications, sensing applications, high precision positioning applications, high density applications, and backhaul infrastructure etc. Further, due to the short wavelengths, THz frequencies are particularly well suited for sensing applications, including health screening, non-invasive quality assurance in pharmaceutical and manufacturing industries, high-resolution positioning, high-density applications and security systems.

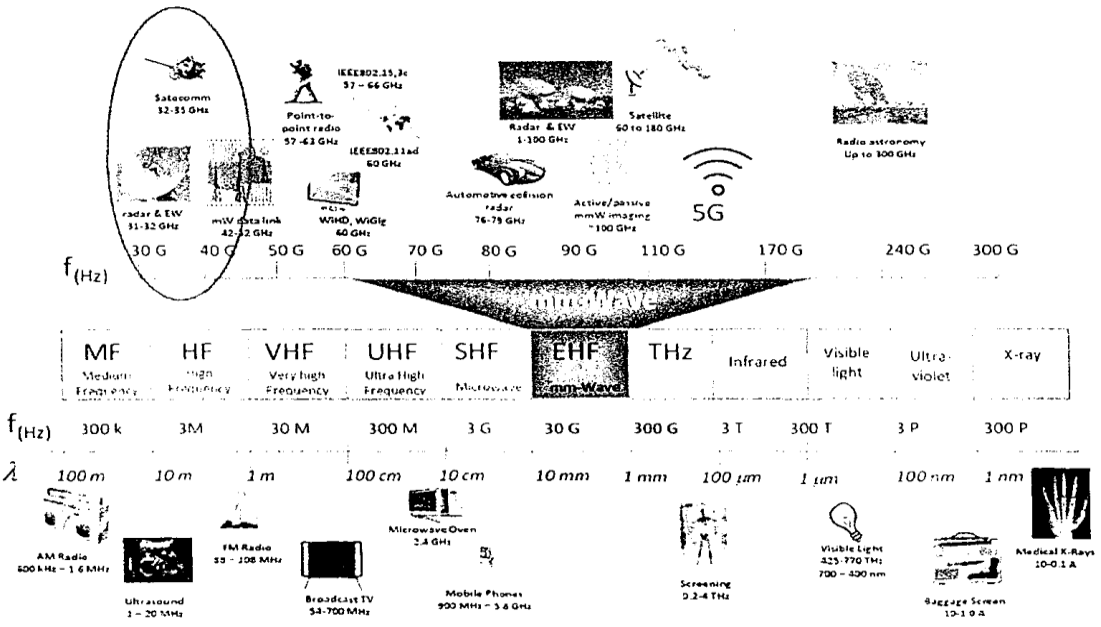

Figure: Terahertz Applications

2.11 Currently, lower terahertz frequency band 95-120 GHz is important for fixed broadband wireless services. As per NFAP 2018, the frequency band 95-120 GHz is allocated for Fixed, Mobile, Radio astronomy, Radionavigation, Radiolocation, Space-research, earth exploration satellite, and Inter-satellite. Out of 25 GHz, 15.7 GHz is allocated for Fixed service as primary service along with other primary services. The rain and gas attenuation is less than 25dB/Km and 1dB/Km respectively. Therefore, gas attenuation is not a dominant factor for this frequency band. It may also be noted that this band is not much affected by Oxygen absorption peaks. The band is most suitable for High Capacity Systems, Mobile backhaul and fronthaul and able to support all services requiring very high speed wireless transmission, drive to the higher part of the spectrum.

2.11 The anticipated massive growth in wireless data traffic require due to introduction of 5G services, backhaul capacity must also continue to increase substantially. Therefore, more backhaul capacity is needed to support the evolving needs of increasing 5G and beyond traffic and number of connected devices. Spectrum above 95 GHz supports wider channels and has higher backhaul capacities.

2.12 The frequency beyond 95 GHz is also well suited for Machine to Machine (M2M) communication. It also supports Industry 4.0 applications, i.e. the next generation of industrial Internet of Things.

2.13 The sixth-generation (6G) wireless system, fully supported by artificial intelligence, will become the dominant paradigm for wireless. 6G is also expected to merge communications and sensing in a new way, and the wide bandwidth needed for data will also benefit many high-precision sensing applications. Therefore, sub-terahertz (subTHz) territory is the focus of active research for 6G communications.

3. International Regulations for Radio Spectrum beyond 95 GHz

3.1 Federal Communication Commission (FCC), USA

(A) Licensed Operation:

- The FCC has created a new experimental radio license, the Spectrum Horizons Experimental Radio License (Spectrum Horizons License), that will be available for experiments and demonstrations of equipment designed to operate exclusively on any frequency above 95 GHz and 3THz.

- These Spectrum Horizons License features should promote a more rapid development of new products and services that will reach a larger number and wider variety of users than would be possible under the existing experimental licensing rules. This would foster an environment where innovators can develop new products and applications absent unnecessary limitation.

- There is no restriction on technical condition for designing and conducting experiments and tests.

- Spectrum Horizons License will be required to show how the experimental operations (and any related devices) will be controlled so that they do not cause harmful interference to other services. Further, Spectrum Horizons License operations will not be entitled to exclusive use; will not be protected from harmful interference from allocated services; and will be prohibited from causing harmful interference to authorized services, including secondary services.

- A Spectrum Horizons License may be authorized over any geographic area.

- Spectrum Horizons Licenses broadly available to persons qualified to conduct the types of operations described in existing experimental radio service rules.

- These licenses will give innovators the flexibility to conduct experiments lasting up to 10 years without further renewal.

- All bands between 95 GHz and 275 GHz are allocated on a shared basis. Above 275 GHz, while there are no allocations, a number of bands are identified for use by passive services. Accordingly, Spectrum Horizons Licenses, will only be granted on a non-interfering basis, only following coordination with existing users and unless a sufficient methodology for preventing harmful interference is detailed, such operations will not be permitted.

- Spectrum Horizons License applicants that propose to use spectrum exclusively allocated for passive use(s), must provide an explanation why nearby bands with non-passive allocations are not appropriate or adequate for the experiment and also acknowledge that they intend to transition any potential long-term use to a band with appropriate allocations.

(B) Unlicensed Operations:

- FCC has also free up 21.2 GHz of the Spectrum Horizons bands for unlicensed use: the 116-123 GHz band, the 174.8-182 GHz band, the 185-190 GHz band, and the 244-246 GHz band. These devices would operate on a non-interference basis while protecting both passive and active services. The services operating in these identified bands are EARTH EXPLORATION-SATELLITE (passive), RADIO ASTRONOMY and SPACE RESEARCH (passive).

- Devices may operate in all of these bands with a maximum EIRP of 40 dBm (average) and 43 dBm (peak), measured with a detection bandwidth that encompasses the band of operation.

- It also permits outdoor fixed point-to-point devices to operate with a higher maximum EIRP of 82 dBm (average) and 85 dBm (peak), also measured with a detection bandwidth that encompasses the band of operation.

- Use of the higher power limits also requires that devices use antennas with a minimum gain of 51 dBi, with a 2 dB reduction in the maximum permissible EIRP for each dB the antenna gain falls below 51 dBi. These highly directional antennas with very narrow beam widths will ensure that the likelihood of harmful interference is minimized.

- Unlicensed devices have to comply with an out-of-band emission limit of 90 picowatts per square centimeter at a distance of three meters.

- No equipment will be permitted to operate on satellites or onboard aircraft.

- Equipment operating in the 174.8-182 GHz and 185-190 GHz bands should not be designed to operate in the 182-185 GHz band

3.2 Office of Communications (Ofcom), United Kingdom

- Ofcom has made available the Spectrum Access in Extremely High Frequency (EHF) band on a non-protection and non-interference basis, with use of multiple devices to support research, innovation and the development and use of new products and applications.

- The following bands has been made available:
    - 57-71GHz
    - 116-122 GHz
    - 174.8-182 GHz
    - 185-190 GHz

- These bands can be shared on uncoordinated basis across the UK with use of multiple devices within the licence band, provided that these meet the licence technical conditions.

- Each licence costs £75, which is payable every five years.

- The maximum permitted equivalent isotropically radiated power (EIRP) is 55 dBm. For outdoor use of 100-200 GHz equipment only, there are additional power limits on EIRP at angles relative to the main beam in the elevation plane.

- "Indoor" means inside premises which: (i) have a ceiling or a roof; and (ii) except for any doors, windows or passageways, are wholly enclosed.

Table: Power limits and restrictions on outdoor use

Power limits (*max EIRP in dBm*) and emissions restrictions on outdoor use			
USE	**116-122 GHz**	**174.8-182 GHz**	**185-190 GHz**
Indoor	55	55	55
Outdoor	55	55	55
Restrictions on outdoor use of equipment	When devices are used outdoors, the main beam elevation angle (φ) of licensed devices shall not exceed 20° above horizontal.		
Airborne use	Airborne use not permitted.		

Other usage conditions	For all systems using bandwidths of less than 100 MHz, all of the above EIRP limits must be adjusted as follows: $EIRP\ Reduction =$ $10\ x\ \log_{10}({}^{BW_{MHz}}/_{100})$

- For outdoor use of 100-200 GHz equipment only, the main beam elevation angle of the device must not exceed 20 degrees above horizontal. There are no elevation angle restrictions for indoor use.
- Any out-of-band emissions must be limited to -10 dBm/MHz EIRP.
- Devices must not be used airborne. This means they cannot be used onboard or attached to an aircraft, drone or balloon.
- The licence has an indefinite duration.
- For any mobile use, accurate records must be kept for the postal address (including postcode) and National Grid Reference (to 1m resolution) of the centre of any 5km radius within which the radio equipment is used.
- If a mobile device operates over an area with a radius larger than 5km, records must be kept for the centre of as many 5km radius areas as are required to reflect the areas of use.

3.3 Ministry of Internal Affairs and Communications (MIC), Japan

- In 2015 MIC make 18 GHz of spectrum available 116-134 GHz for "Commercial Telecommunications Service" subject to the provision that "all practicable steps shall be taken to protect the radio astronomy service from harmful interference" in parts of the band. Japan authorities are currently studying future regulation for the 110-174.8

GHz band (which includes part of both D and W bands) for fixed service.

3.4 CEPT Regulation

- European Conference of Postal and Telecommunications Administrations CEPT released a report in September 2018 (ETSI GR mWT 018 V1.1.1 (2019-08) on point-to-point links in frequency ranges 92-114.25 GHz and 130-174.8 GHz, referred to as the W-band and D-band, respectively. The report provides information, considerations and application use cases in the W and D bands and discusses the flexible and efficient use of these bands.

- The European Union (EU) has already adopted harmonized standards, (ETSI EN 305 550-1 and ETSI EN 305 550-2), which allow short range devices (SRDs) to operate between 40 GHz and 246 GHz includes provisions for such devices at 122.0–122.25 GHz and 244–246 GHz. SRDs are allowed to operate at a maximum e.i.r.p. of 10 dBm in the 122-122.25 GHz band and at a maximum e.i.r.p. of 20 dBm in both the 122.25-123 and the 244-246 GHz bands. Unlike the Japanese provisions, power limits are given, and they are quite modest at 20 dBm effective isotropic radiated power (EIRP).

4. Recommendations of the Committee

4.1 Spectrum above 95 GHz

4.1.1 Considering the requirements of emerging new radiocommunications technologies, to promote R&D activities, indoor/outdoor testing/ experimentation in the field of wireless radiocommunications and also to promote Make in India in wireless products, and international practices, the committee recommends that a new experimental radio license category 'Spectrum-Terahertz Applications License (STAL)' may be created that will

(Also refer to the note on Page 22)

be applicable for 'Experiment' and 'Demonstration' of equipment designed to operate exclusively on any frequency above 95 GHz.

4.1.2 As per available frequency assignment, there are very few assignments above 95 GHz. The spectrum beyond 95 GHz is considered to be vacant, therefore, spectrum beyond 95 GHz and upto 3 THz may be opened for experiments under 'Spectrum-Terahertz Applications License'.

4.1.3 It is anticipated this new License will make experimentation more attractive, resulting in a greater number of thoughtful and innovative experiments. Such experiments are vital for the development of new applications and services suited for the unique properties of the bands above 95 GHz. It would promote a more rapid development of new products and services that will reach a larger number and wider variety of users than would be possible under the existing experimental licensing rules.

4.1.4 Any Indian National or any Indian Entity (Academic institutes, R&D Labs, Central/State Governments or their PSUs, UTs, Technology parks, TSPs, incubators, industry partners, OEMs etc.) may be allowed. The other eligibility criteria may be kept similar to the existing experimental license to encourage wider participation.

4.1.5 There shall not be any restriction on technical condition for designing and conducting experiments and tests provided they should not cause harmful interference to existing services including secondary services.

4.1.6 No exclusive assignment should be given under 'STAL'. The assignment will be given on 'Non-interference basis and Non-protection basis' (NIB/NPB). The operations under the license would also not claim any protection from allocated services or incumbent users.

4.1.7 The License may be given initially for five years and further extendable for periods of five years at a time with an interim report to be submitted at the time of each renewal for an experiment considering research/innovation is a time taking process and short duration license would not give desired result.

4.1.8 The applicant may submit details of experiment to be undertaken along with possible outcomes and interference mitigation techniques that may be required to protect the existing users

4.1.9 There should not be any restriction on geographical areas for STAL. The user may be allowed to request operations over any area, except restricted areas, that they deem appropriate for their experiment.

4.1.10 The spectrum assignment is subject to the condition that such spectrum, if subsequently assigned for regular (commercial, strategic, etc.) use will entail termination/modification/relocation of any test or experimentation being carried out in the said spectrum band. In the event, user will be offered alternative spectrum band. If alternative spectrum band is not feasible, the user will be allowed to continue experiment till the completion of license period in coordination with the licensed assignees.

4.1.11 The licensees will be permitted to market experimental devices designed to operate in the bands above 95 GHz via direct sale. The characteristics of signals in the bands above 95 GHz effectively limit the range of each device to such an extent that a larger number of devices can operate without increasing the potential of harmful interference to authorized services. However, the licensees shall ensure that trial devices are either rendered inoperable or retrievable at the conclusion of the trial. Additionally, each device sold under this program must be labeled as "Authorized Under STAL and may be subject to further conditions including Termination of Operation" and carry with it a licensee assigned equipment ID number to be issued by WPC, DOT. Licensees who take advantage of these marketing provisions must uniquely identify each device (e.g., through a serial number) in a manner that will enable them to easily track each one. Finally, at the time of sale, the licensee is required to provide trial participants with a written disclosure that clearly states that the equipment being purchased is part of an experiment that may be terminated at any time by the licensee or the licensor, and the device will be surrendered or rendered inoperable at the conclusion of the experiment.

4.1.12 Government may prescribe any test/measurement etc. from health safety/environment safety/EMI/EMC etc. as per international practice, if case application wants to market experimental devices.

4.1.13 The Committee recommends that applicant will have to Rs.1000/- towards spectrum charges for 5 years.

4.2 Delicensed Bands

4.2.1 FCC has offered four different bands namely, 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz under unlicensed category. Ofcom has made available frequency bands 116-122 GHz, 174.8-182 GHz and 185-190 GHz on a non-protection and non-interference basis. CEPT has also recommended frequency bands 122.0–122.25 GHz and 244–246 GHz for unlicensed use.

4.2.2 Considering the international practice and to gain the advantage of scale of economy, the frequency bands, 116-123 GHz, 174.8-182 GHz, 185-190 GHz, and 244-246 GHz may be opened for unlicensed use. As per NFAP 2018, allocation in these bands are as under:

Band (GHz)	Current Allocation
114.25-116	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)
116-122.25	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)
122.25-123	FIXED INTER-SATELLITE MOBILE Amateur

174.8-182	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)
185-190	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)
244-246	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite

Note: Frequency band 122-123 GHz and 244-246 GHz are ISM bands and regulate in accordance with RR provision 5.138

4.2.3 The devices in above bands would operate on non-interference and non-protection basis while protecting both passive and active services running in these bands and adjacent bands. Services such as earth exploration satellite, and radio astronomy services in these bands and adjacent bands require stringent protection criteria as these services received signal from space. There is no risk of harmful interference from unlicensed devices to space research service (passive) because stations in this service are space-based and looking away from earth. The other services namely fixed service, mobile service and radiolocation services have not yet been deployed due to non-availability of eco system. Therefore, protection criteria for these services may not be required at this stage. The inter-satellite service operates solely between satellites in space and therefore there is no significant risk of harmful interference from relatively low power unlicensed devices operating on the Earth.

4.2.5 Considering the scale of economy, technical parameters for unlicensed devices in above bands devised by the FCC may be adopted. The initial proposed technical parameters are as under:

- Devices may operate in all of these bands with a maximum EIRP of 40 dBm (average) and 43 dBm (peak), measured with a detection bandwidth that encompasses the band of operation.

- It also permits outdoor fixed point-to-point devices to operate with a higher maximum EIRP of 82 dBm (average) and 85 dBm (peak), also measured with a detection bandwidth that encompasses the band of operation.

- Use of the higher power limits also requires that devices use antennas with a minimum gain of 51 dBi, with a 2 dB reduction in the maximum permissible EIRP for each dB the antenna gain falls below 51 dBi. These highly directional antennas with very narrow beam widths will ensure that the likelihood of harmful interference is minimized.

- Transmitters with an emission bandwidth of less than 100 MHz must limit their peak radiated power to the product of the maximum permissible radiated power (in milliwatts) times their emission bandwidth divided by 100 MHz. The emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kHz resolution bandwidth spectrum analyzer.

- The power density of any emissions outside the band of operation shall consist solely of spurious emissions. Unlicensed devices have to comply with an out-of-band emission limit of 90 picowatts per square centimeter at a distance of three meters. The levels of the spurious emissions shall not exceed the level of the fundamental emission.

- No equipment will be permitted to operate on satellites or onboard aircraft. This means they cannot be used onboard or attached to an aircraft.

- Equipment operating in the 174.8-182 GHz and 185-190 GHz bands should not be designed to operate in the 182-185 GHz band

4.2.4 It may be noted that Indian environment namely; temperature, wind speed and rain conditions are different than other parts of the globe. Therefore, limit on transmit power, beamwidth etc. may be different from other parts of the world for Indian environment. It is recommended that FCC's technical parameters may be adopted initially and after conducting intensive research in Indian environment, technical parameters may accordingly be modified at later stage.

4.3 Frequency Bands between 40 GHz and 95 GHz

4.3.1 It may be noted that Government has already in the process for making regulations for V Band (57 GHz to 66 GHz) and E Band (71-76 GHz/81-86 GHz). The frequency band 76-77 GHz has already been delicensed, vide G.S.R 699 (E) dated 16.09.2015, for the purpose of usage of very low power Radio Frequency devices or equipments for short range radar systems.

4.3.2 Department of Telecom has constituted a Committee for implementation of V2X in the country. Frequency bands 76-77 GHz and 77-81 GHz are being used for long range radar and short & medium range radars respectively for V2X application.

4.3.3 The Federal Communications Commission (FCC) and the Ministry of Internal Affairs and Communications (MIC) in Japan have designated 76-77 GHz band for automotive radar. MIC, Japan has also recommended introduction of high-resolution radar in 77-81 GHz band for safety related applications. The European Conference of Postal & Telecommunications (CEPT) has designated the band 77-81 GHz for automotive radars. The European Telecommunications Standards Institute (ETSI) has adopted the harmonized standard in the frequency band 77-81 GHz for the applications of short range radars. FCC has also allowed 77-81 GHz band for vehicular radar operations aligning with rest of the world. Countries in Asia Pacific

Region have also designated 76-77 GHz and 77-81 GHz bands for short range automotive radar application for ITS. Therefore, the frequency bands 76-77 GHz and 77-81 GHz are globally harmonised bands for short range automotive radar applications.

4.3.4 It is recommended that frequency band 77-81 GHz band may also be delicensed for automotive radar applications in line with international practice.

May please also see the NOTE below.

Abhay Karandikar, Director, IIT Kanpur Member	V. J. Christopher Director (WMO) Member	Y. G. S. Kishore Babu DDG(SRI) Member
M. K. Pattanaik Sr. Deputy Wireless Adviser Member	R K Saxena Wireless Adviser Chairman	P S M Tripathi Deputy Wireless Adviser Member

note: Additional specific recommendations from Prof Abhay Karandikar, Director, IITK and YGSC Kishore Babu, DDG(SRI) are placed at Annexure II on Page 27. wrt to frequency bands between 40 GHz and 95 GHz to enable enhanced utilization of 57-66 GHz and other IMT bands recognized in WRC-2019.

Region have [illegible] 76-77 GHz and 77-81 GHz [illegible] automotive radar application for ITS. Therefore, the frequency [illegible] GHz and 77-81 GHz are globally harmonised band [illegible] automotive radar applications.

4.3.4 It is recommended that frequency band 77-81 GHz [illegible] delicensed for automotive radar applications in line with [illegible] practice.

[illegible]

Abhay Karandikar
Director, IIT Kanpur
Member

V. J. Christopher
Director (WMO)
Member

[illegible] Babu
[illegible]
Member

M. K. Pattenaik
Sr. Deputy Wireless Adviser
Member

R. K. Saxena
Wireless Adviser
Chairman

[illegible]

Annexure-I

QUESTION ITU-R 256-1/5

Technical and operational characteristics of the land mobile service in the frequency range 275-1 000 GHz

(2015-2019)

The ITU Radiocommunication Assembly,

considering

a) that there is a growing demand for high speed and large capacity radiocommunications having data rates of several tens of Gbit/s to over 100 Gbit/s for land mobile service applications;

b) that due to progress in the recent terahertz technologies, the integrated devices and circuits operating above 275 GHz can achieve various sophisticated applications;

c) that the above devices and circuits could provide such high speed and large capacity radiocommunications for land mobile service systems;

d) that standard development organizations such as IEEE are developing standards for terahertz wireless systems which utilize the broadband contiguous bandwidth larger than 50 GHz using the frequency range above 275 GHz;

e) that broadband contiguous bandwidths larger than 50 GHz for the land mobile service are not available in the frequency range below 275 GHz;

f) that certain parts of the frequency range 275-1 000 GHz are identified in Radio Regulations No. **5.565** for use by administrations for passive service applications;

g) that the use of the frequency range 275-1 000 GHz by the passive services does not preclude the use of this range by active services;

h) that the technical and operational characteristics of the land mobile service need to be specified for sharing and compatibility studies with the passive service applications indicated in *considering f)*;

i) that the frequency range 275-450 GHz has been studied under WRC-19 for use by the land-mobile and fixed services applications,

recognizing

a) that Report ITU-R RS.2431 "Technical and operational characteristics of EESS (passive) systems in the frequency range 275-450 GHz" provides the technical and operational characteristics of Earth Observation (passive) sensors in the frequency range 275-450 GHz;

b) that Report ITU-R SM.2352 provides the technology trends of active services in the frequency range 275-3 000 GHz;

c) that Report ITU-R RA.2189 initiated sharing studies between the radio astronomy service and active services in the frequency range 275-3 000 GHz,

decides that the following Question should be studied

What are the technical and operational characteristics of the land mobile service in the frequency range 275-1 000 GHz?

further decides

1 that sharing studies between the land mobile and passive services, as well as the land mobile and other active services should be carried out, taking into account the characteristics mentioned in *decides* as well as the relevant results of the studies under WRC-19;

2 that the results of studies in the frequency range 275-1 000 GHz should be brought to the attention of the other Study Groups, in particular, Study Group 7;

3 that the results of the above studies should be included in one or more Recommendations, Reports or Handbooks;

4 that the above studies should be completed by 2023.

QUESTION ITU-R 257-1/5

Technical and operational characteristics of stations in the fixed service in the frequency range 275-1 000 GHz

(2015-2019)

The ITU Radiocommunication Assembly,

considering

a) that there is a growing demand for high speed and large capacity radiocommunications having data rates of several tens of Gbit/s to sometime over 100 Gbit/s for fixed service systems;

b) that due to progress in the recent terahertz technologies, the integrated devices and circuits operating above 275 GHz can achieve various sophisticated applications;

c) that the above devices and circuits will be able to provide such high speed and large capacity radiocommunications for fixed service systems;

d) that the traffic demands for backhaul and fronthaul for mobile systems are increasing due to mobile broadband communications such as IMT-Advanced, IMT-2020 and future IMT;

e) that certain parts of the spectrum in the frequency range 275-1 000 GHz are identified in No. **5.565** for passive services in the Radio Regulations;

f) that the use of the frequency range 275-1 000 GHz by the passive services does not preclude use of this range by active services;

g) that the technical and operational characteristics of the fixed service need to be specified for sharing and compatibility studies with the passive service applications indicated in *considering f)*;

h) that the frequency range 275-450 GHz has been studied for use by the land-mobile and fixed services applications,

noting

a) that Report ITU-R SM.2352 provides the technology trends of active services in the frequency range 275-3 000 GHz;

b) that Report ITU-R F.2323 provides guidance on the future development of the fixed service operating in the millimetric-wave band;

c) that Report ITU-R RA.2189 initiated sharing studies between radio astronomy service and active services in the frequency range 275-3 000 GHz;

d) that Report ITU-R F.2416 provides technical and operational characteristics and applications of the point-to-point fixed service operating in the frequency band 275-450 GHz;

e) that Report ITU-R M.2417 provides technical and operational characteristics of land-mobile service applications in the frequency range 275-450 GHz;

f) that Report ITU-R RS.2431 provides the technical and operational characteristics of Earth Observation (passive) sensors in the frequency range 275-450 GHz,

decides that the following Question should be studied

What are the technical and operational characteristics of the fixed service in the frequency range 275-1 000 GHz?

further decides

1 that sharing studies between the fixed and passive services, as well as the fixed and other active services should be carried out taking into account the characteristics mentioned in *decides*;

2 that the results of studies in the frequency range 275-1 000 GHz should be brought to the attention of the other Study Groups;

3 that the results of the above studies should be included in one or more Recommendations, Reports, or Handbooks;

4 that the above studies should be completed by 2023.

ANNEXURE – II

Additional Recommendations of Prof. Abhay Karandikar and DDG (SRI) as the Members of the Committee

4.3 Frequency Bands between 40 GHz and 95 GHz

1. Band 57-66 GHz

The band 57-71 GHz, popularly known as V Band has been under diverse uses across the world. The WRC 2019 while examining the suitable bands for IMT, apportioned 66-71 GHz for IMT purposes. Further, during the CoS deliberations, the DoS was asked to restrict its services to 57 GHz and 57 GHz-66GHz would be used for telecom as below.

(v) 57 to 66 GHz

- *DoS agreed to limit the EESS services up to 57 GHz, so that the band 57-66 GHz is fully available to DOT for Wi-Fi / Public Wi-Fi, fixed links etc.*

Several countries have delicensed the band 57-66 GHz for innovative applications like Wi-Fi (Wi-Gig) and point to point links etc. The band also includes ISM band (60 GHz). This is envisaged to enable wireless homes, point to point links in rural and urban areas for households and enterprises. Analogy may be drawn how the 5GHz delicensed band has transformed backhaul and enterprise connectivity in both wi-fi, enterprises segments. It is also learnt a few lakhs of point to point links are established in the country in mobile and enterprise segments and also in rural areas apart from home wi-fi.

2. IMT Bands: 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 GHz (WRC 2019)

Further, the IMT bands identified in WRC-2019, viz. 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 GHz are still under development for devices and it may take several more years to build both equipment and device ecosystem. Even in the millimeter band, which is auctioned recently i.e. 24.25-27.5 GHz, only some part is sold and ecosystem is still evolving.

The above bands, yet to be opened in the country, may take several years to build devices and equipment as these frequencies have high attenuation. Hence, it is necessary to generate demand in these bands by opening the bands for TSPs, without any charges/fees for 5 years (extendable) for IMT services only for the products developed and deployed by domestic companies. This should permit marketing and selling of the said products. This will enable indigenous 5G / IMT products development and will also enhance bands' economic value. TSPs may be encouraged to take this opportunity to encourage development and deployment in their networks.

3. Recommendations

1. It is recommended to consider to delicense the band 57-66 GHz for all applications including access, Wi-Fi hotspots and point to point links.
2. The IMT bands in 45.5 GHz – 48.2 GHz, where there is no allocation for India on Primary basis may be taken up to include India in the respective foot-list.
3. The bands 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 GHz, 66-71 GHz will be opened and made available freely to TSPs for development, deployment and sale of indigenously developed products by domestic companies for 5 years (extendable for additional period as may be necessary) for IMT services to generate demand and enhance its economic value[1].

7/10/22

(Prof. Abhay Karandikar), Director IITK **(YGSC Kishore babu) DDG (SRI)**

[1] Domestic Company is defined as those which are owned by resident Indian citizens as defined in the FDI Circular of 2017. A company is considered as 'Owned' by resident Indian citizens if more than 50% of the capital in it is beneficially owned by resident Indian citizens and / or Indian companies, which are ultimately owned and controlled by resident Indian citizens. Further, it should be a DSIR recognized entity holding IPR ownership in India and carrying out R&D activities in India.

Additional Recommendations of Prof. Abhay Karandikar and DDG (SRI) as the Members of the Committee

4.3 Frequency Bands between 40 GHz and 95 GHz

1. Band 57-66 GHz

The band 57-71 GHz, popularly known as V Band has been under diverse uses across the world. The WRC 2019 while examining the suitable bands for IMT, apportioned 66-71 GHz for IMT purposes. Further, during the CoS deliberations, the DoS was asked to restrict its services to 57 GHz and 57 GHz-66GHz would be used for telecom as below.

(v) 57 to 66 GHz

- *DoS agreed to limit the EESS services up to 57 GHz, so that the band 57-66 GHz is fully available to DOT for Wi-Fi / Public Wi-Fi, fixed links etc.*

Several countries have delicensed the band 57-66 GHz for innovative applications like Wi-Fi (Wi-Gig) and point to point links etc. The band also includes ISM band (60 GHz). This is envisaged to enable wireless homes, point to point links in rural and urban areas for households and enterprises. Analogy may be drawn how the 5GHz delicensed band has transformed backhaul and enterprise connectivity in both wi-fi, enterprises segments. It is also learnt a few lakhs of point to point links are established in the country in mobile and enterprise segments and also in rural areas apart from home wi-fi.

2. IMT Bands: 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 GHz (WRC 2019)

Further, the IMT bands identified in WRC-2019, viz. 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 GHz are still under development for devices and it may take several more years to build both equipment and device ecosystem. Even in the millimeter band, which is auctioned recently i.e. 24.25-27.5 GHz, only some part is sold and ecosystem is still evolving.

The above bands, yet to be opened in the country, may take several years to build devices and equipment as these frequencies have high attenuation. Hence, it is necessary to generate demand in these bands by opening the bands for TSPs, without any charges/fees for 5 years (extendable) for IMT services only for the products developed and deployed by domestic companies. This should permit marketing and selling of the said products. This will enable indigenous 5G / IMT products development and will also enhance bands' economic value. TSPs may be encouraged to take this opportunity to encourage development and deployment in their networks.

3. Recommendations

1. It is recommended to consider to delicense the band 57-66 GHz for all applications including access, Wi-Fi hotspots and point to point links.
2. The IMT bands in 45.5 GHz – 48.2 GHz, where there is no allocation for India on Primary basis may be taken up to include India in the respective foot-list.
3. The bands 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 GHz, 66-71 GHz will be opened and made available freely to TSPs for development, deployment and sale of indigenously developed products by domestic companies for 5 years (extendable for additional period as may be necessary) for IMT services to generate demand and enhance its economic value[1].

(Prof. Abhay Karandikar), Director IITK **(YGSC Kishore babu) DDG (SRI)**

[1] Domestic Company is defined as those which are owned by resident Indian citizens as defined in the FDI Circular of 2017. A company is considered as 'Owned' by resident Indian citizens if more than 50% of the capital in it is beneficially owned by resident Indian citizens and / or Indian companies, which are ultimately owned and controlled by resident Indian citizens. Further, it should be a DSIR recognized entity holding IPR ownership in India and carrying out R&D activities in India.

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning & Coordination (WPC) Wing
6th Floor, Sanchar Bhawan, 20, Ashoka Road, New Delhi

No: L-14035/08/2022-BWA **Date: 16.06.2022**

Office Memorandum

Sub: Constitution of the committee for Open and De-license unused or limited used Spectrum bands for demand generation for limited period including THz band.

A committee with the following composition has been constituted with the approval of Member (T), Deptt. of Telecom to give its recommendations for Open and De-license unused or limited used Spectrum bands for demand generation for limited period including THz band in view of Post-budget webinar on "Technology enabled Development" held on 02.03.2022 "Breakaway session 1: Building a strong 5G ecosystem for Service Delivery" organized by the Indian Government (see Item no. 11 copy enclosed).

1. Shri R. K. Saxena, Wireless Adviser - Chairman
2. Prof. Abhay Karandikar, Director, IIT Kanpur - Co Chair
3. Shri Y.G.S.C. Kishore Babu, DDG (SRI) - Member
4. Shri V. J. Christopher, Director WMO - Member
5. Shri M. K. Pattanaik, Sr. DWA (Sat) - Member
6. Shri P. S. M. Tripathi, DWA (Security) - Member Convener

2. The Term of Reference (TOR) of the above committee is under:

To give its recommendations for Open and De-license unused or limited used Spectrum bands for demand generation for limited period including THz band.

3. Wireless Adviser may co-opt some member from startup, MSME and Academia with the help of DDG (SRI).

16.6.22

S.K. Rawat
Assistant Wireless Adviser
To the Govt. of India

To,

1. Shri R. K. Saxena, Wireless Adviser, DoT, Sanchar Bhawan, New Delhi
2. Prof. Abhay Karandikar, Director, IIT Kanpur
3. Shri Y.G.S.C. Kishore Babu, DDG (SRI), DoT, Sanchar Bhawan, New Delhi
4. Shri V. J. Christopher, Director WMO, Pushpa Bhawan, Madangir Road, New Delhi
5. Shri M. K. Pattanaik, Sr. DWA (Sat), DoT, Sanchar Bhawan, New Delhi
6. Shri P. S. M. Tripathi, DWA (Security) - Member Convener

Subject: "Follow up action on inputs received during Post-budget webinar on "5G Technology enabled Development" held on 2.3.2022 –"Breakaway session 1: Building a strong 5G ecosystem for Service Delivery"

Sl. No.	Issue	Inputs received	If agreeable, manner of implementation	Responsible Centre/Unit
Theme 1: Promote Make in India of 5G products including semiconductor fab, mobile phones and design led manufacturing				
1.	Issue 1.1	Enhance the PLI Scheme for supporting Design-led manufacturing	DoT has constituted Expert Committee to examine this aspect for design led manufacturing of 5G telecom products. This issue is presently under deliberations in DoT.	DDG(IC)
2.	Issue 1.2	Leverage large home market demand to help achieve economies-of-scale for PLI products	DoT will implement PMI Order to boost economies of scale for domestic manufacturers.	JS(T)
3.	Issue 1.3	Incentivize TSPs for procuring Preference to make in India (PMI) - compliant products	TRAI has issued consultation on Promoting Networking and Telecom Equipment Manufacturing in India on 11th February 2022. One of the issues for consultation is incentivising TSPs for buying domestically manufactured products. DoT would be able to comment after receiving TRAI recommendations.	JS(T)
4.	Issue 1.4	Use of domestic products in critical sectors	Telecom service providers are mandated to use trusted source and trusted products only in the telecom network. However, a policy decision in this regard will be examined with regard to use of domestic products.	DDG(SA)
5.	Issue 1.5	Consortium approach for 5G end to end products from Indian companies	DoT is working with C DoT for 5G end to end products from Indian companies. C DoT has been requested to submit draft strategy in this regard where Government- academia-industry consortium will work for development of 5G products for TSPs and enterprises.	DDG(SRI), DDG (SA-II)

[illegible]	Issue 1.6	[illegible] set up [illegible] 5G [illegible] beds for [illegible] development in the country, for testing the products and solutions	DoT is working with [illegible] Departments for development of different use cases.	[illegible] (DoT)
7.	Issue 1.7	Mission Mode approach for 6G Technology development with Institutional Framework- consortium approach	DoT has constituted Technology Innovation Group on 6G in November 2021. DoT will finalise Vision, Mission and deliverables for 6G by June 2022. Based on the report, DoT will work in consortium mode for development of 6G technologies from India including contributions in global standards.	DDG(TEC)/ DDG(SRI)
Theme 2: Design, development and creation of technologies for affordable broadband and mobile service proliferation in rural and remote areas				
8.	Issue 2.1	• Accelerate R&D investments for 5G products with Indian design and IPR. • R&D grants (on a 1:1 matching basis) for investments made for developing Indian 5G products over the next 2-3 years.	Budget has announced 5% USOF levy for design, development and IPR. The Committee has been constituted for recommendations. Based on the report, DoT will take next steps.	Admin, USOF
9.	Issue 2.2	Building Indian Champions in IPR creation	DoT, under Champion sector scheme, is implementing DCIS scheme for promotion of IPRs from startups/MSMEs.	JS(T)

10.	Issue 2.3	• Collaborate with DISCOMs to deliver fibre to all villages and rural households • Build strong backhaul and plan connectivity in new highways	• DoT and work with Ministry of Power for utilisation of their infrastructure for reaching villages. • DoT is working with Ministry of Road Transport.	DoT, MoP, MoRTH
11.	Issue 2.4	• Open and delicense unused or limitedly used Spectrum bands for demand generation for limited periods including THz band. • Delicense V Band and some carriers in E band	DoT is working on Spectrum Policy.	WA, WPC

*****

ANNEXURE – II

LIST OF ACRONYMS

S. No.	Acronym	Description
1.	5G	Fifth Generation
2.	6G	Sixth Generation
3.	CEPT	European Conference of Postal and Telecommunications
4.	dBi	Decibels Relative to Isotropic
5.	dBm	Decibel-milliwatts
6.	DNA	Deoxyribonucleic Acid
7.	DoT	Department of Telecommunication
8.	EESS	Earth Exploration Satellite Service
9.	EHF	Extremely High Frequency
10.	EIRP	Equivalent Isotropic Radiated Power
11.	EMC	Electromagnetic Compatibility
12.	EMI	Electromagnetic Interference
13.	ERS	Experimental Radio Service
14.	ETSI	European Telecommunications Standards Institute
15.	EU	European Union
16.	FCC	Federal Communications Commission
17.	FWA	Fixed Wireless Access
18.	Gbits	Gigabits per second

S. No.	Acronym	Description
19.	GHz	Gigahertz
20.	HD	High Definition
21.	IEEE	Institute of Electrical and Electronics Engineers
22.	IIT Kanpur	Indian Institute of Technology Kanpur
23.	IMT	International Mobile Telephony
24.	ISM	Industrial, Scientific, And Medical
25.	ITU-R	ITU- Radio Communication
26.	ITU-RR	ITU- Radio Regulations
27.	MIC	Ministry of Internal Affairs & Communications
28.	MW	Microwave
29.	NFAP	National Frequency Allocation Plan
30.	NIB	Non-Interference Basis
31.	NPB	Non-Protection Basis
32.	OFCOM	Office Of Communications
33.	R&D	Research & Development
34.	RAS	Radio Astronomy Service
35.	RF	Radio Frequency
36.	SRD	Short Range Devices
37.	SRS	Space Research Service

S. No.	Acronym	Description
38.	STAL	Spectrum-Terahertz Applications License
39.	Tbps	Terabits per second
40.	THz	Terahertz
41.	TOR	Term of Reference
42.	TRAI	Telecom Regulatory Authority of India
43.	USOF	Universal Service Obligation Fund
44.	WARC	World Administrative Radio Conference
45.	WP-5D	Working Party 5D
46.	WPC	Wireless Planning and Coordination
47.	WRC	World Radiocommunication Conferences