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Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

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1 Scope

This document is to provide use cases and deployment scenarios for NR system operation in carriers between 52.6 GHz and 100 GHz and also provide operational and system design requirements, which can facilitate 3GPP's future enhancements to NR beyond 52.6 GHz. NR physical layer channels in Release 15 were designed to be optimized for uses under 52.6 GHz and with the potential to be used for above 52.6 GHz. In general, high frequencies are faced with more challenges, such as higher phase noise, larger propagation loss, and lower power amplifier efficiency, compared to low frequency bands. Additionally, the frequency ranges above 52.6 GHz potentially contain larger spectrum allocations and larger bandwidths that are not available for bands lower than 52.6 GHz and may support widely ranging use cases, such as V2X, IAB, NR licensed and unlicensed, fixed wireless access, Wireless HDMI, Industrial Automation/IoT, and non-terrestrial operations. With the aim of enabling and optimizing 3GPP NR systems for operation in above 52.6 GHz, as originally planned during the NR SI (TR 38.913 [4]), 3GPP should further work on physical layer channels including potential introduction of new waveform, procedures, and requirements, etc., where the operation is applicable for operations in licensed and unlicensed spectrum, to WAN operation, private networks, Integrated Access Backhaul (IAB), ITS application using vehicular communications (V2X), etc.

The objectives of the study item are the following [2]:

- identify target spectrum ranges, including survey on global spectrum availability, regulatory requirements, channelization, and licensing regimes,
- identify potential use cases and deployment scenarios,
- identify NR design requirements and considerations on top of regulatory requirements.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TD RP-181435: "New SID: Study on NR beyond 52.6 GHz".
- [3] 3GPP TR 38.805: "Study on New Radio access technology; 60 GHz unlicensed spectrum".
- [4] 3GPP TR 38.913: "Study on New Radio access technology; Next Generation Access Technologies".
- [5] WRC-15 Resolution 238: "Studies on frequency-related matters for International Mobile Telecommunications identification including possible additional allocations to the mobile services on a primary basis in portion(s) of the frequency range between 24.25 and 86 GHz for the future development of International Mobile Telecommunications for 2020 and beyond".
- [6] International Telecommunication Union, "CPM Report to WRC-19: Chapter 2, agenda item 1.13, Method C2, " <https://www.itu.int/md/R15-CPM19.02-R-0001/en>
- [7] APG19-3/INP-35, Australia, "PRELIMINARY VIEWS ON WRC-19 AGENDA ITEMS 1.13, 1.16, 9.1 (ISSUES 9.1.1, 9.1.5 AND 9.1.8)", APG19-3, March, 2018, Australia

- [8] APG19-3/INP-87, China, "PRELIMINARY VIEWS ON WRC-19 AGENDA ITEMS 1.13, 1.16, 9.1 (ISSUES 9.1.1, 9.1.5, 9.1.8) ", APG19-3, March, 2018, Australia
- [9] Independent Communications Authority of South Africa. Standard procedures and guideline regarding the use of radio frequency spectrum in the E-band (71 – 76 GHz paired with 81 – 86 GHz). April 28, 2017.
- [10] Independent Communications Authority of South Africa. National Radio Frequency Plan 2018. May 25, 2018.
- [11] Independent Communications Authority of South Africa. Electronic Communications Act (781/2016): Amendment to the Radio Frequency Spectrum Regulations 2015. No. 404436, November 22, 2016.
- [12] Independent Communications Authority of South Africa. Radio Frequency Spectrum Regulations (279/2015): Amendment to the Radio Frequency Spectrum Regulations, 2015. November 22, 2016.
- [13] Canada Spectrum Management and Telecommunications. Canadian Table of Frequency Allocations 2018 Edition. April 2018.
- [14] Canada Spectrum Management and Telecommunications. Technical Requirements for Fixed Line-of-Sight Radio Systems Operating in the Bands 71-76 GHz and 81-86 GHz. May 2017.
- [15] MIIT, "Notice on wireless technical applications with very low transmission power (short distance) in 60GHz. 2006-082" (关于60GHz 频段微功率 (短距离) 无线电技术应用有关问题的通知 2006-082)
<http://www.miit.gov.cn/n1146295/n1146592/n1146754/n1235566/n1235603/n1235609/n1235611/c3176263/part/3176264.pdf>
- [16] MIIT, "Technical requirement of wireless devices with very low transmission power (short distance 2005-423)." (微功率 (短距离) 无线电设备的技术要求 2005-043)
<http://www.miit.gov.cn/n1146295/n1146592/n1146754/n1235566/n1235603/n1235609/n1235611/c3176241/part/3176242.pdf>
- [17] ARIB STD-B43 v2.1, "PORTABLE MILLIMETER-WAVE DIGITAL TRANSMISSION SYSTEM FOR TELEVISION PROGRAM CONTRIBUTION," Jan. 2018.
- [18] ARIB STD-T69 v4.0, "LOW POWER DATA COMMUNICATION SYSTEM/MILLIMETER-WAVE VIDEO TRANSMISSION EQUIPMENT," Sept. 2016.
- [19] ARIB STD-T117 v1.0, "LOW POWER DATA COMMUNICATION SYSTEM/60 GHz-BAND WIRELESS LAN FOR VERY HIGH THROUGHPUT DATA COMMUNICATIONS," Sept. 2016.
- [20] ARIB STD-T48 v2.2, "MILLIMETER-WAVE RADAR EQUIPMENT FOR SPECIFIED LOW POWER RADIO STATION," Dec. 2015.
- [21] ARIB STD-T111 v1.1, "79 GHz BAND HIGH-RESOLUTION RADAR," Mar. 2017.
- [22] Republic of Korea Communications Agency. Republic of Korea Frequency Allocations Status. May 2018.
- [23] Republic of Korea National Radio Research Agency. National Radio Research Agency Publication 2014-12. July 02, 2014.
- [24] Republic of Korea Ministry of Science and ICT. Ministry of Science and ICT Publication 2018-3. July 02, 2014.
- [25] Republic of Korea Ministry of Science and ICT. Ministry of Science and ICT Publication 2018-4. July 02, 2014.
- [26] NFAP-18 "National Frequency Allocation Plan – 2018", Government of India Ministry of Communications.

- [27] IMDA (Infocomm Media Development Authority), IMDA TS SRD, April 2018.
<https://www.imda.gov.sg/-/media/imda/files/regulation-licensing-and-consultations/ict-standards/telecommunication-standards/radio-comms/imdatssrd.pdf?la=en>
- [28] ACMA (Australian Communications and Media Authority), "Radiocommunications (Low Interference Potential Devices) Class Licence 2015", 2018.
<https://www.legislation.gov.au/Details/F2018C00500>
- [29] No. 2018-71 Ministry of Science and ICT notice
- [30] No. 2018-26 National Radio Research Agency notice
- [31] No. 2018-36 Ministry of Science and ICT notice
- [32] Ministry of Transportation and Communications, "TABLE OF RADIO FREQUENCY ALLOCATIONS OF THE REPUBLIC OF CHINA", Feb. 2017,
<http://www.motc.gov.tw/post/home.jsp?id=364&parentpath=0>.
- [33] China, "People's republic of China Regulations on the Radio Frequency Allocation", The People's Posts and Telecommunications Press, 2010.
- [34] IMDA (Infocomm Media Development Authority), "Singapore Spectrum Allocation Chart",
<https://www.imda.gov.sg/-/media/imda/files/regulation-licensing-and-consultations/frameworks-and-policies/spectrum-management-and-coordination/spectrumchart.pdf?la=en>
- [35] ACMA, "Australian Radiofrequency Spectrum Plan 2017-including general information",
<https://www.acma.gov.au/theacma/australian-radiofrequency-spectrum-plan-spectrum-planning-acma>
- [36] The Wireless Planning & Coordination (WPC) Wing of the Ministry of Communication & Information Technology, "License Exemption for SRD Device GSR 1047(E) dated 18/10/ 2018"
- [37] International Telecommunication Union, "ITU-R, The Radio Regulations," Edition of 2016,
<https://www.itu.int/pub/R-REG-RR> (Edition of 2016)
- [38] 3GPP TR 22.826: "Study on communication services for critical medical applications"
- [39] 3GPP TR 33.853: "Technical report on key issues and potential solutions for Integrity protection of the User Plane"
- [40] CEPT ECC, "ERC Recommendation 12-12: Radio frequency channel, arrangement for Fixed Service Systems operating in the band 55.78 to 57.0 GHz," January 2015.
- [41] CEPT ECC, "THE EUROPEAN TABLE OF FREQUENCY ALLOCATIONS AND APPLICATIONS IN THE FREQUENCY RANGE 8.3 kHz to 3000 GHz (ECA TABLE)", March 2019.
- [42] CEPT ECC, "ERC Recommendation 70-03: Relating to the use of Short Range Devices (SRD)," June 2019.
- [43] CEPT ECC, "Recommendation 02-05: Unwanted Emissions," March 2012.
- [44] CEPT ECC, "ERC Recommendation 74-01: Unwanted emissions in the spurious domain," May 2019.
- [45] Official Journal of the European Union, " COMMISSION IMPLEMENTING DECISION (EU) 2017/1483 of August 2017 amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices and repealing Decision 2006/804/EC," August 2017.
- [46] CEPT ECC, "ECC RECOMMENDATION (05)02: USE OF THE 64-66 GHz FREQUENCY BAND FOR FIXED SERVICE," February 2009.
- [47] CEPT ECC, "ECC Decision (09)01: Harmonised use of the 63.72-65.88 GHz frequency band for Intelligent Transport Systems (ITS)," March 2009.

- [48] CEPT ECC, "ECC RECOMMENDATION (05)07: RADIO FREQUENCY CHANNEL ARRANGEMENTS FOR FIXED SERVICE SYSTEMS OPERATING IN THE BANDS 71-76 GHz AND 81-86 GHz," May 2013.
- [49] CEPT ECC, "ECC Decision (04)03: The frequency band 77-81 GHz to be designated for the use of Automotive Short Range Radars," March 2015.
- [50] CEPT ECC, "EC Decision 2004/545/EC: Commission Decision of 8 July 2004 on the harmonisation of radio spectrum in the 79 GHz range for the use of automotive short-range radar equipment in the Community (notified under document number C(2004) 2591)(Text with EEA relevance)," August 2004.
- [51] CEPT ECC, "ECC Recommendation (18)02: Radio frequency channel/block arrangements for Fixed Service systems operating in the bands 92-94 GHz, 94.1-100 GHz, 102-109.5 GHz and 111.8-114.25 GHz," September 2018.
- [52] ETSI, "ETSI EN 302 217-2: Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2: Digital systems operating in frequency bands from 1,3 GHz to 86 GHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU," June 2016.
- [53] CEPT ECC, "ECC RECOMMENDATION (05)07: RADIO FREQUENCY CHANNEL RRANGEMENTS FOR FIXED SERVICE SYSTEMS OPERATING IN THE BANDS 71-76 GHz AND 81-86 GHz," May 2013.
- [54] CEPT ECC, "ECC Report 80: ENHANCING HARMONISATION AND INTRODUCING FLEXIBILITY IN THE SPECTRUM REGULATORY FRAMEWORK," March 2006.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

3.2 Symbols

For the purposes of the present document, the following symbols apply:

B	transmission bandwidth
G	antenna gain

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

BS	Base Station
CEPT	European Conference of Postal and Telecommunications Administrations
ECC	Electronic Communications Committee
ECO	European Communications Office
EESS	Earth Exploration Satellite Service
EIRP	Equivalent Isotropic Radiated Power
ERC	European Research Council

FDD	Frequency Duplex Division
FS	Fixed Service
FSS	Fixed Satellite Service
HDMI	High-Definition Multimedia Interface
IAB	Integrated Access Backhaul
ICASA	Independent Communication Authority of South Africa
IMT	International Mobile Telecommunications
ISM	Industrial, Scientific and Medical
ISS	International Space Station
ITU	International Telecommunication Union
LBT	Listen Before Talk
MCOT	Maximum Channel Occupancy Time
MSS	Mobile Satellite Service
NR	New Radio
OCB	Occupied Bandwidth
OOBE	Out-Of-Band Emission
PSD	Power Spectral Density
PTP	Point to point
RAS	Radio Astronomy Service
RLAN	Radio Local Area Network
RLS	Radio Location Service
RNS	Radio Navigation Satellite
RNSS	Radio Navigation Satellite Service
SI	Study Item
SID	Study Item Description
SRD	Short Range Device
SRS	Space Radiocommunication Stations
TDD	Time Duplex Division
UE	User Equipment
V2X	Vehicle to Everything
WAN	Wide Area Network
WAS	Wireless Access System

4 Operational Requirements

4.1 Overview of Global Spectrum Availability

In 2015, the international telecommunication union (ITU) proposed 11 millimetre-wave bands between 24 and 86 GHz to be studied towards WRC-19 for possible identification for IMT. See Table 4.1-1 with the bands to be studied under AI 1.13 towards WRC-19 [5].

Table 4.1-1 Bands to be studied under AI 1.13 towards WRC-19

Candidate frequency bands which have allocations to the mobile service on a primary basis	Candidate frequency bands which required a co-primary mobile allocation
24.25-27.5 GHz [Note1]	31.8-33.4 GHz,
37-40.5 GHz	40.5-42.5 GHz
42.5-43.5 GHz	47-47.2 GHz
45.5-47 GHz	
47.2-50.2 GHz	
50.4-52.6 GHz	
66-76 GHz	
81-86 GHz	
NOTE 1: When conducting studies in the band 24.5-27.5 GHz, to take into account the need to ensure the protection of existing earth stations and the deployment of future receiving earth stations under the EESS (space-to-Earth) and SRS (space-to-Earth) allocation in the frequency band 25.5-27 GHz	

Table 4.1-2 provides information on the allocation within the frequency range 52.6 GHz to 116 GHz in ITU Radio Regulation [37]. The column with comments contains (a subset of) information on protection requirements for incumbent services. For the full details please refer to the Radio Regulations

Table 4.1-2: Frequency bands in the range 52.6 to 116 GHz in radio regulation

Frequency band (GHz)	Allocated to Mobile Service on a primary basis	Allocated to Fixed Service on a primary basis	Comments
52.6-54.25	No	No	EESS (passive) and SRS (passive), All emissions are prohibited in this band, footnote 5.340
54.25-55.78	No	No	EESS (passive) and SRS (passive)
55.78-59	Yes	Yes	EESS (passive) and SRS (passive) This band available for high-density applications in the fixed service, footnote 5.547
59-59.3	Yes	Yes	EESS (passive) and SRS (passive) Radiolocation
59.3-64	Yes	Yes	Radiolocation
64-65	Yes	Yes	This band available for high-density applications in the fixed service, footnote 5.547
65-66	Yes	Yes	This band available for high-density applications in the fixed service, footnote 5.547
66-71	Yes	No	WRC-19 AI 1.13 frequency band, sharing and compatibility studies and potential limitations information in clause 2.2.
71-76	Yes	Yes	WRC-19 AI 1.13 frequency band, sharing and compatibility studies and potential limitations information in clause 2.2.
76-81	No	No	Radiolocation
81-86	Yes	Yes	WRC-19 AI 1.13 frequency band, sharing and compatibility studies and potential limitations information in clause 2.2.

Frequency band (GHz)	Allocated to Mobile Service on a primary basis	Allocated to Fixed Service on a primary basis	Comments
86-92	No	No	EESS (passive) and SRS (passive), All emissions are prohibited in this band, footnote 5.340
92-94	Yes	Yes	Radiolocation
94-94.1	No	No	Radiolocation
94.1-95	Yes	Yes	Radiolocation
95-100	Yes	Yes	Radiolocation
100-102	No	No	EESS (passive) and SRS (passive), All emissions are prohibited in this band, footnote 5.340
102-105	Yes	Yes	N/A
105-109.5	Yes	Yes	SRS (passive)
109.5-111.8	No	No	EESS (passive) and SRS (passive), All emissions are prohibited in this band, footnote 5.340
111.8-114.25	Yes	Yes	SRS (passive)
114.25-116	No	No	EESS (passive) and SRS (passive), All emissions are prohibited in this band, footnote 5.340

Within the range 52.6 to 116 GHz, the frequency bands 66-76 GHz (including 66-71 and 71-76 GHz) and 81-86 GHz are being studied under WRC-19 Agenda Item 1.13 for potential IMT identification. Results of sharing and compatibility studies, potential technical and regulatory conditions are included in Draft CPM Report [6], and the final decisions are to be made in WRC-19 with respect to IMT identification or no IMT identification, along with the corresponding technical and regulatory conditions.

For 66-71 GHz, Studies were carried out for the ISS, MSS (Earth-to-space) indicating that sharing is feasible, with a need for separation distance in the order of few kilometers for the case of MSS (space-to-Earth). The need for studies addressing interference from IMT towards RNS is still under debate. Thus, final conclusions in the regulatory and technical conditions for this band cannot be drawn.

For 71-76 GHz, studies were carried out for the FS, RLS and FSS (space-to-Earth) indicating that sharing with FS and FSS is feasible. However, additional limits of the IMT BS and UE unwanted emissions is needed to protect RLS in the adjacent frequency band 76-81 GHz.

For 81-86 GHz, studies were carried out for the FS, FSS (Earth-to-space), RAS (in band and adjacent band), EESS (passive) and RLS. Studies are not needed for the SRS (passive), as this service is dealing with sensors around other planets and no interference issue is expected. Studies were also not carried out for the MSS. The results of those studies indicate that sharing with FS, FSS and RAS (in band and adjacent band) is feasible. Notice that additional limits of the IMT BS and UE unwanted emissions would be needed to ensure protection of EESS (passive) in the adjacent frequency band 76-81 GHz and RLS in the adjacent frequency band 86-92 GHz. Table 4.1-3 and Table 4.1-4 depicts the limits of the IMT BS and UE maximum unwanted emissions levels according to the individual compatibility studies.

Table 4.1-3: Limits of unwanted emission levels from IMT BS and UE operating on 71-76 and 81-86 GHz frequency bands into the 76-81 GHz frequency band according to WRC-19 compatibility studies

Limits of unwanted emissions into 76-81 GHz from IMT stations	76-77 GHz dB(W/200 MHz)	77-81 GHz dB(W/200 MHz)
BS	[TBD/-29.6/-31.5/]	[TBD/-33]
UE	[TBD/-20]	[TBD/-35]

Table 4.1-4: Limits of unwanted emission levels from IMT BS and UE operating on 81-86 GHz into 86-92 GHz frequency band according to WRC-19 compatibility studies

Limits of unwanted emissions into 86-92 GHz from IMT stations	dB(W/100 MHz)
BS	[TBD/-43.6/-49.9/-31.3/-20]
UE	[TBD/-43.5/-49.8/-31.2/-19.9]

4.2 Country Specific Spectrum Availability and Spectrum Regulatory Requirements

4.2.1 Country Specific Licensing situation

Table 4.2-1 and 4.2-2 provide an overall summary of the current licensing situation for data communication (Mobile and Fixed, excluding radar based telemetry) between frequencies 52.6GHz and 100GHz for various countries under ITU region 1, 2, and 3. Symbol 'U', and 'L', represent unlicensed spectrum and licensed spectrum (including light licensing and other licensing forms), respectively. Notice that Table 4.2-1 and 4.2-2 does not include information about the service allocated to each frequency band. It neither includes information about the frequency bands currently studied in AI 1.13 WRC-19 which are listed in Table 4.1-1. Also, it is worthwhile noticing that type of licensing for each frequency band is a national decision.

Table 4.2.1-1: Current Licensing situation for various countries between frequency 52.6GHz and 71GHz

Region	Country	Frequency (GHz)										
		52.6-54.25	54.25-55.78	55.78-56.9	56.9-57	57-58.2	58.2-59	59-59.3	59.3-64	64-65	65-66	66-71 ¹⁾
ITU Region 1	Europe/CEPT					U (Mobile)						
	Israel											
	South Africa					U (Mobile)				U (Mobile)		
ITU Region 2	USA					U (Mobile)						
	Canada					U (Mobile)						
	Brazil					U (Mobile)						
	Mexico					U (Mobile)						
ITU Region 3	China							U (Mobile)				
	Japan					U (Mobile)						
	Korea					U (Mobile)						
	India											
	Taiwan					U (Mobile)						
	Singapore					U (Mobile)						
	Australia					U (Mobile)						
NOTE 1: Access regime currently under discussion in CEPT												

Table 4.2.1-2: Current Licensing situation for various countries between frequency 71GHz and 100GHz

Region	Country	Frequency (GHz)										
		71-74 ¹⁾	74-76 ¹⁾	76-77	77-81	81-84 ¹⁾	84-86 ¹⁾	86-92	92-94	94-94.1	94.1-95	95-100
ITU Region 1	Europe/CEPT	L (Fixed)				L (Fixed)			L (Fixed)	L (Fixed)		
	Israel											
	South Africa	L (Fixed)				L (Fixed)						
ITU Region 2	USA	L (Fixed / Mobile)				L (Fixed / Mobile)			L (Fixed / Mobile)		L (Fixed / Mobile)	
	Canada	L (Fixed)				L (Fixed)						
	Brazil	L (Fixed)				L (Fixed)						
	Mexico	L (Fixed)				L (Fixed)						
ITU Region 3	China											
	Japan	L (Fixed)				L (Fixed)						

Region	Country	Frequency (GHz)									
	Korea	L (Fixed)				L (Fixed)					
	India										
	Taiwan	L(Fixed)				L (Fixed)					
	Singapore	L (Fixed)				L (Fixed)					
	Australia										
Note 1: Candidate frequency band for IMT identification under WRC-19 AI 1.13											

4.2.2 ITU Region 1

4.2.2.1 Europe and CEPT

General information for usages in CEPT can be found in [41]. When it comes to Regulation about Short Range Devices additional information can be found in [42]. Unwanted emission limits can be found in [43] and [44].

The bands above 52.6 GHz that are discussed due to WRC-19 AI 1.13 (IMT), within CEPT are three, 66-71 GHz as IMT candidate band and the bands 71-76/81-86 GHz as no IMT bands. The band 71-76 GHz, paired with 81-86 GHz, is a fixed link band important for backhauling of 5G. Therefore fixed link usage is expected to increase in the future.

From a European perspective, the focus should be on bands that are proposed for IMT as well as on the unlicensed band 57-66 GHz. The current status, seen by CEPT, for IMT bands can be found in the draft ECP, European Common Proposal and Brief for WRC-19 Agenda Item 1.13. There are no limitations concerning output powers or channel bandwidth in the 66-71 GHz band, only that the band 66-71 GHz is planned for "Future Civil systems".

Table 4.2.2.1-1 and Table 4.2.2.1-2 provide summary of frequency allocations in the range of 52.6 and 114.25 GHz and regulatory requirements for existing Mobile and Fixed services in the frequency bands between 52.6 GHz and 114.25 GHz, respectively.

Table 4.2.2.1-1: Frequency bands in the range 52.6 to 100 GHz

Frequency range in GHz	Comments	Region
52.6 to 54.25	EESS service, all emissions are prohibited (footnote 5.340 of [37])	ITU/CEPT
55.78 to 57	Recommended to be used by fixed services [40](footnote 5.547 of [37])	ITU/CEPT
57 to 66	Several usage of Short range devices [42][45] 57-64 GHz recommended by CEPT for fixed service limited to point to point [47] 64-66 GHz recommended by CEPT for fixed service limited to point to point [46] 63-64 GHz ITS band in Europe [47])	EC/CEPT
66 to 71	There is currently no limitations on channel bandwidths, output powers etc. Access regime currently under discussion in CEPT	CEPT
71 to 76 and 81 to 86	Recommended by CEPT for fixed services [48]	CEPT
77 to 81	Automotive RADAR in Europe [49][50]	EC/CEPT
86 to 92, 100 to 102, 109.5 to 111.8	EESS service, all emissions are prohibited (footnote 5.340 of [37])	ITU/CEPT
92 to 94, 94.1 to 100, 102 to 109.5 and 111.8 to 114.25	Recommended by CEPT for fixed services [51])	CEPT

Table 4.2.2.1-2: Europe/CEPT – Current Regulatory Requirements for spectrum between 52.6 GHz and 114.25 GHz

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
57 – 66	40 dBm mean EIRP. This refers to the highest power level of the transmitter power control range during the transmission burst if transmitter power control is implemented	Adequate spectrum sharing mechanism (e.g. Listen-before-Talk, Detect-And-Avoid) shall be implemented by the equipment	Not specified	Short Range Devices - Wide Data Transmissions [42]	Fixed outdoor installations are not allowed. The maximum mean EIRP density is limited to 13 dBm/MHz. Point-to-point links of the Fixed Service are regulated by [46][47]
66 – 71	To be defined	To be defined	To be defined	To be defined	
71-76, 81-86	Maximum power limit= 30dBm Maximum EIRP= 85dBm (55 dBW) Minimum antenna gain= Pout (dBm) + 15; or 38 (whichever is the greater) maximum antenna gain= 85- Pout(dBm) Complete set of specification (part 2-2 and part 3 of [52])	Access to the frequency bands by Authorization regimes or by Block assignment/auction regimes.	An aggregation of 250 MHz channels for wider channels as defined in [53] (channel arrangements for channel sizes ranging from 250 to 4750 MHz)	Fixed Services defined in [53] To assist the planning of fixed links, self-coordination approach, similar to the "light licensing", described in [54] can be considered.	
92-94, 94.1-100, 102-109.5, 111.8-114.25	Not defined [51]	Not defined [51]	Radio frequency channel/block arrangements should be derived by aggregation of 250 MHz channels. Inside a specific sub-band no upper limit is given to block size, provided that the blocks' duplex separation is maintained. Details in Annex 3 of [51]	Fixed Services defined in [51]. The choice of the appropriate assignment method and licensing regime for Fixed Service remains a decision for national administrations, based on several technical and not technical factors	To assist the planning of fixed links, self-coordination approach, similar to the "light licensing", described in [54] can be considered.

4.2.2.2 Void

4.2.2.3 South Africa

Table 4.2.2.3-1 shows summary of the spectrum allocations for South Africa for frequency between 52.6GHz and 100GHz, based on [9]. Primary services are listed in upper case, e.g., MOBILE, and secondary services are listed in with Capitalization. e.g. Amateur.

Table 4.2.2.3-1: South Africa spectrum allocation between 52.6 GHz and 100 GHz

Frequency [GHz]	Allocations	Notes and ITU Radio Regulations Footnotes
52.6-54.25	EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive)	5.340, 5.556;
54.25-55.78	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)	5.556A;
55.78-56.9	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	5.557A, NF14, 5.556A, 5.558, 5.547;
56.9-57	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	NF14, 5.558, 5.547;
57-58.2	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	NF14, 5.556A, 5.558;
58.2-59	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive)	NF14, 5.547, 5.556
59-59.3	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE INTER-SATELLITE RADIOLOCATION SPACE RESEARCH (passive)	5.556A, 5.558
59.3-64	FIXED MOBILE INTER-SATELLITE RADIOLOCATION	5.558, 5.559 The band 61-61.5 GHz is designated for ISM applications (5.138). The band 59 - 61 GHz reserved for government use.
64-65	FIXED INTER-SATELLITE MOBILE except aeronautical mobile	5.547, 5.556
65-66	EARTH EXPLORATION-SATELLITE FIXED INTER-SATELLITE MOBILE except aeronautical mobile SPACE RESEARCH	5.547
66-71	INTER-SATELLITE MOBILE MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE	5.553, 5.558, 5.554
71-74	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth)	Paired with 81 – 86 GHz.
74-76	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth)	5.561 Paired with 81 – 86 GHz.
76-77.5	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	5.149 Radio Frequency Spectrum Regulations as amended (Annex B) (GG. No. 38641, 30 March 2015) [10].
77.5-78	AMATEUR AMATEUR-SATELLITE Radio astronomy Space research (space-to-Earth)	5.149

Frequency [GHz]	Allocations	Notes and ITU Radio Regulations Footnotes
78-79	RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	5.149, 5.560
79-81	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	5.149
81-84	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE MOBILE-SATELLITE (Earth-to-space) RADIO ASTRONOMY Space research (space-to-Earth)	5.338A, NF14, 5.149, 5.561A Paired with 71-76 GHz.
84-86	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE RADIO ASTRONOMY	5.561B, 5.338A, NF14
86-92	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)	5.340
92-94	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	5.149
94-94.1	RADIOLOCATION Radio astronomy	5.562, 5.562A
94.1-95	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	NF14, 5.149
95-100	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION RADIONAVIGATION RADIONAVIGATION-SATELLITE	5.149, 5.554
NOTE NF14: The frequency bands 71GHz – 76GHz paired with 81GHz – 86GHz are allocated to the fixed services and is earmarked for very high capacity Broadband Fixed Wireless Systems over very short hop lengths. Radio frequency channel arrangements for fixed service systems operating in the bands 71-76GHz and 81-86GHz are according to the Radio Frequency Spectrum Regulations (GG. No.38641, 30 March 2015) [10].		

The use of E-band, 73.375 – 75.875GHz paired with 83.375 – 85.375GHz, is based on point-to-point light-licensing in units of 2 x 250 MHz channels. The band is segmented into two blocks, Block A and Block B. Block A is for self-coordinated spectrum. Block B is for ICASA-coordinated spectrum. The channel allocations for Block A and B are shown in Figure 4.2.2.3-1.

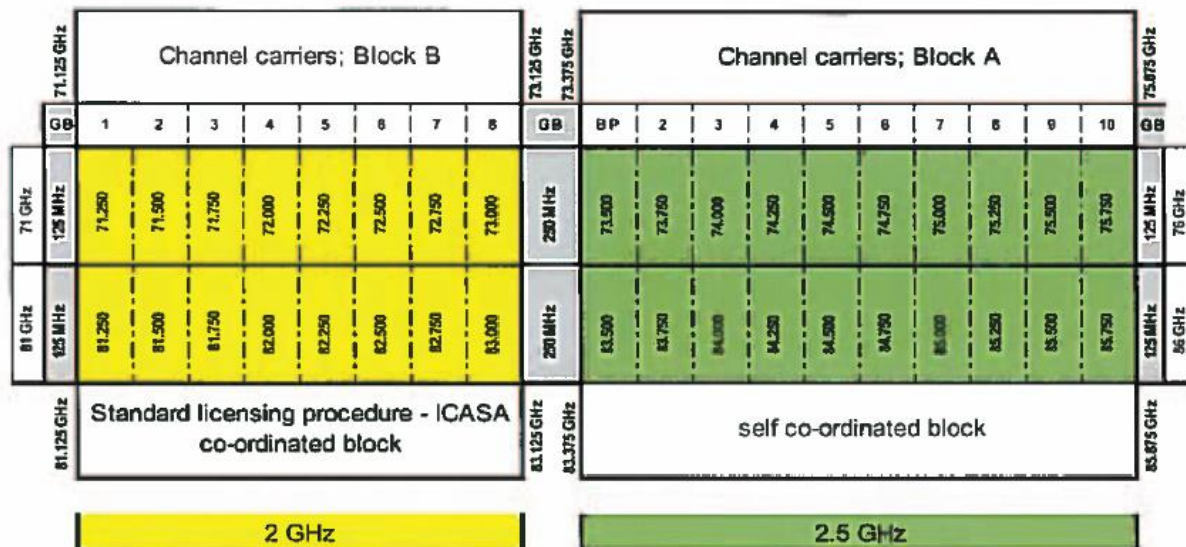
E-BAND (71 - 81 GHz paired with 81 - 86 GHz)**250 MHz channel spacing****Figure 4.2.2.3-1: South Africa E-band channel arrangements (from [11])**

Table 4.2.2.3-2 shows summary of regulatory requirements for frequency ranges that are designed for mobile and fixed link use between 52.6GHz and 100GHz in South Africa, which are based on [11] and [12].

Table 4.2.2.3-2: South Africa regulatory requirements for frequency between 52.6GHz and 100GHz

Frequency band [GHz]	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Additional Notes
57 – 64	Max EIRP 55dBm Max Tx power 10dBm. Min antenna gain 30dBi.	No requirements.		Point-to-point links	Unlicensed. Use EN 305 550 standard.
57 – 66	Max EIRP 40dBm	The use of these systems is as described in ITU-R Report ITU-R M.2227 and recommended in ITU-R M.2003.		Multi-gigabit wireless systems. Fixed outdoor installers are not allowed.	Unlicensed. Use EN 302 567 standard.
76 – 77	Max peak power 55dBm	No duty cycle restriction. No channel spacing.		RTTT radar	Use EN 300 091, EN 301 489-1,3, and EN60950 standard
71 – 76	Max Tx power 35 dBm. Max EIRP 85dBm (Gant > 55dBi), Max EIRP 85 – (55-Gant) dBm (55dBi ≥ Gant > 45 dBi), and Max EIRP 75 – 2x(45-Gant) (45dBi ≥ Gant > 38 dBi), where Gant: antenna gain. Max PSD 150mW/100MHz. Min antenna gain 38 dBi.	N/A		Fixed links	Light licensed

Frequency band [GHz]	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Additional Notes
81 – 86	Max Tx power 35 dBm. Max EIRP 85dBm (Gant > 55dBi), Max EIRP 85 – (55-Gant) dBm (55dBi ≥ Gant > 45 dBi), and Max EIRP 75 – 2× (45-Gant) (45dBi ≥ Gant > 38 dBi), where Gant: antenna gain. Max PSD 150mW/100MHz. Min antenna gain 38 dBi.	N/A		Fixed links	Light licensed

4.2.3 ITU Region 2

4.2.3.1 USA

Table 4.2.3.1-1 shows the spectrum allocations for USA for frequency between 52.6GHz and 100GHz. Primary services are listed in upper case, e.g., MOBILE, and secondary services are listed with Capitalization, e.g. Amateur. The FCC rules part(s) and additional requirements are rules and regulations that pertain to specified frequency ranges and detailed description of the rules and regulations are listed in FCC code of federal regulations Title 47 Part 2.

Table 4.2.3.1-1: USA spectrum allocation between 52.6 GHz and 100 GHz

Frequency [GHz]	Allocations	Governing FCC Rule Part(s)
52.6-54.25	EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive)	General Rules and Regulations (2.105 -US246)
54.25-55.78	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)	Satellite Communications (25) General Rules and Regulations (2.105 -5.556A)
55.78-56.9	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	Satellite Communications (25) General Rules and Regulations (2.105 -US353, US532, US379, 5.556A, 5.558)
56.9-57	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive)	General Rules and Regulations (2.105 - US532, 5.558)
57-58.2	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	RF Devices (15) Satellite Communications (25) General Rules and Regulations (2.105 -US532, 5.556A, 5.558)
58.2-59	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive)	RF Devices (15) General Rules and Regulations (2.105 -US353, US354)
59-59.3	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE RADIOLOCATION SPACE RESEARCH (passive)	RF Devices (15) General Rules and Regulations (2.105 -US353, 5.558, 5.559)

Frequency [GHz]	Allocations	Governing FCC Rule Part(s)
59.3-64	FIXED MOBILE RADIOLOCATION	RF Devices (15) ISM Equipment (18) General Rules and Regulations (2.105 -5.138, US353, 5.559, 5.558)
64-65	FIXED MOBILE except aeronautical mobile	RF Devices (15)
65-66	EARTH EXPLORATION-SATELLITE FIXED INTER-SATELLITE MOBILE except aeronautical mobile SPACE RESEARCH	RF Devices (15) Satellite Communications (25)
66-71	INTER-SATELLITE MOBILE MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE	RF Devices (15) Satellite Communications (25) General Rules and Regulations (2.105 -5.554, 5.553, 5.558)
71-74	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth)	Fixed Microwave (101) General Rules and Regulations (2.105 -US389)
74-76	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth)	RF Devices (15) Fixed Microwave (101) General Rules and Regulations (2.105 -US389)
76-77	RADIO ASTRONOMY RADIOLOCATION Amateur Space research (space-to-Earth)	RF Devices (15) Personal Radio (95) Amateur Radio (97) General Rules and Regulations (2.105 -US342)
77-81	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	RF Devices (15) Personal Radio (95) Amateur Radio (97) General Rules and Regulations (2.105 -5.560, US342)
81-84	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE MOBILE-SATELLITE (Earth-to-space) RADIO ASTRONOMY Space research (space-to-Earth)	RF Devices (15) Fixed Microwave (101) General Rules and Regulations (2.105 -US161, US342, US389, US297)
84-86	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE RADIO ASTRONOMY	RF Devices (15) Fixed Microwave (101) General Rules and Regulations (2.105 -US161, US342, US389)
86-92	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)	RF Devices (15) Fixed Microwave (101) General Rules and Regulations (2.105 -US246, US74)
92-94	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	RF Devices (15) Fixed Microwave (101) General Rules and Regulations (2.105 -US161, US342)
94-94.1	RADIOLOCATION Radio astronomy	RF Devices (15) General Rules and Regulations (2.105 -5.562A)
94.1-95	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	RF Devices (15) Fixed Microwave (101) General Rules and Regulations (2.105 -US161, US342)
95-100	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION RADIONAVIGATION RADIONAVIGATION-SATELLITE	General Rules and Regulations (2.105 -5.554, US342)

Among the spectrum allocations for U.S.A., frequency ranges 57GHz to 71GHz are available for mobile use as part of unlicensed spectrum regulated by Title 47 Part 15 of the FCC regulations. Frequency ranges 71GHz to 74GHz and 81GHz to 86GHz are available for fixed use as part of licensed spectrum using universal licensing system regulated by Title 47 Part 101 of the FCC regulations. Frequency ranges 92GHz to 95GHz (TBC) are available for fixed indoor wireless use as part of licensed spectrum using universal licensing system regulated by Title 47 Part 101 of the FCC regulations.

The 70/80/90GHz bands in US are licensed on the basis of non-exclusive nationwide licenses. There is no limit to the number of non-exclusive nationwide licenses that may be granted for these bands, and these licenses will serve as a prerequisite for registering individual links. An entity may request any portion of the 71-76GHz and 81-86GHz bands, up to 5 gigahertz in each segment for a total of 10 gigahertz. Licensees are also permitted to register smaller segments. The 92-95GHz band is divided into three segments: 92.0-94.0GHz and 94.1-95.0 GHz for non-government and government users, and 94.0-94.1 GHz for Federal Government use. Pairing is allowed and segments may be aggregated without limit (possible 12.9 gigahertz maximum aggregation). Licensees may use the 70GHz, 80GHz and 90GHz bands for any point-to-point, non-broadcast service. The segments may be unpaired or paired, but pairing will be permitted only in a standardized manner (e.g., 71-72.25GHz may be paired only with 81-82.25GHz, and so on).

Table 4.2.3.1-2 shows regulatory requirements for frequency ranges that are designed for mobile use between 52.6GHz and 100GHz in U.S. It should be noted that no channel occupancy time, occupied channel bandwidth, and listen-before-talk requirements exist for unlicensed operations in above 52.6GHz.

Table 4.2.3.1-2: USA regulatory requirements for frequency between 52.6GHz and 100GHz that are available for fixed and mobile use

Frequency band [GHz]	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Additional Notes
57 – 71	Max avg, EIRP 40dBm Max peak EIRP 43dBm If emission-BW is less than 100 MHz, max peak conducted output power is {500mW x emission-BW / 100MHz} [Note 1] Otherwise, max peak conducted output power is 500mW	No requirements.	No specified requirements.	Equipment other than fixed outdoor. [Note 4]	Unlicensed. [Note 2] [Note 3] [Note 10]
57 – 71	Max avg. EIRP (82 – 2N) dBm Max peak EIRP (85 – 2N) dBm. N = max(0, 51 dBi – antenna-gain) If emission-BW is less than 100 MHz, max peak conducted output power is {500mW x emission-BW / 100MHz} [Note 1] Otherwise, max peak conducted output power is 500mW	No requirements.	No specified requirements.	Fixed outdoor equipment	Unlicensed. [Note 10]
71 – 76	Max EIRP 55dBW, Max Tx Power 5dBW Max Tx PSD 150mW/100MHz [Note 8] [Note 9]	Sharing and coordination among non-government licensees and between non-government and government services.	Max of 5 GHz [Note 5]	Any point-to-point, non-broadcast service	Lightly licensed

Frequency band [GHz]	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Additional Notes
81 – 86	Max EIRP 55dBW Max Tx power 5dBW Max Tx PSD 150mW/100MHz [Note 8] [Note 9]	Sharing and coordination among non-government licensees and between non-government and government services.	Max of 5 GHz [Note 5]	Any point-to-point, non-broadcast service	Lightly licensed
92 – 94	Max EIRP 55dBW [Note 8] [Note 9]	Sharing and coordination among non-government licensees and between non-government and government services.	Max of 2 GHz [Note 5]	Any point-to-point, non-broadcast service	Lightly licensed
94 – 94.1	Max EIRP 55dBW [Note 8] [Note 9]	N/A		Any point-to-point, non-broadcast service (Government use only)	Lightly Licensed
94.1 – 95	Max EIRP 55dBW [Note 8] [Note 9]	Sharing and coordination among non-government licensees and between non-government and government services.	Max of 0.9 GHz [Note 5]	Any point-to-point, non-broadcast service	Lightly Licensed
92 – 95	Max avg. PSD 9uW/sq.cm [Note 6] Max peak PSD 18uW/sq. cm [Note 6] Max Tx power 500mW	Sharing and coordination among non-government licensees and between non-government and government services.	No specified requirements.	Fixed Indoor Only	Unlicensed. [Note 2] [Note 7] [Note 10]

Frequency band [GHz]	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Additional Notes
95 – 100, 102 – 109.5, 111.8 – 114.25	Rules being defined by FCC as part of the Spectrum Horizons 95-275GHz proceeding	Rules being defined by FCC as part of the Spectrum Horizons 95-275GHz proceeding	Rules being defined by FCC as part of the Spectrum Horizons 95-275GHz proceeding	There are passive services like radio astronomy service (RAS), Earth exploration-satellite service (EESS) (passive), and space research service (SRS) (passive) in the gaps (100-102GHz and 109.5-111.8 GHz) between bands considered	Licensed [Note 12]
<p>Note 1: 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 100kHz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (e.g., for frequency hopping devices). Peak transmitter conducted output power shall be measured with an RF detector that has a detection bandwidth that encompasses the 57-71GHz band and that has a video bandwidth of at least 10MHz.</p> <p>Note 2: The power density of any emissions outside the 57-71GHz band shall consist solely of spurious emissions. Radiated emissions below 40GHz shall not exceed the general limits of 5 uV/m measured at a distance of 3 m. Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm² at a distance of 3m. The levels of the spurious emissions shall not exceed the level of the fundamental emission.</p> <p>Note 3: Equipment is presumed to operate over the temperature range -20 to + 50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.</p> <p>Note 4: Operation on aircraft is permitted under the following conditions: (1) when the aircraft is on the ground, and (2) while airborne, only in closed exclusive on-board communication networks within the aircraft, with the following exceptions: (i) Equipment shall not be used in wireless avionics intra-communication (WAIC) applications where external structural sensors or external cameras are mounted on the outside of the aircraft structure. (ii) Equipment shall not be used on aircraft where there is little attenuation of RF signals by the body/fuselage of the aircraft. These aircraft include, but are not limited to, toy/model aircraft, unmanned aircraft, crop-spraying aircraft, aerostats, etc.</p> <p>Note 5: Licensees are also permitted to register smaller bandwidth segments and segments may be aggregated without limit (up to 12.9 gigahertz maximum aggregation).</p> <p>Note 6: Measured at 3 meters from the radiating structure.</p> <p>Note 7: The use of outdoor mounted antennas, e.g., antennas mounted on the outside of a building or on a telephone pole, or any other outdoors infrastructure is prohibited. The emissions from equipment operated under this section shall not be intentionally directed outside of the building in which the equipment is located, such as through a window or a doorway. Spurious emission Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm² at a distance of 3 meters.</p> <p>Note 8: The mean power of emissions must be attenuated below the mean output power of the transmitter in any 1 MHz band by A, where $A = \max\{56, 11 + 0.4 \times (P - 50) + 10 \times \log_{10}(B)\}$ dB and A = Attenuation (in decibels) below the mean output power level, P = Percent removed from the center frequency of the transmitter bandwidth and between 50 and 250 percent, and B = Authorized bandwidth in MHz. Attenuation to an absolute power of less than -13dBm/1MHz is not required.</p> <p>Note 9: Unless otherwise authorized upon specific request by the applicant, each station authorized must employ a directional antenna adjusted with the center of the major lobe of radiation in the horizontal plane directed toward the receiving station with which it communicates: provided, however, where a station communicates with more than one point, a multi- or omni-directional antenna may be authorized if necessary. Fixed stations must employ transmitting and receiving antennas (excluding second receiving antennas for operations such as space diversity) meeting the appropriate performance indicated in Table 4.2.3.1-3. Other than frequency 92 to 95 GHz, the antenna gain less than 50 dBi (but greater than or equal to 43 dBi) is permitted only with a proportional reduction in maximum authorized EIRP in a ratio of 2 dB of power per 1 dB of gain, so that the maximum allowable EIRP (in dBW) for antennas of less than 50 dBi gain becomes $+55 - 2 \times (50 - G)$, where G is the antenna gain in dBi. In addition, antennas in these bands must meet two additional standards for minimum radiation suppression: At angles between 1.2 and 5 degrees from the</p>					

Frequency band [GHz]	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Additional Notes
<p>centerline of the main beam, co-polar discrimination must be $G-28$, where G is the antenna gain in dBi; and at angles of less than 5 degrees from the centerline of main beam, cross-polar discrimination must be at least 25 dB.</p> <p>Note 10: Any transmitter that has received the necessary FCC equipment authorization may be mounted in a group installation for simultaneous operation with one or more other transmitter(s) that have received the necessary FCC equipment authorization, without any additional equipment authorization. However, no transmitter may be equipped with external phase-locking inputs that permit beam-forming arrays to be realized.</p> <p>Note 11: First, a licensee applies for a non-exclusive nationwide license; second, the licensee registers individual point-to-point links with a database manager. Registration process verifies potential for harmful interference to or from all previously registered non-government links.</p> <p>Note 12: On February 22nd, 2018, the FCC adopted their Spectrum Horizons Notice of Proposed Rulemaking (NPRM) that seeks comment on bands above 95GHz; A mmW coalition has been active in this proceeding and has petitioned FCC to include these passive bands (100-102GHz and 109.5-111.8 GHz), and other passive bands above 114.25GHz for consideration for terrestrial fixed and mobile use. If approved, then the whole 95-114.25GHz range could be available in USA.</p>					

Table 4.2.3.1-3: Transmit and receive antenna performance for fixed stations operating in E-band

Frequency (GHz)	Max BW to 3 dB points (included angle in degrees)	Min antenna gain (dBi)	Min radiation suppression to angle in degrees from centerline of main beam in (dB)						
			5° to 10°	10° to 15°	15° to 20°	20° to 30°	30° to 100°	100° to 140°	140° to 180°
71 - 76 (co-polar)	1.2	43	35	40	45	50	50	55	55
71 - 76 (cross-polar)	1.2	43	45	50	50	55	55	55	55
81 – 86 (co-polar)	1.2	43	35	40	45	50	50	55	55
81 – 86 (cross-polar)	1.2	43	45	50	50	55	55	55	55
92 - 95	0.6	50.0	36	40	45	50	55	55	55

4.2.3.2 Canada

Table 4.2.3.2-1 shows the spectrum allocations for Canada for frequency between 52.6GHz and 100GHz based on [13]. Primary services are listed in upper case, e.g., MOBILE, and secondary services are listed with Capitalization, e.g. Amateur.

Table 4.2.3.2-1: Canada spectrum allocation between 52.6GHz and 100GHz

Frequency [GHz]	Allocations	Notes and ITU Radio Regulations Footnotes
52.6-54.25	EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive)	5.3.40, 5.556
54.25-55.78	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)	5.556A

Frequency [GHz]	Allocations	Notes and ITU Radio Regulations Footnotes
55.78-56.9	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	5.557A, 5.556A, 5.5558, 5.547
56.9-57	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive)	5.558A, 5.558, 5.547
57-58.2	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	5.556A, 5.558, 5.547
58.2-59	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive)	5.547, 5.556
59-59.3	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE INTER-SATELLITE RADIOLOCATION SPACE RESEARCH (passive)	5.556A, 5.558, 5.559
59.3-64	FIXED MOBILE INTER-SATELLITE RADIOLOCATION	5.558, 5.559, 5.138
64-65	FIXED INTER-SATELLITE MOBILE except aeronautical mobile	5.547, 5.556
65-66	EARTH EXPLORATION-SATELLITE FIXED INTER-SATELLITE MOBILE except aeronautical mobile SPACE RESEARCH	5.547
66-71	INTER-SATELLITE MOBILE MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE	5.553, 5.558, 5.554
71-74	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth)	
74-76	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth)	5.561
76-77.5	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	5.149
77.5-78	AMATEUR AMEUR-SATELLITE RADIOLOCATION Radio astronomy Space research (space-to-Earth)	5.149

Frequency [GHz]	Allocations	Notes and ITU Radio Regulations Footnotes
78-79	RADIOLOCATION Amateur Amateur-satellite Radio astronomy Space research (space-to-Earth)	5.149, 5.560
79-81	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	5.149
81-84	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE MOBILE-SATELLITE (Earth-to-space) RADIO ASTRONOMY Space research (space-to-Earth)	5.338A, 5.149, 5.561A
84-86	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE RADIO ASTRONOMY	5.338A, 5.149
86-92	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)	5.340
92-94	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	5.338A, 5.149
94-94.1	EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION SPACE RESEARCH (active) Radio astronomy	5.562, 5.562A
94.1-95	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	5.149
95-100	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION RADIONAVIGATION RADIONAVIGATION-SATELLITE	5.149, 5.554

Canada has designed frequency bands 71-76GHz, 81-86GHz, and 92-95GHz for use by fixed service. Frequency bands 71-76GHz, 81-86GHz are subject to licensing and frequency band 92-95GHz will be subject to future revision of the Canada's Standard Radio System Plan (SRSP). Figure 4.2.3.2-1 illustrates the band plan and associated usage for the bands 71-76 and 81-86GHz. The channel center frequencies are also described in Table 4.2.3.2-2 and 4.2.3.2-3. The frequency ranges 71.125 to 74.375 GHz and 81.125 to 84.375GHz provide for thirteen pairs of 250MHz channels (A1/A1' to A13/A13') for systems employing FDD. The frequency ranges 74.375GHz to 75.875GHz and 84.375GHz to 85.875GHz provide for 6 pairs of 250MHz channels (A14/A14' to A19/A19') for systems employing either FDD or TDD.

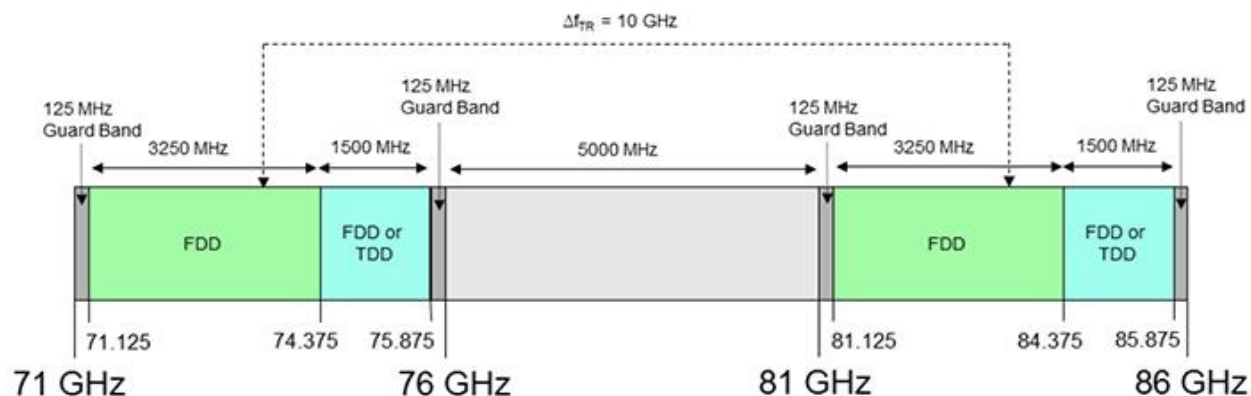


Figure 4.2.3.2-1: Canada's 71-76GHz and 81-86GHz band plan and associated usage (from [14])

Table 4.2.3.2-2: 71-76GHz and 81-86GHz band plan and associated usage for systems using 250MHz wide channels for Canada

Channel	Centre frequency (MHz)	Duplex
A1/A1'	71250/81250	FDD
A2/A2'	71500/81500	FDD
A3/A3'	71750/81750	FDD
A4/A4'	72000/82000	FDD
A5/A5'	72250/82250	FDD
A6/A6'	72500/82500	FDD
A7/A7'	72750/82750	FDD
A8/A8'	73000/83000	FDD
A9/A9'	73250/83250	FDD
A10/A10'	73500/83500	FDD
A11/A11'	73750/83750	FDD
A12/A12'	74000/84000	FDD
A13/A13'	74250/84250	FDD
A14/A14'	74500/84500	FDD, TDD
A15/A15'	74750/84750	FDD, TDD
A16/A16'	75000/85000	FDD, TDD
A17/A17'	75250/85250	FDD, TDD
A18/A18'	75500/85500	FDD, TDD
A19/A19'	75750/85750	FDD, TDD

Table 4.2.3.2-3: 71-76GHz and 81-86GHz band plan and associated usage for systems using aggregation of multiple 250MHz wide channels for Canada

Channel	Bandwidth (MHz)	Centre frequency (MHz)	Duplex
B1/B1'	500	71375 / 81375	FDD
B2/B2'	500	71875 / 81875	FDD
B3/B3'	500	72375 / 82375	FDD
B4/B4'	500	72875 / 82875	FDD
B5/B5'	500	73375 / 83375	FDD
B6/B6'	500	73875 / 83875	FDD
B7/B7'	500	74375 / 84375	FDD
B8/B8'	500	74875 / 84875	FDD, TDD
B9/B9'	500	75375 / 85375	FDD, TDD
C1/C1'	750	71500 / 81500	FDD
C2/C2'	750	72250 / 82250	FDD
C3/C3'	750	73000 / 83000	FDD
C4/C4'	750	73750 / 83750	FDD
C5/C5'	750	74500 / 84500	FDD
C6/C6'	750	75250 / 85250	FDD, TDD
D1/D1'	1000	71625 / 81625	FDD
D2/D2'	1000	72625 / 82625	FDD

Channel	Bandwidth (MHz)	Centre frequency (MHz)	Duplex
D3/D3'	1000	73625 / 83625	FDD
D4/D4'	1000	74625 / 84625	FDD
E1/E1'	1250	71750 / 81750	FDD
E2/E2'	1250	73000 / 83000	FDD
E3/E3'	1250	74250 / 84250	FDD
F1/F1'	1500	71875 / 81875	FDD
F2/F2'	1500	73375 / 83375	FDD
G1/G1'	1750	72000 / 82000	FDD
G2/G2'	1750	73750 / 83750	FDD
H1/H1'	2000	72125 / 82125	FDD
H2/H2'	2000	74125 / 84125	FDD
I1/I1'	2250	72250 / 82250	FDD
I2/I2'	2250	74500 / 84500	FDD
J1/J1'	2500	72375 / 82375	FDD
K1/K1'	2750	72500 / 82500	FDD
L1/L1'	3000	72625 / 82625	FDD
M1/M1'	3250	72750 / 82750	FDD
N1/N1'	3500	72875 / 82875	FDD
O1/O1'	3750	73000 / 83000	FDD
P1/P1'	4000	73125 / 83125	FDD
Q1/Q1'	4250	73250 / 83250	FDD
R1/R1'	4500	73375 / 83375	FDD

Table 4.2.3.2-4 shows regulatory requirements for frequency ranges that are designed for mobile use between 52.6GHz and 100GHz in Canada.

Table 4.2.3.2-4: Canada regulatory requirements for frequency between 52.6GHz and 100GHz that are available for fixed and mobile use

Frequency band [GHz]	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Additional Notes
57 – 64	Max Peak conducted power: - If BW >100MHz, 500mW - If BW<100MHz; 500mW (Emission BW/100MHz) In EIRP: Indoor: 40dBm avg/43dBm Peak Outdoor PtP: 82dBm when Gant>51dBi; 82-2x (51-Gant) when Gant≤51dBi	No requirements.	No specified requirement s.	Indoor/outdoor	Unlicensed.
64 – 71	In June 2017, Canada proposed to extend the 60GHz band to this range.				[Note 3]
71 – 76	Max power 5dBW. Max PSD -15dBW/MHz Minimum antenna gain 38 dBi Max EIRP 55dBm (Gant > 55dBi), Max EIRP 55 – (55-Gant) dBm (55dBi ≥ Gant > 45 dBi), and Max EIRP 45 – 2x (45-Gant) (45dBi ≥ Gant > 38 dBi), where Gant: antenna gain. [Note 1] [Note 2]	N/A		fixed point-to-point	Licensed
81 – 86	Max power 5dBW. Max PSD -15dBW/MHz Minimum antenna gain 38 dBi Max EIRP 55dBm (Gant > 55dBi), Max EIRP 55 – (55-Gant) dBm (55dBi ≥ Gant > 45 dBi), and Max EIRP 45 – 2x(45-Gant) (45dBi ≥ Gant > 38 dBi), where Gant: antenna gain. [Note 1] [Note 2]	N/A		fixed point-to-point	Licensed

Note 1:	For unwanted emission limits described in Table 4.2.3.2-5 shall be applied. The power spectral density, delivered to the antenna input, outside the edges of the bands 71-76 GHz and 81-86 GHz shall be limited to a maximum of -55 dBW/MHz. Additionally, emissions into the band 86-92 GHz are furthermore limited. The power spectral density, delivered to the antenna input, shall be limited to a maximum of -41 dBW/100 MHz at 86 GHz and reducing proportionally to -55 dBW/100 MHz at and beyond 87 GHz
Note 2:	Antenna pattern must satisfy Envelop A or B specified in Table 4.2.3.2-6. The co-polarized radiation pattern envelope in the horizontal plane of the antenna must remain within Envelope A for both vertical and horizontal polarizations. The deployment of a radio system using an RF channel bandwidth greater than 2000 MHz and an antenna radio pattern remaining within Envelope B is not permitted. The values for the radiation pattern envelopes are shown table below and specified as off-axis antenna gain in units of dBi, as opposed to dBs of attenuation from the main lobe gain. In order to convert the pattern values to attenuation from the main lobe, the antenna main beam gain in dBi can be subtracted from the off-axis dBi values of the applicable envelope.
Note 3:	The June 2017 Consultation on Releasing Millimetre Wave Spectrum to Support 5G from Innovation, Science and Economic Development Canada (ISED) is accessible at http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11298.html . ISED proposal remains pending.

Table 4.2.3.2-5: Unwanted emission limits for E-band in Canada

Maximum power spectral density (dBW/MHz)	Frequency separation (% of channel bandwidth)
-30	50
-45	57.5
-45	70
-65	125
-75	250 or 150 + 500 MHz [NOTE]
NOTE: The 250% value is applied for a channel bandwidth that is less than or equal to 500 MHz. For a bandwidth greater than 500 MHz, the 150%+500 MHz value is applied.	

Table 4.2.3.2-6: Antenna pattern for envelop A and B for E-band in Canada

Azimuth (in degrees) from main lobe peak	Antenna directivity co-polarization (dBi)	
	Envelope A	Envelope B
5°	16	25
10°	9	17.5
15°	5	10
20°	1	7
40°	-0.33	2
50°	-1	0.66
70°	-4	-2
88.75°	-16.18	-7
90°	-17	-7
100°	-17	-7
100°	-17	-10
180°	-17	-10

4.2.3.3 Brazil

Table 4.2.3.3-1 shows regulatory requirements for frequency ranges that are designed for mobile use between 52.6GHz and 100GHz in Brazil.

Table 4.2.3.3-1: Regulatory requirements for available spectrum between 52.6 GHz and 100 GHz in Brazil

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
52.6 – 57, 64 – 71, 86 – 100,	No regulation				
57 – 64	Total Peak Power at transmitter output ≤	No channel occupancy	No occupied channel	Restricted Radiation Equipment (Low	Anatel Resolution

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
	<p>27dBm (500mW)</p> <p>Max avg. Power Density: 9 microW/cm² @3m</p> <p>Max peak Power Density: 18 microW/cm² @3m</p>	<p>time requirements</p> <p>No LBT requirements</p>	bandwidth (OCB) requirements	<p>power devices)</p> <p>Not permitted for use in aircraft or satellites, and field disturbance sensors (including vehicular radar systems).</p>	<p>680/2017 (act 14448)</p> <p>Spurious emissions:</p> <p>40-200 GHz: ≤90 pW / cm² @3m</p> <p>Spurious emission levels shall not exceed the emission level at the fundamental radio frequency.</p>
71 – 76	<p>EIRP:</p> <p>a) below 85 dBm, for antennas with gain equal to or greater than 55 dBi;</p> <p>b) below 85 – (55 – G), for antennas with gain (G) equal to or greater than 45 dBi and less than 55 dBi; and,</p> <p>c) below 75 - 2 × (45 - G), for antennas with gain (G) of less than 45 dBi.</p>	<p>Must ensure that the power density in the "Itapetinga Radio Observatory", located in Atibaia-SP, at 23°11'5.077" South and 46°33'28.429" West, do not exceed -228 dB (W/(m2Hz)).</p> <p>The main lobes of the antennas cannot be directed to the Radio station of Itapetinga when the distance between the antennas and the Radio station of Itapetinga is less than 60 km, and the compatibility at a lower distance must be proven by a study.</p>	No occupied channel bandwidth (OCB) requirements	Point to Point Telecommunications Service	<p>Anatel Resolution 642/2014</p> <p>PSD for out of band emissions:</p> <p>PSD = -55 dBW / MHz, for frequencies below 71 GHz and between 76 GHz and 81 GHz;</p> <p>PSD = -41 dBW / 100 MHz at 86.05 GHz, decreasing linearly to -55 dBW / 100 MHz at 87 GHz, being flat from this frequency.</p>
76 – 77	If the vehicle is not moving, the power density of any emission ≤ 200 nanoW / cm ² @ 3 m from the outer surface of the radiation structure.	<p>No channel occupancy time requirements</p> <p>No LBT requirements</p>	No occupied channel bandwidth (OCB) requirements	<p>Restricted Radiation Equipment</p> <p>Variable electromagnetic field sensors installed in vehicle and used as vehicle radar</p>	<p>Anatel Resolution 680/2017 (act 14448)</p> <p>Spurious emissions:</p>

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
	<p>For field variation sensors installed in any part to be seen frontally in the vehicle, the power density of any emission when the vehicle is in motion $\leq 60 \text{ microW / cm}^2 @ 3 \text{ m}$ from the outer surface of the radiation structure.</p> <p>For field variation sensors installed anywhere to be seen sideways or behind the vehicle, when the vehicle is in motion $\leq 30 \text{ microW / cm}^2 @ 3 \text{ m}$ from the outer surface of the radiation structure.</p>			<p>systems</p> <p>Not permitted for use in aircraft or satellites.</p>	<p>$\leq 600 \text{ pW / cm}^2 @ 3\text{m}$, for field variation sensors installed anywhere to be viewed frontally on the vehicle</p> <p>$\leq 300 \text{ pW / cm}^2 @ 3\text{m}$, for field variation sensors installed anywhere to be viewed sideways or behind on the vehicle</p>
76 – 81	The power at the transmitter output of a repeater station should be limited to 100 watts RMS.			Ham radio (Amateur radio) through specific authorization from Anatel arising from a substantiated request	Anatel Resolution 452/2006
81 – 86	<p>EIRP:</p> <p>a) below 85 dBm, for antennas with gain equal to or greater than 55 dBi;</p> <p>b) below 85 – (55 – G), for antennas with gain (G) equal to or greater than 45 dBi and less than 55 dBi; and,</p> <p>c) below 75 - 2 × (45 - G), for antennas with gain (G) of less than 45 dBi.</p>	<p>Must ensure that the power density in the "Itapetinga Radio Observatory", located in Atibaia-SP, at 23°11'5.077" South and 46°33'28.429" West, do not exceed -228 dB (W/(m2Hz)).</p> <p>The main lobes of the antennas cannot be directed to the Radio station of Itapetinga when the distance between the antennas and the Radio station of Itapetinga is less than 60 km, and the compatibility</p>	No occupied channel bandwidth (OCB) requirements	Point to Point Telecommunications Service	<p>Anatel Resolution 642/2014</p> <p>PSD for out of band emissions:</p> <p>PSD = -55 dBW / MHz, for frequencies below 71 GHz and between 76 GHz and 81 GHz;</p> <p>PSD = -41 dBW / 100 MHz at 86.05 GHz, decreasing linearly to -55 dBW / 100 MHz at 87 GHz, being flat from this frequency.</p>

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
		at a lower distance must be proven by a study.			

4.2.3.4 Mexico

Table 4.2.3.4-1 shows regulatory requirements for frequency ranges that are designed for mobile use between 52.6GHz and 100GHz in Mexico.

Table 4.2.3.4-1: Regulatory requirements for available spectrum between 52.6 GHz and 100 GHz in Mexico

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
57 – 64	Min EIRP: 82 dBm Max EIRP: 85 dBm In cases where the antenna gain is less than 51 dBi, to the average EIRP and the maximum EIRP must be subtracted 2 dB for each dB that the gain is less than 51 dBi.			ITS systems that operate in the 63-64 GHz segment must operate with a maximum EIRP of 40 dBm and antenna gain ≤ 23 dBi.	For the 61-61.5 GHz segment, the fixed field disturbance sensors with bandwidth ≤ 500 MHz must operate with an average EIRP not exceeding 40 dBm and a maximum EIRP not exceeding 43 dBm For the 57-64 GHz band, except the 61-61.5 GHz segment, the fixed field disturbance sensors with bandwidth ≤ 500 MHz must operate with an average EIRP not exceeding 10 dBm and a maximum EIRP not exceeding 13 dBm.
71 – 76, 81 – 86	Max EIRP: 55 dBW with a max input power to the radiator of 3 W (5 dBW). Maximum limit of transmitted spectral density of 150 mW per 100 MHz. Directional antennas with a maximum of 1.2° opening angle of the main lobe of radiation at 3 dB, in the azimuthal and elevation planes. It is allowed the operation of antennas with gain less than 50 dBi and more				Out-of-band emissions: The attenuation of transmitters employing digital modulation techniques, in any MHz of the spectrum whose center frequency is separated from the carrier frequency allocated by more than 50 and up to 250% of the bandwidth used, shall be calculated according to the following equation and it cannot be less than 11 dB: $A = 11 + 0.4 (P-50) + 10 \log_{10} B = 11 + 0.4 (P-50) + 27$ Where: P.- Percentage of separation between the carrier frequency of the channel bandwidth used and the central

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
	than 38 dBi with a reduction of the maximum EIRP values at a ratio of 2 dB of power for every 1 dB of gain, so the max allowed EIRP will be calculated as: Maximum value of EIRP = 55 - 2 (50 - G) where, G is the gain of the antenna.				frequency of the MHz under analysis. B = 500 MHz No attenuations greater than 56 dB or with absolute powers less than -13 dBm / MHz are necessary.

4.2.4 ITU Region 3

4.2.4.1 China

Table 4.2.4.1-1 shows the spectrum allocations for China for frequency between 52.6GHz and 114.25GHz based on [33]. Primary services are listed in upper case, e.g., MOBILE, and secondary services are listed with Capitalization, e.g. Amateur.

Table 4.2.4.1-1: China spectrum allocation between 52.6GHz and 114.25GHz

Frequency [GHz]	Allocations	Notes and ITU Radio Regulations Footnotes
52.6-54.25	EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive) RADIO ASTRONOMY	5.340, 5.556
54.25-55.78	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)	5.556A for INTER-SATELLITE
55.78-56.9	EARTH EXPLORATION-SATELLITE (passive) Fixed INTER-SATELLITE Mobile SPACE RESEARCH (passive)	5.557A for Fixed, 5.556A for INTER-SATELLITE, 5.5558 for Mobile , 5.547
56.9-57	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive) Mobile Fixed	5.558A for INTER-SATELLITE, 5.558 for Mobile, 5.547
57-58.2	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive) Mobile Fixed	5.556A for INTER-SATELLITE, 5.558 for Mobile, 5.547
58.2-59	EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive) RADIO ASTRONOMY Mobile Fixed	5.547, 5.556

Frequency [GHz]	Allocations	Notes and ITU Radio Regulations Footnotes
59-59.3	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive) Mobile Fixed	5.556A for INTER-SATELLITE, 5.558 for Mobile, 5.559
59.3-64	FIXED MOBILE INTER-SATELLITE RADIOLOCATION	5.558 for MOBILE, 5.559 for INTER-SATELLITE, 5.138
64-65	FIXED INTER-SATELLITE RADIO ASTRONOMY	5.547, 5.556
65-66	EARTH EXPLORATION-SATELLITE FIXED INTER-SATELLITE MOBILE except aeronautical mobile SPACE RESEARCH	5.547
66-71	INTER-SATELLITE MOBILE MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE RADIOLOCATION	5.553 for MOBILE, 5.558 for MOBILE, 5.554
71-74	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth)	
74-76	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth)	5.561
76-77.5	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	5.149
77.5-78	AMATEUR AMEUR-SATELLITE RADIOLOCATION Radio astronomy Space research (space-to-Earth)	5.149, 5.559B for RADIOLOCATION
78-79	RADIOLOCATION Amateur Amateur-satellite Radio astronomy Space research (space-to-Earth)	5.149, 5.560
79-81	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	5.149
81-84	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE MOBILE-SATELLITE (Earth-to-space) RADIO ASTRONOMY Space research (space-to-Earth)	5.338A for FIXED, 5.149, 5.561A
84-86	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE RADIO ASTRONOMY	5.338A for FIXED, 5.149

Frequency [GHz]	Allocations	Notes and ITU Radio Regulations Footnotes
86-92	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)	5.340
92-94	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	5.338A for FIXED, 5.149
94-94.1	EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION SPACE RESEARCH (active) Radio astronomy	5.562, 5.562A
94.1-95	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	5.149
95-100	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION RADIONAVIGATION RADIONAVIGATION-SATELLITE	5.149, 5.554
100-102	SPACE RESEARCH (passive) EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY	5.340, 5.341
102-105	FIXED MOBILE RADIO ASTRONOMY	5.149, 5.341
105-109.5	FIXED MOBILE RADIO ASTRONOMY SPACE RESEARCH (passive)	5.149 for RADIO ASTRONOMY, 5.341, 5.562B for SPACE RESEARCH (passive)
109.5-111.8	RADIO ASTRONOMY SPACE RESEARCH (passive) EARTH EXPLORATION-SATELLITE (passive)	5.340, 5.341
111.8-114.25	FIXED MOBILE RADIO ASTRONOMY SPACE RESEARCH (passive)	5.149 for RADIO ASTRONOMY, 5.341, 5.562B for SPACE RESEARCH (passive)

In China, MIIT (Ministry of Industry and Information Technology of the People's Republic China) publishes that short distant unlicensed applications can be applied between 59-64 GHz. While, 76-77GHz is considered for Vehicle Radar ranging application [15][16]. Details are summarized in Table 4.2.4.1-2.

Table 4.2.4.1-2: Regulatory requirements for available spectrum between 52.6 GHz and 114.25 GHz in China

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
59-64	Output power of antenna port: ≤ 10 dBm Peak EIRP: 47dBm Mean EIRP: ≤ 44 dBm	No requirement	Not specified	very low transmission power and short distant unlicensed applications	The unlicensed devices operating in 59-64 GHz shall cause interference to, nor claim protection from legal radio services, i.e. the space research service, earth exploration satellite service, radio astronomy service, etc. Carrier frequency tolerance: 500×10^{-6} Out of Band Emission limit (EIRP): -5dBm/MHz Spurious Emission limit (corresponding to frequency range outside $2.5 \times$ carrier bandwidth): -20dBm/1MHz Spurious Emission limit in Idle/stand-by state (corresponding to frequency range outside $2.5 \times$ carrier bandwidth): -47dBm/1MHz
76-77	Maximum EIRP: 55dBm	No requirement	Not specified	Vehicle Range Radar	Spurious Emission limit (corresponding to frequency range outside $2.5 \times$ carrier bandwidth): -20dBm/1MHz Spurious Emission limit in Idle/stand-by state (corresponding to frequency range outside $2.5 \times$ carrier bandwidth): -47dBm/1MHz

4.2.4.2 Japan

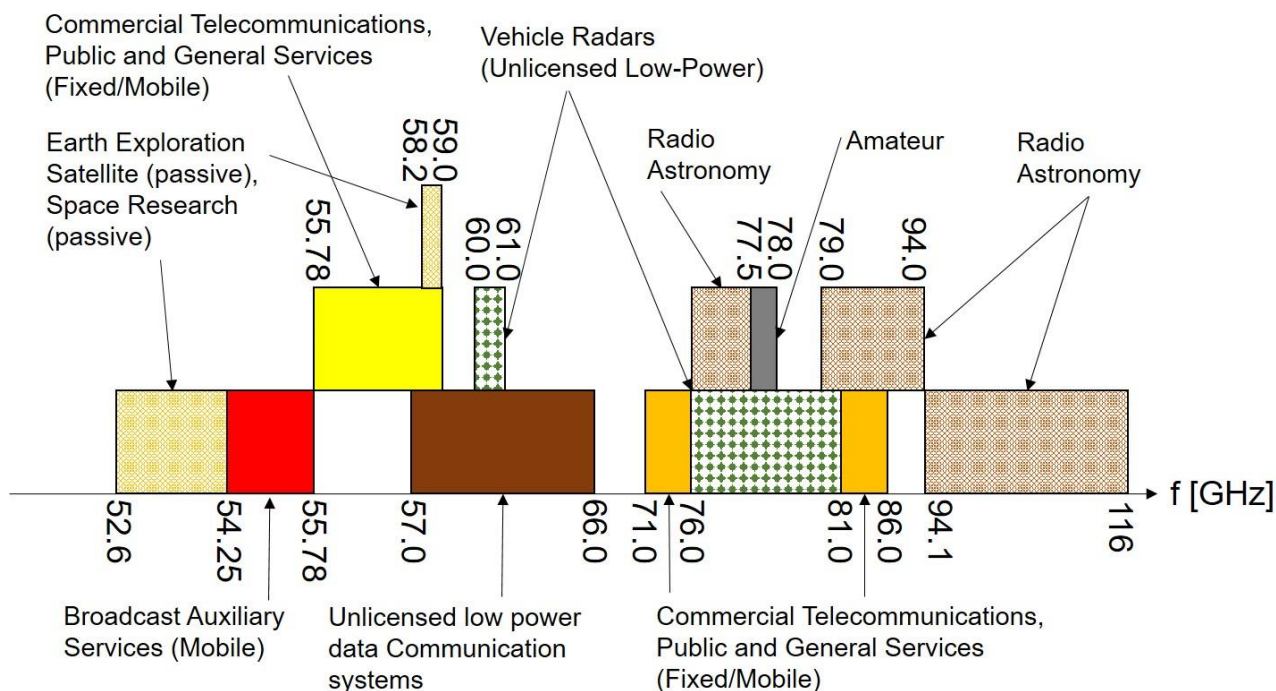


Figure 4.2.4.2-1: Major spectrum usage in the frequency band above 52.6GHz in Japan

(source: <https://www.tele.soumu.go.jp/resource/search/share/pdf/wari3.pdf>)

Figure 4.2.4.2-1 shows frequency usage for frequency above 52.6GHz in Japan. Table 4.2.4.2-1 below summarize the survey on Japanese regulatory requirements in the frequency band above 52.6GHz.

Table 4.2.4.2-1. Major spectrum usage and regulatory requirements between 52.6 GHz and 100 GHz in Japan^[NOTE 9]

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
52.6 – 54.25 58.2 – 59.0				For Earth Exploration Satellite Service (passive), Space Research Service (passive)	
54.25 – 55.78	Power below 1W		See Note 1	For Broadcast Auxiliary Services (Mobile)	ARIB STD-B43 [17] See Note 2 for additional regulatory requirements.
55.78 – 59				For Commercial Telecommunications, Public and General Services (Fixed/Mobile)	
57 – 66	Power below 250mW	See Note 3	Occupied BW shall be below 9GHz	For Unlicensed low power data Communication systems	ARIB STD-T69 [18], ARIB STD-T117 [19] See Note 4 for additional regulatory requirements.

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
60 – 61, 76 – 77	Power below 10mW		See Note 5	For Vehicle Radars (Unlicensed Low-Power)	ARIB STD-T48 [20] See Note 6 for additional regulatory requirements.
77 – 81	Power below 10mW or PSD below 5μW/MHz in case of occupied BW below 2GHz		Occupied BW shall be below 4GHz	For Vehicle Radars (Unlicensed Low-Power)	ARIB STD-T111 [21] See Note 7 for additional regulatory requirements.
71 – 76, 81 – 86	Peak power below 1W		Occupied BW shall be below 5GHz	For Commercial Telecommunications, Public and General Services (Fixed/Mobile)	See Note 8 for additional regulatory requirements.
77.5 – 78				For Amateur	
76 – 77.5 79 – 94 94.1 – 116				For Radio Astronomy	
<p>NOTE 1: For system with 125MHz BW, PSK, QAM and OFDM are available. For system with 500MHz BW, PSK is available. For system with 1GHz BW, PSK and QAM are available.</p> <p>NOTE 2: The unwanted emission shall satisfy below 50μW.</p> <p>NOTE 3: The carrier sensing functionality is required for transmission power above 10dBm.</p> <p>NOTE 4: The antenna absolute gain shall be less than 47dBi. In case of transmission power above 10mW, directivity with above 10dBi antenna absolute gain for main beam direction is necessary and EIRP shall be less than 40dBm. In addition, the unwanted emission shall satisfy Table 4.2.4.2-2.</p> <p>NOTE 5: The allowed value for occupied channel bandwidth (which is defined as bandwidth containing 99.5% of transmission power) is shown in Table 4.2.4.2-3.</p> <p>NOTE 6: The antenna gain shall be less than 40dB. In addition, the unwanted emission shall satisfy Table 4.2.4.2-4.</p> <p>NOTE 7: The antenna absolute gain shall be less than 35dBi. In addition, the unwanted emission shall satisfy Table 4.2.4.2-5.</p> <p>NOTE 8: The antenna absolute gain shall be less than 55dBi. In addition, the unwanted emission shall satisfy Table 4.2.4.2-6.</p> <p>NOTE 9: Other radio stations may be used in the respective frequency bands.</p>					

Table 4.2.4.2-2. Unwanted emission limits for antenna gain less than 47 dBi in Japan

Frequency	Unwanted emission requirement
Below 55.62GHz	Below -30dBm/MHz
Between 55.62GHz and 57GHz, Between 66GHz and 67.5GHz	Below -26dBm/MHz
Above 67.5GHz	Below -30dBm/MHz

Table 4.2.4.2-3. Allowed occupied channel bandwidth for Vehicle Radars in Japan

Frequency	Occupied channel bandwidth
Between 60GHz and 61GHz	Below 500MHz
Between 76GHz and 77GHz	Below 1GHz

Table 4.2.4.2-4. Unwanted emission limits for antenna gain less than 40dBi in Japan

Out-of-band domain emission limit	Spurious domain emission limit
Below 100μW	Below 50μW

Table 4.2.4.2-5. Unwanted emission limits for antenna gain less than 35dBi in Japan

Out-of-band domain emission limit	Spurious domain emission limit
Peak power below 100 μ W/MHz	Peak power below 50 μ W/MHz

Table 4.2.4.2-6. Unwanted emission limits for antenna gain less than 55dBi in Japan

Out-of-band domain emission limit	Spurious domain emission limit
Peak power below 100 μ W/MHz	Peak power below 50 μ W/MHz

4.2.4.3 Korea

Table 4.2.4.3-1 shows summary of the spectrum allocations for South Korea for frequency between 52.6GHz and 114.25GHz, based on [22]. Primary services are listed in upper case, e.g., MOBILE, and secondary services are listed with Capitalization, e.g. Amateur.

Table 4.2.4.3-1: South Korea spectrum allocation between 52.6 GHz and 114.25 GHz

Frequency [GHz]	Allocations	Notes
52.6-54.25	EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive)	
54.25-55.78	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)	
55.78-58.2	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	
58.2-59	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive)	
59-59.3	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE INTER-SATELLITE RADIOLOCATION SPACE RESEARCH (passive)	
59.3-64	FIXED MOBILE INTER-SATELLITE RADIOLOCATION	
64-65	FIXED INTER-SATELLITE MOBILE except aeronautical mobile	
65-66	EARTH EXPLORATION-SATELLITE FIXED INTER-SATELLITE MOBILE except aeronautical mobile SPACE RESEARCH	
66-71	INTER-SATELLITE MOBILE MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE	
71-74	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth)	

Frequency [GHz]	Allocations	Notes
74-76	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth)	
76-77.5	RADIO ASTRONOMY RADIOLOCATION Space research (space-to-Earth)	
77.5-78	AMATEUR AMATEUR-SATELLITE RADIOLOCATION Radio astronomy Space research (space-to-Earth)	
78-79	RADIOLOCATION Amateur Amateur-satellite Radio astronomy Space research (space-to-Earth)	
79-81	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	
81-84	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE MOBILE-SATELLITE (Earth-to-space) RADIO ASTRONOMY Space research (space-to-Earth)	
84-86	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE RADIO ASTRONOMY	
86-92	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)	
92-94	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	
94-94.1	EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION SPACE RESEARCH (active) Radio astronomy	
94.1-95	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	
95-100	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION RADIONAVIGATION RADIONAVIGATION-SATELLITE	
100-102	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)	
102-105	FIXED MOBILE RADIO ASTRONOMY	
105-109.5	FIXED MOBILE RADIO ASTRONOMY SPACE RESEARCH (passive)	

Frequency [GHz]	Allocations	Notes
109.5-111.8	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)	
111.8-114.25	FIXED MOBILE RADIO ASTRONOMY SPACE RESEARCH (passive)	

Table 4.2.4.3-2 shows regulatory requirements for frequency ranges that are designed for mobile use between 52.6GHz and 114.25GHz in South Korea based on [23], [24], [25], [29], [30], and [31].

Table 4.2.4.3-2: South Korea regulatory requirements for frequency between 52.6 GHz and 114.25 GHz

Frequency band [GHz]	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Additional Notes
52.6 – 54.25	All emission is prohibited	No requirement	No requirement	No requirement	All emission is prohibited
57 – 66	Max Tx power 500mW (beamformed antenna) Max Tx power 100mW (omni-direction antenna). Max PSD 13dBm/MHz Max EIRP 43dBm Max antenna gain 16dBi [Note 1]	No requirement. Note 3	Occupied BW shall be within the range of 57-66 GHz	Other than fixed point-to-point	Unlicensed
57 – 66	Max Tx power 500mW (beamformed antenna) Max Tx power 100mW (omni-direction antenna). Max PSD 13dBm/MHz Max EIRP 57dBm [Note 1]	No requirement. Note 3	Occupied BW shall be within the range of 57-66 GHz	Fixed point-to-point	Unlicensed
71 – 76	Max EIRP 85dBm Max Tx power 3W Max PSD 150mW/100MHz Min antenna gain 43dBi, antenna half beamwidth less than 1.2 degrees. [Note 2]	Permits use under condition that do not cause interference to Astronomy stations that are already in use.	Max bandwidth 5GHz. Occupied BW shall be within the range of 71-76 GHz	For licensed fixed point-to-point wireless communications For amateur radio station (see Note 4 for channelization)	Frequency error should be less than $\pm 150 \times 10^{-6}$. Note 4.
76 – 77	Max Tx power 10mW EIRP below 55dBm [Note 5]	Function for interference avoidance shall be required. (No Specific technical requirement is described)	Occupied BW shall be within the range of 76-77 GHz	Automotive crash prevention radar	Unlicensed

Frequency band [GHz]	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Additional Notes
76 – 81	PSD below -3 dBm/MHz EIRP below 34dBm/50MHz Fixed antenna orientation with down tilt angle. The half power beamwidth of the antenna array must be smaller than 8 degrees Unwanted emission outside the 76-81GHz shall be at least attenuated 20dB more than the PSD	No requirement	Occupied BW shall be within the range of 76-81 GHz	For outdoor level detection radars. For amateur radio station (see Note 4 for channelization)	
81 – 86	Max EIRP 55dBW Max Tx power 3W Max PSD 150mW/100MHz Min antenna gain 43dBi, antenna half beamwidth less than 1.2 degrees. [Note 2]	Permits use under condition that do not cause interference to Astronomy stations that are already in use.	Max bandwidth 5GHz. Occupied BW shall be within the range of 81-86 GHz	For licensed fixed point-to-point wireless communications	Frequency error should be less than $\pm 150 \times 10^{-6}$.
86 – 92	No requirement	No requirement	No requirement	No requirement	All emissions are prohibited
100-102	No requirement	No requirement	No requirement	No requirement	All emissions are prohibited
109-5-111.8	No requirement	No requirement	No requirement	No requirement	All emissions are prohibited
<p>NOTE 1: Antenna absolute gain shall be less than 16dBi. If antenna gain greater than 16dBi may be employed than conducted output power shall be reduced as much as the increased antenna gain. A user identification code shall be used in each device to prevent malfunction of other devices and to prevent malfunction caused by signals from other devices. However, it does not apply to fixed point-to-point communication. Unwanted emission shall not exceed emission level given in Table 4.2.4.3-3. Additionally, Tx or Rx spurious emission for Standby state (not operating) shall not exceed emission level given in Table 4.2.4.3-4.</p> <p>NOTE 2: The mean power of emissions must be attenuated below the mean output power of the transmitter in any 1 MHz band by A, where $A = \max\{56, 11 + 0.4 \times (S-50) + 10 \times \log_{10}(B)\}$ dBc and A = attenuation (in decibels) below the mean output power level, S = percent removed from the center frequency of the transmitter bandwidth and between 50 and 250 percent, and B = occupied bandwidth in MHz. Attenuation to an absolute power of less than -13dBm/1MHz is not required. Spurious emission must be below the mean output of the transmission in any 1 MHz band by $A = 43 + 10 \times \log_{10}(P)$, where A = attenuation (in decibels) below the mean output power level, and P = average transmit power.</p> <p>NOTE 3: For equipment with more than 27dBm EIRP operating in 57-58GHz, the following instruction shall be indicated in user the instruction manual. "User who would like to use this equipment within 300 m from Astronomical antenna have to obtain consent from astronomical observatory"</p> <p>NOTE 4: From 75.5 to 81GHz, 75.75, 77.75, 78.5, and 80 GHz are assigned for the carrier frequencies of amateur radio station.</p> <p>NOTE 5: The unwanted emission outside the 76-77GHz shall not exceed emission level given in Table 4.2.4.3-5.</p>					

Table 4.2.4.3-3: Unwanted emission limits in 57 to 66 GHz frequency range in South Korea

Spectrum Range	Unwanted Emission Limit	Measurement Bandwidth
Less than 1GHz	-36dBm	100kHz
1GHz to 40GHz	-30dBm	1MHz
More than 40GHz	-10dBm	1MHz

Table 4.2.4.3-4: Spurious emission limits for non-operating state in South Korea

Spectrum Range	Unwanted Emission Limit	Measurement Bandwidth
Less than 1GHz	-54dBm	100kHz
More than 1GHz	-47dBm	1MHz

Table 4.2.4.3-5: Unwanted emission limits in 76 to 77 GHz frequency range in South Korea

Spectrum Range	Unwanted Emission Limit	Measurement Bandwidth
Less than 1GHz	-26dBm ^[NOTE 1] or 0dBm ^[NOTE 2]	100kHz
More than 1GHz	-26dBm ^[NOTE 1] or 0dBm ^[NOTE 2]	1MHz
NOTE 1: In case that Conducted power level shall be less than 10mW		
NOTE 2: In case that EIRP shall be less than 55dBm		

4.2.4.4 India

The Government of India Ministry of Communications' Telecommunications Department has recently released a national frequency allocation plan [26]. Table 4.2.4.4-1 is populated per this plan. The NFAP is released typically every 3 to 4 years and the next one is not expected until after 2020.

Table 4.2.4.4-1: India spectrum allocation between 52.6 GHz and 114.25 GHz

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
56.9 – 59.3	Not defined	Not defined	Not defined	-ESS (Passive) -Space Research (Passive) - Fixed - Mobile	
59.3 – 71	Not defined	Not defined	Not defined	-Fixed -Inter-satellite -Mobile -Radiolocation -Space Research	
71 – 78	Not defined	Not defined	Not defined	-fixed satellite(space-to-earth) -Fixed -Broadcasting -Space Research -Radio astronomy	
78 – 86	Not defined	Not defined	Not defined	-Radiolocation -Amateur Satellite -Radio astronomy -Space Research (Space-to-Earth) -Fixed -Mobile	
86-95	Not defined	Not defined	Not defined	-Earth Exploration Satellite -Radio astronomy -Space Research	

95-111.8	Not defined	Not defined	Not defined	-Fixed -Mobile -Radio Astronomy -Radiolocation -Radionavigation -Radionavigation-satellite -Space research	
111.8-114.25	Not defined	Not defined	Not defined	-Fixed -Mobile -Radio astronomy -Space Research Inter satellite	

Table 4.2.4.2-2 below summarizes the survey on India regulatory requirements in the frequency band above 52.6GHz in India [36].

Table 4.2.4.4-2: India – Regulatory Requirements for Available and Potential Spectrum between 52.6 GHz and 114.25 GHz

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
61-61.5	100 mW EIRP			Non-Specific Short Range Device [NOTE 1]	EN 305 550
NOTE 1: Non-specific short range device means radio device, regardless of the application or the purpose, which fulfil the technical conditions as specified for a given frequency band and used for telemetry, telecomm, alarms, data transmissions in general and other applications.					

4.2.4.5 Taiwan

Table 4.2.4.5-1 shows the spectrum allocations for Taiwan for frequencies between 52.6GHz and 114.25GHz based on [32]. For the frequencies above 52.6 GHz, the power requirements, spectrum access, modulation and occupied bandwidth remain undefined. The Ministry of Transportation and Communications (MOTC) releases the plan of spectrum supply and allocation every year typically, and the next frequency allocation will be after WRC-19. The Taiwanese Association of Information and Communication Standards (TAICS) has a proposal the paired band 71-76 GHz and 81-86 GHz, which is currently allocated to High Speed Wireless Transmission (Fixed) on licensed basis, would also be used by IMT services on light licensing scheme basis.

Table 4.2.4.5-1: Taiwan spectrum allocation between 52.6 GHz and 114.25 GHz

Frequency [GHz]	Allocations	Notes
52.6-54.25	EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive)	
54.25-55.78	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)	
55.78-58.2	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	55.78 – 59 GHz available for High Density Fixed Service (HDFS) use according to WRC-2000 resolution
58.2-59	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive)	57 – 66 GHz assigned for unlicensed use
59-59.3	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE INTER-SATELLITE RADIOLOCATION	61.25 GHz ± 250 MHz plan for Work, department, medical equipment use 64 – 66 GHz for High Density Fixed Service (HDFS) use according to WRC-2000 resolution

Frequency [GHz]	Allocations	Notes
	SPACE RESEARCH (passive)	
59.3-64	FIXED MOBILE INTER-SATELLITE RADIOLOCATION	
64-65	FIXED INTER-SATELLITE MOBILE except aeronautical mobile	
65-66	EARTH EXPLORATION-SATELLITE FIXED INTER-SATELLITE MOBILE except aeronautical mobile SPACE RESEARCH	
66-71	INTER-SATELLITE MOBILE MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE	
71-74	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth)	71 – 76 GHz for High Speed Wireless Transmission. Paired with 81-86 GHz.
74-76	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth)	WARC-92 resolution for space research business use
76-77.5	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	77-81 GHz for short-range radar for low-power vehicles Equipment (SRR) and Tank Level Probing Radar (TLPR) use
77.5-78	AMATEUR AMATEUR-SATELLITE RADIOLOCATION Radio astronomy Space research (space-to-Earth)	
78-79	RADIOLOCATION Amateur Amateur-satellite Radio astronomy Space research (space-to-Earth)	
79-81	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	
81-84	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE MOBILE-SATELLITE (Earth-to-space) RADIO ASTRONOMY Space research (space-to-Earth)	81 – 86 GHz for High Speed Wireless Transmission. Paired with 71-76 GHz.
84-86	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE RADIO ASTRONOMY	
86-92	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)	
92-94	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	
94-94.1	EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION	

Frequency [GHz]	Allocations	Notes
	SPACE RESEARCH (active) Radio astronomy	
94.1-95	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	
95-100	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION RADIONAVIGATION RADIONAVIGATION-SATELLITE	
100-102	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)	
102-105	FIXED MOBILE RADIO ASTRONOMY	
105-109.5	FIXED MOBILE RADIO ASTRONOMY SPACE RESEARCH (passive)	
109.5-111.8	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)	
111.8-114.25	FIXED MOBILE RADIO ASTRONOMY SPACE RESEARCH (passive)	

4.2.4.6 Singapore

Figure 4.2.4.6-1 shows the spectrum allocations for Singapore for frequency between 52.6GHz and 114.25GHz based on [34]. More specifically, ISM means industrial, scientific and medical applications.

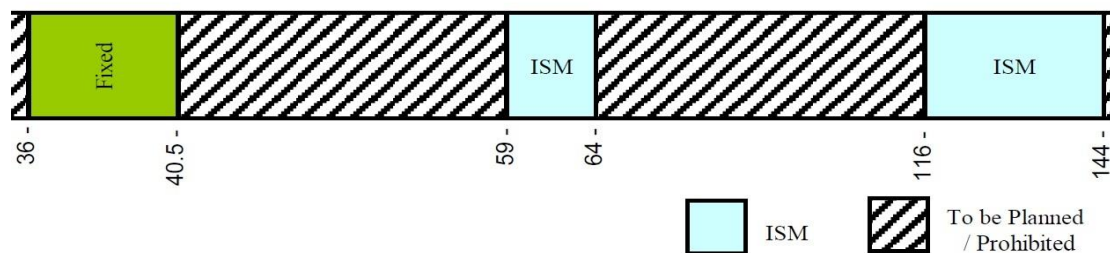


Figure 4.2.4.6-1: Singapore spectrum allocation between 52.6GHz and 114.25GHz (from [34])

In Singapore, IMDA (Info-communications Media Development Authority) shows that 57-66 GHz is considered for Wireless LAN and broadband access application [27]. On the other hand, short range radar systems, such as automatic cruise control and collision warning systems for vehicle, are applied from 76 to 77 GHz. Moreover, details of their regulatory requirements can be found in Annex. Furthermore, it is notable that both spectrum band, 71 – 76 GHz paired with 81 – 86 GHz, will be available for short-term commercial use in fixed-wireless backhaul and inter-building fixed-wireless network.

Table 4.2.4.6-1: Regulatory requirements for available spectrum between 52.6 GHz and 114.25 GHz in Singapore

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
76 – 77 [Note1]	Maximum EIRP: 23.5 dBm when stationary Maximum EIRP: 37 dBm when vehicle is in motion Transmitter Spurious Emissions limit: -30dBm for $f \geq 1$ GHz, refer to ITU-R Rec. SM.329-12 §4.3, Table 3 Category B limits	No requirement	Not specified	Short range radar systems such as automatic cruise control and collision warning systems for vehicle	A short range radar system is a movement and position detection device which is used to give a warning of collision by identifying the delay between a transmitted pulse and a return pulse. Standards for Measurement Methods FCC Part 95 Subpart M; or EN 301 091-1
57 – 66 [Note1]	Maximum EIRP: 10 W Indoor use is restricted to maximum mean EIRP density of 13 dBm/MHz Outdoor use is restricted to max EIRP of 25 dBm and max EIRP power spectral density of -2 dBm/MHz Transmitter Spurious Emissions limit: -30dBm for $f \geq 1$ GHz, refer to ITU-R Rec. SM.329-12 §4.3, Table 3 Category B limits	No requirement	Not specified	Wireless LAN and broadband access	Standards for Measurement Methods EN 302 567 EN 305 550
71-76, 81-86				fixed wireless system	See Note 2 for specific information
NOTE 1: The development of spectrum allocations for short range devices is an ongoing policy review process. IMDA will revise and update its frequency allocations for short range devices as new technologies emerge.					
NOTE 2: IMDA will make available 71 – 76 GHz paired with 81 – 86 GHz of the E-band for commercial wireless applications such as fixed-wireless backhaul and inter-building fixed-wireless network. The spectrum will be available for short-term commercial use of up to 12 months until 31 December 2019. IMDA will monitor market and technology developments of the E-band, and take into consideration the World Radiocommunication Conference 2019 recommendations before allocating the spectrum in this band beyond 2020.					

4.2.4.7 Australia

Table 4.2.4.7-1 shows the spectrum allocations for Australia for frequency between 52.6GHz and 114.25GHz based on [35]. Primary services are listed in upper case, e.g., MOBILE, and secondary services are listed with Capitalization, e.g. Amateur.

Table 4.2.4.7-1: Australia spectrum allocation between 52.6GHz and 114.25GHz

Frequency [GHz]	Allocations	Notes and ITU Radio Regulations Footnotes
52.6-54.25	EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive) RADIO ASTRONOMY	5.340
54.25-55.78	EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE SPACE RESEARCH (passive)	5.556A for INTER-SATELLITE
55.78-56.9	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	5.557A for Fixed, 5.556A for INTER-SATELLITE, 5.558 for Mobile
56.9-57	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	5.558A for INTER-SATELLITE, 5.558 for Mobile, 5.547
57-58.2	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE SPACE RESEARCH (passive)	5.556A for INTER-SATELLITE, 5.558 for Mobile, 5.547
58.2-59	EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive) RADIO ASTRONOMY	5.547
59-59.3	EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE MOBILE RADIOLOCATION SPACE RESEARCH (passive)	5.556A for INTER-SATELLITE, 5.558 for Mobile, 5.559 for RADIOLOCATION
59.3-64	FIXED MOBILE INTER-SATELLITE RADIOLOCATION	5.558 for MOBILE, 5.559 for INTER-SATELLITE,
64-65	FIXED MOBILE except aeronautical mobile INTER-SATELLITE RADIO ASTRONOMY	5.547, 5.556
65-66	EARTH EXPLORATION-SATELLITE FIXED INTER-SATELLITE MOBILE except aeronautical mobile SPACE RESEARCH	5.547
66-71	INTER-SATELLITE MOBILE MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE	5.553 for MOBILE, 5.558 for MOBILE

Frequency [GHz]	Allocations	Notes and ITU Radio Regulations Footnotes
71-74	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth)	
74-76	FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth)	
76-77.5	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	5.149
77.5-78	AMATEUR AMEUR-SATELLITE RADIOLOCATION Radio astronomy Space research (space-to-Earth)	5.559B for RADIOLOCATION
78-79	RADIOLOCATION Amateur Amateur-satellite Radio astronomy Space research (space-to-Earth)	
79-81	RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth)	
81-84	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE MOBILE-SATELLITE (Earth-to-space) RADIO ASTRONOMY Space research (space-to-Earth)	5.338A for FIXED
84-86	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE RADIO ASTRONOMY	5.338A for FIXED, 5.561B for FIXED-SATELLITE (Earth-to-space)
86-92	EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive)	
92-94	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	5.338A for FIXED
94-94.1	EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION SPACE RESEARCH (active) Radio astronomy	
94.1-95	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION	
95-100	FIXED MOBILE RADIO ASTRONOMY RADIOLOCATION RADIONAVIGATION RADIONAVIGATION-SATELLITE	
100-102	SPACE RESEARCH (passive) EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY	

Frequency [GHz]	Allocations	Notes and ITU Radio Regulations Footnotes
102-105	FIXED MOBILE RADIO ASTRONOMY	
105-109.5	FIXED MOBILE RADIO ASTRONOMY SPACE RESEARCH (passive)	5.562B for SPACE RESEARCH (passive)
109.5-111.8	RADIO ASTRONOMY SPACE RESEARCH (passive) EARTH EXPLORATION-SATELLITE (passive)	
111.8-114.25	FIXED MOBILE RADIO ASTRONOMY SPACE RESEARCH (passive)	5.562B for SPACE RESEARCH (passive)

ACMA (Australian Communications and Media Authority) publishes sensors using radar which can be applied in some different bands from 52.6GHz to 85GHz in Australia [28]. Moreover, details of their regulatory requirements can be found in Table 4.2.4.7-2.

Table 4.2.4.7-2: Regulatory requirements for available spectrum between 52.6 GHz and 100 GHz in Australia

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
61-61.5	Maximum EIRP: 100 mW	No requirement	Not specified	Transmitters for non-specific applications	
59–63	Maximum EIRP: 50 W The maximum transmitter power must not exceed 20 mW.	No requirement	Not specified	WiFi and RLAN transmitters	The transmitter must not be operated on board an aircraft. The transmitter must only be used outdoors. The transmitter must not cause spurious emissions outside the band at or greater than –30 dBm/MHz.
57–66	Maximum EIRP: 20 W	No requirement	Not specified	WiFi and RLAN transmitters	The transmitter must comply with FCC Rules Title 47 Part 15 Section 255.
60-61	Maximum EIRP: 20 mW	No requirement	Not specified	Radio determination: sensors using radar for measurement	
75-85	Maximum EIRP: 75 nW	No requirement	Not specified	Same as 60-61GHz	The maximum EIRP applies outside the shielded room enclosure. The transmitter must meet the requirements of ETSI Standard EN 302 372.
76-77	Maximum EIRP: 25 W	No requirement	Not specified	Same as 60-61GHz	

Frequency band (GHz)	Power/Magnetic Field Requirements	Spectrum access and mitigation requirements	Modulation / maximum occupied bandwidth	Purpose/Node Placement requirements	Notes
77-81	See Note1 below	No requirement	Not specified	Same as 60-61GHz	The transmitter must meet the requirements of ETSI Standard EN 302 264. The transmitter must not be operated within a nominated distance of a specified Australian radio-astronomy site.
57-64, 75-85	See Note2 below	See Note3 below	Not specified	Same as 60-61GHz	The transmitter must be operated in a position such that emissions are directed towards: (i) the ground; or (ii) the floor or a wall of a building or similar structure. The transmitter must comply with ETSI Standard EN 302 729. The transmitter must not be operated within a nominated distance of a specified Australian radio-astronomy site.
<p>NOTE 1: Section 4.3.3.3 in ETSI EN 302 264 V2.1.1. The peak power for EUT with fixed beam or scanning antenna shall not be greater than 55 dBm.</p> <p>NOTE 2: Section 4.3.4.3 in ETSI EN 302 729 V2.1.1. 57-64 GHz: Maximum peak power limit EIRP is 35dBm, measured in 50MHz within main beam. 75-85 GHz Maximum peak power limit EIRP is 34dBm, measured in 50MHz within main beam.</p> <p>NOTE 3: Section 4.7 in ETSI EN 302 729 V2.1.1</p>					

5 Use Cases and Deployment Scenarios

5.1 Use Cases

The relatively underutilized millimeter-wave (mmWave) spectrum offers excellent opportunities to provide high speed data rate, low latency, and high capacity due to the enormous amount of available contiguous bandwidth. However, operation on bands in frequencies above 52.6GHz will be limited by the performance of devices, for example, poor power amplifier (PA) efficiency and larger phase noise impairment, the increased front-end insertion loss together with the low noise amplifier (LNA) and analog-to-digital converter (ADC) noise. In addition, bands in frequencies above 52.6GHz have high propagation and penetration losses challenge. Even so, various use cases are envisioned for NR operating in frequencies between 52.6GHz and 114.25GHz. Some of the use cases are illustrated in Figure 5.1-1 and following section provide detailed description of the uses cases. It should be noted that there is not a 1-to-1 mapping of use cases and wireless interfaces, e.g. Uu, sidelink, etc. Various wireless interfaces could be applicable to various uses cases described.

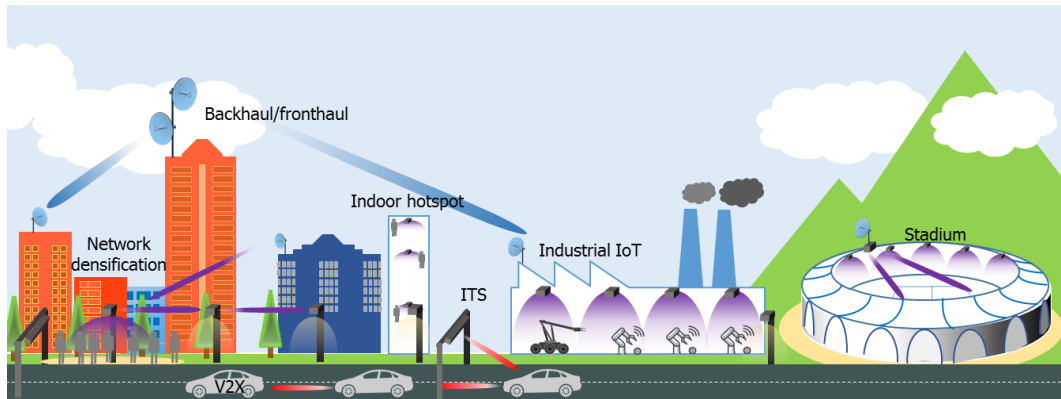


Figure 5.1-1: Use Cases for NR above 52.6GHz

5.1.1 High data rate eMBB

The use case serves high-definition multimedia and high user density by cellular network, which will increase in many indoor and outdoor open areas, such as stadium, main event for entertainment, sport and so on; and media delivery will be both to individuals and to groups of users. Moreover, user devices will get enhanced media consumption capabilities, such as Ultra-High Definition display, multi-view High Definition display, mobile 3D projections, immersive video conferencing, and augmented reality and mixed reality display and interface. This will all lead to a demand for significantly higher data rates and wide bandwidth from 52.6GHz to 114.25 GHz.

The increased demand for high data rates from MBB application in dense urban and indoor hotspots deployments is one of the main drivers for using the higher frequency spectrum. Frequencies above 52.6GHz are interesting for these use case classes due to vast availability of spectrum. The large availability of spectrum permits system bandwidth of the order of *GHz* and high spatial reuse. An overview of use cases with high data rate requirements is illustrated in Figure 5.1.1-1.

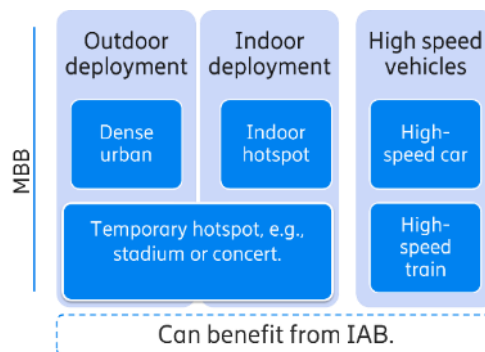


Figure 5.1.1-1: High data rate use cases

The requirements for MBB services are provided in Table 5.1.1-1. These services are:

- Indoor hotspot: this scenario covers users/devices in residential/commercial complexes, e.g., offices and homes. The wireless connection of surveillance cameras is an example of an indoor commercial use cases.
- Dense urban: this scenario includes outdoor to outdoor as well as outdoor to indoor coverage. For example, outdoor users in shopping strips and city centers, indoor user in residential/commercial complex, or even users in low speed urban vehicles can be served by gNB.
- Provisional hotspots: this scenario covers broadband access in a crowd, e.g., in stadiums or at concerts. In this case, in addition to high density of users, the data rate requirements in the uplink connections are more demanding than the corresponding requirements in the downlink connections as the users are interested in sharing what they see/hear.

Table 5.1.1-1: Requirements for use cases with high data rate

Scenario	Experienced Data Rate (DL \ UL)	Area Traffic Capacity (DL \ UL)	Overall User Density	Activity Factor	UE Speed	Coverage
Indoor hotspot	1 Gbps \ 500 Mbps	15 Tbps/km ² \ 2 Tbps/km ²	250 000/km ²		Pedestrians	Office and residential (NOTE 1)
Dense urban	300 Mbps \ 50 Mbps	750 Gbps/km ² \ 125 Gbps/km ²	25 000/km ²	10%	Pedestrians and users in vehicles (up to 60 km/h)	Downtown
Provisional hotspots	25 Mbps \ 50 Mbps	[3,75] Tbps/km ² \ [7,5] Tbps/km ²	[500 000]/km ²	30%	Pedestrians	Confined area
NOTE 1: All the values in this table are targeted values and not strict requirements.						

5.1.2 Mobile data offloading

The use of complementary network technologies, such as NR-U, with much wider spectrum for delivering data originally targeted for cellular networks, which has met heavily traffic load, in both indoor and outdoor open area eMBB usage scenario. Operators may leverage bands to offload data from macro cell at hot spots. In such scenarios, high band may be dual connectivity (DC) or carrier aggregation (CA) with low band for mobility purposes. Coverage for this scenario may not be chosen as optimization target.

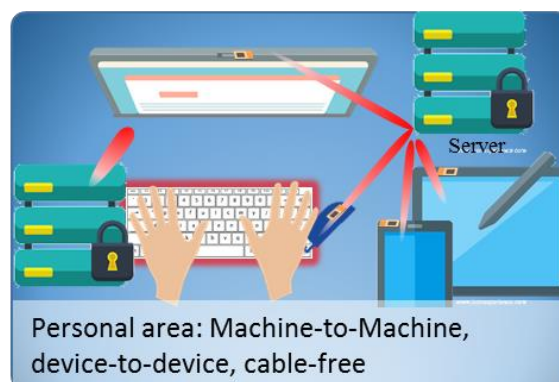
Given that more than 10GHz of bandwidth is available for short range communications in unlicensed spectrum above 52.6GHz, UEs could significantly mitigate eMBB data congestion with use of these spectrum. Users requiring enhanced media reception in hotspot areas or utilizing other high bandwidth applications in hotspot areas could be serviced with available licensed or unlicensed spectrum without impacting network load in lower frequencies.

5.1.3 Short-range high-data rate D2D communications

Wireless docking at office has attracted much interest for future wireless office environment. For wireless application at smart home and office meeting, data transmission from UE to large screen or projector also needs energy efficient transmission mechanisms. Bands above 52.6GHz provide great potential for such low latency and high data rate transmission.

Productivity docking, such as Monitor 8K UHD docking, is one of the typical short-range high-data rate D2D use case. The directional transmission, which results in highly local beam characteristics, and high capacity from wide bandwidths can satisfy the requirement of this use case. Additionally, due to high pathloss, NFC-like use cases including personal identification, digital key, wireless USB, and cable-free are suitable. This service requires high capacity and low latency to exchange security data or encrypted data between devices.

Wireless display transfer to smart TVs, augmented reality (AR), virtual reality (VR) headsets, monitors, and video distribution screens (e.g. screens/monitors at in-flight entertainment, classrooms, high-speed rail, exhibitions, etc) can be performed using licensed/unlicensed spectrum.

**Figure 5.1.3-1: Short range high data rate person area communications**

In today's home, office and factory, there are lots of cables between devices (e.g., the HDMI cables between the monitors and set-top boxes, cables to connect racks and cabinets in data centers) to provide very high data rate connection. Due to the capability of providing high speed data transmission, frequency band above 52.6GHz can also be used for this kind of high speed D2D connection, and this cable-less high speed connection is promising to enable new smart home/office/factory applications.

5.1.4 Vertical industry factory application

There is not only a single class of services, but there are various services of different requirement need to support in this use case: such as motor control, mobile control, motor robot, Augmented Reality (AR), and etc, thus resulting in the need for a high adaptability and scalability of the system. Some services of industrial-grade quality have stringent requirements in terms of end-to-end latency, communication service availability and jitter, and some services, such as AR, requires high data rate transmission, high reliability, and low latency, and some applications have stringent requirements on safety, security, and privacy. The millimeter wave technique is quite suited for vertical industry application networks or other private/security networks due to its highly local characteristic and wide bandwidth.

5.1.5 Broadband distribution network

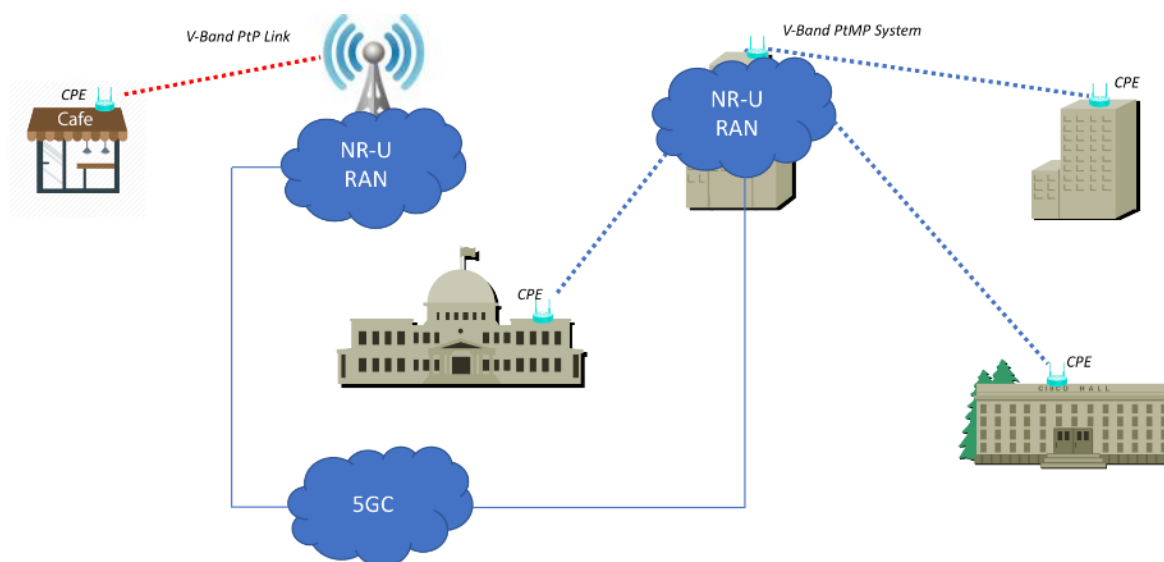


Figure 5.1.5-1: PtP and PtMP outdoor fixed broadband transmissions

Today, wireless Ethernet networks (a.k.a. 802.11 based) offer broadband connectivity to confined outdoor venues such as university campuses, stadiums, malls etc. When operating in carrier frequency above 52.6GHz NR should offer feature parity (if not exceed) to such wireless Ethernet based networks to serve either as replacement or complimentary network. Here, the expectation is for a single node (e.g. gNB) to offer broadband service (in order of roughly above 20Gbps) to a few fixed (non-mobile) devices (e.g. UE) over a distance of approximately 300m to 500m. The resulting network could either be public or non-public. Both point to point, and point-to-multipoint transmissions should be supported.

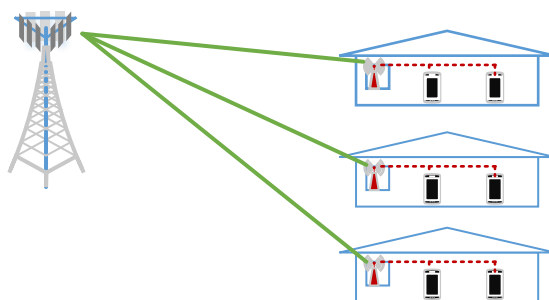


Figure 5.1.5-2: Wireless to the home (WTTH) distribution network

The last mile distribution of wideband internet access (e.g. fiber) using fixed wireless licensed/unlicensed spectrum available for above 52.6 GHz could be useful. Backhauling of wireless to the home/building/curb/neighborhood (WTTx) distribution networks would require high data rates to be supported in both downlink and uplink. The access nodes could be specialized UE that enables home/building networking via Wi-Fi or Ethernet networks, or could be an Integrated Access Backhaul (IAB) that enables NR using either licensed or unlicensed spectrum within the home/building area.

5.1.6 Integrated access backhaul (IAB)

The use case mainly is applied for backhauling deployment when optical or dedicated wireless backhaul is unavailable or inconvenient. Such backhauling can take advantage from the currently developed NR Integrated Access Backhaul (IAB), where some nodes serve both backhaul and access. In this use case, devices operate with LOS under most conditions, though obstruction of the LOS may occur occasionally, so directional transmission can extend the distance between the gNBs.

There are already lots of commercial deployments of backhaul applications using the bands above 52.6GHz. Compared with the lower frequency bands, the abundance of available spectrum can support higher capacity for both wireless access link and backhaul link. Low latency requirement can also be satisfied by NR flexible frame structure.

Where a wired connection is not a feasible option, various wireless technologies e.g. point to point (PTP) microwave links are used to offer backhaul / relay service. 3GPP Rel-16 offers backhaul / relay service under the IAB umbrella. However, this service is presently limited to carrier frequency below 52.6GHz. NR operating in carrier frequency above 52.6GHz NR should extend such capabilities to this higher frequency range. Here, the expectation is for a single node (e.g. gNB) to offer broadband services to a few devices (e.g. UE) or to offer relay services (up to certain hops) to a few devices (e.g. other nodes) or a combination thereof. The expected coverage range is approximately 300m to 500m.

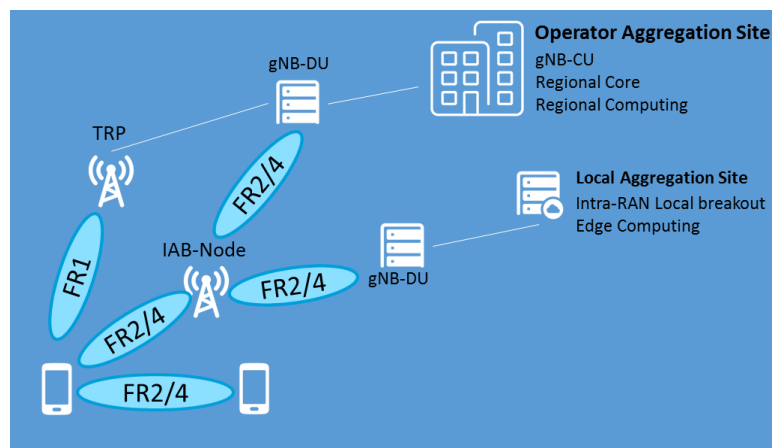


Figure 5.1.6-1: Integrated access backhaul

A distributed architecture including the flexible deployment of access points using IAB can be used to support both intra-RAN local breakout/edge computing services on a private network and MBB/voice services on a public network with a common control plane/management framework. This architecture can apply to multiple use cases, especially for the ease of deploying cost-effective enterprise and industrial Private Networks. An illustration is shown in Figure 5.1.6-1, where FR1 refers to wireless link using carrier frequencies below 7 GHz and "FR2/4" terminology in the figure refers to wireless link using carrier frequency above 7 GHz.

Abundance of millimeter wave spectrum along with the native deployment of massive MIMO or multi-narrow-beam systems in NR creates an opportunity to develop and deploy IAB links. The benefits of IAB are crucial during network rollout and MBB network growth. SA1 has already established service requirements for wireless self-backhauling (TS 22.261, Service requirement for the 5G System, Section 6.12.2). These requirements are:

- The 5G network shall enable operators to support wireless self-backhaul using NR and E-UTRA.
- The 5G network shall support flexible and efficient wireless self-backhaul both for indoor and outdoor scenarios.
- The 5G network shall support flexible partitioning of radio resources between access and backhaul functions.
- The 5G network shall support the autonomous configuration of access and wireless self-backhaul functions.

- The 5G network shall support multi-hop wireless self-backhauling to enable a flexible extension of range and coverage area.
- The 5G network shall support autonomous adaptation on wireless self-backhaul network topologies to minimize service disruptions.
- The 5G network shall support topologically redundant connectivity on the wireless self-backhaul to enhance reliability and capacity, and reduce latency.

5.1.7 Factory automation/Industrial IoT (IIoT)

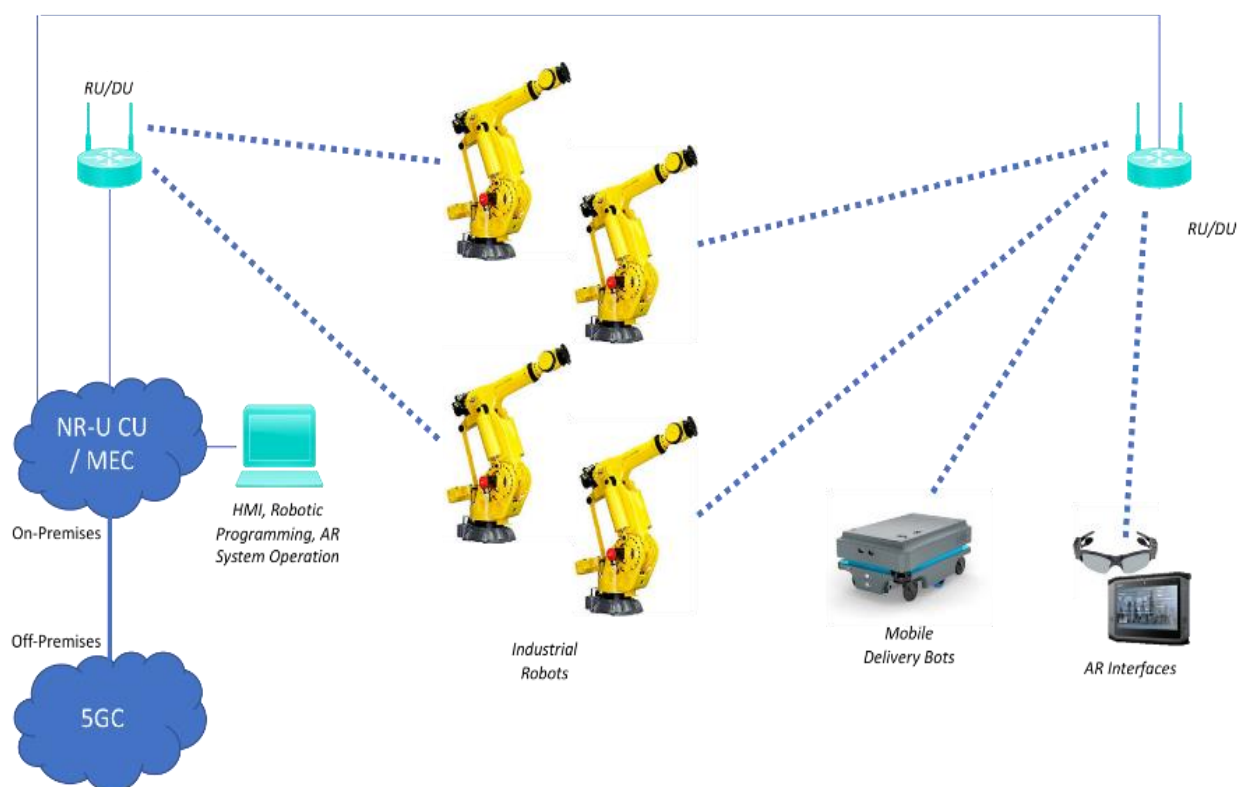


Figure 5.1.7-1: IIoT factory robots

This set of use-cases is expected to target indoor industrial automation applications over a distance of approximately 50 to 100m, with speed below 5km/hr, and other characteristics such as latency, and packet error rate in accordance with performance requirements mentioned in Annex E of TS 22.261, “Service requirements for next generation new services and markets”.

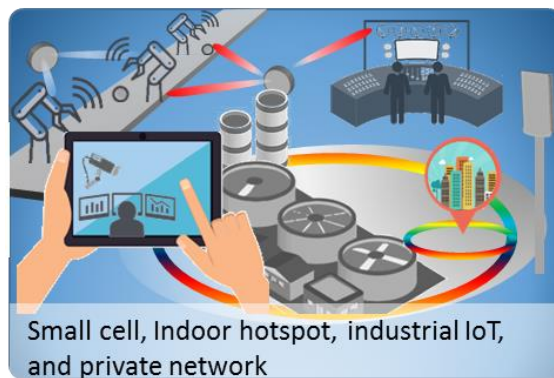


Figure 5.1.7-2: Indoor industrial IoT and private network use cases

Industrial IoT is one of the key enablers of cost-efficient industrial mass production with high quality in factory automation. In the factories of the future, static sequential production systems will be more and more replaced by novel modular production systems offering a high flexibility and versatility. This involves a large number of increasingly mobile production assets, for which powerful wireless communication and localization services are required. The corresponding applications are often characterized by very high requirements on the underlying connectivity of the infrastructure, especially in terms of latency and reliability. High resolution time synchronization, low delay jitter, guaranteed delay constraints are important characteristics of industrial IoT operations.

The challenge with indoor-to-outdoor dampening in millimeter wave bands will, in these scenarios, become a benefit as the band offers good isolation from/to outside world. In such scenarios, controlled interference and the wide spectrum can be utilized to meet high reliability and low latency in a factory.

5.1.8 Augmented reality/virtual reality headsets and other high-end wearables

For high-end augmented reality or virtual reality wearables like glasses, they typically demand large data rate and low transmission power. For AR/VR application, due to small latency requirement, those video may not be compressed and thus require larger than 10Gbps data rate. They may also have low transmission power since high transmission power would require large battery and increase weight of the wearable. Additionally, augmented reality relies on substantial sensor information to process and resolve the environment. The higher bandwidths may improve both sensor resolution and reduce latency.

5.1.9 Intelligent Transport Systems (ITS) and V2X

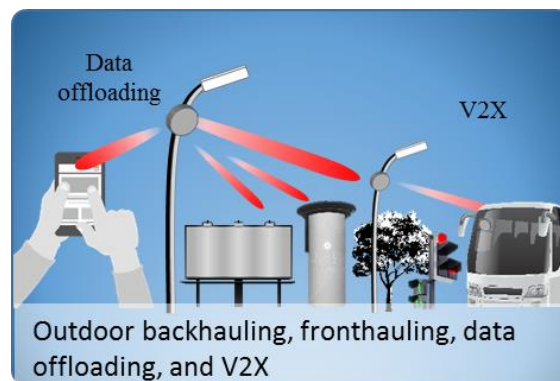


Figure 5.1.9-1: Outdoor V2X, backhauling, and fronthauling use cases

ITS supports transportation of good and humans in order to efficiently and safely use transport infrastructure and transport means. Wireless connectivity for inter-vehicle and vehicle to roadside communication applications was deemed suitable to be operated in frequencies above 52.6GHz. These networks operate over a short range with very wideband communications using a variety of directional medium and high gain antennas to enable a high degree of spectrum reuse, and may use a flexible bandwidth scheme under which they normally operate in a wideband mode, and periodically reduce their bandwidth (e.g. for antenna training and other activities). The wide millimeter wave spectrum can be exploited for providing low latency, high reliability, and often high data requirements in various short range ITS and V2X scenarios.

Extended sensors: this service enables the exchange of raw/processed data gathered through local sensors or live video data among vehicles, pedestrians, and V2X application servers. This service helps vehicles to enhance the perception of their environment beyond what their own sensors can detect. This leads to a more holistic view of their local situation.

Precise positioning for automated driving: automated driving systems require highly resolved and dynamic maps to maneuver the vehicles safely, in particular as a means of providing decimeter localization which is not achieved by typical consumer-grade satellite navigation equipment. Exchanging high definition (HD) dynamic map information between vehicles is required to widen the visibility area of HD maps to enhance positioning accuracy. The V2V/V2X communication targeting automated driving requires high data rate, low latency, and high reliability within a communication range of 150m to 300m, which can be done in millimeter wave.

5.1.10 Data Center Inter-rack Connectivity

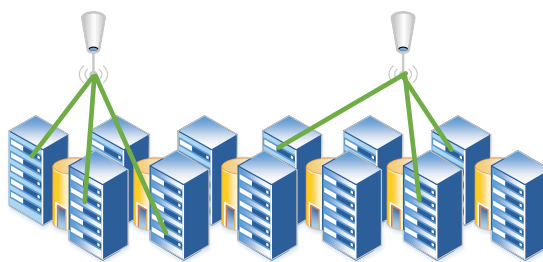


Figure 5.1.10-1: Inter-rack wireless connectivity within Data Centers

Wireless connectivity may be used as a secondary interface in lieu of fiber optic failure for links between racks within a data center. A backup network relying on wireless technology can be used to increase maximum communication service availability. Some inter-rack links could be replaced with high bandwidth and high reliable NR communications. Although use of unlicensed spectrum could be possible, due to high bandwidth and reliability required for inter-rack communications use of licensed spectrum, which typically has higher EIRP allowance, could be useful. The use of wireless communications for some links within the data center, could potentially reduce cabling complexity and allow flexible on-demand re-organization of equipment within the facility.

5.1.11 Smart grid automation

Electricity distribution possesses high requirements on service availability. In power distribution system, while lower frequencies are more suitable for long distance wireless inter-substation communication, short range intra-substation wireless communication can be performed in millimeter wave. The communication requirements for factory automation and medium and high voltage electricity distribution are summarized in Table 5.1.11-1.

Table 5.1.11-1: Performance requirements for smart grid automation.

Scenario	End-to-End Latency	Jitter	Survival Time	Communication Service Availability	Reliability	User Experienced Data Rate
Factory automation	10 ms	100 μ s	~0 ms	99,99%	99,99%	10 Mbps
Electricity distribution – medium voltage	25 ms	25 ms	25 ms	99,9%	99,9%	10 Mbps
Electricity distribution – high voltage	5 ms	1 ms	10 ms	99,9999%	99,9999%	10 Mbps

5.1.12 Radar/Positioning

High positioning accuracy (e.g., error standard deviations of 0.5m or lower) in both outdoor and indoor deployments services are critical. Unlike lower carrier frequencies, where transmission is position agnostic, in millimeter wave carrier frequencies, positioning information is required to avoid blocking. In addition, positioning information can also enhance the process of beam alignment. Beam-related information can be used to localize a user within a beam or within the intersection of multiple beams, or to enhance positioning accuracy of existing position systems. In addition, applications that require high positioning accuracy can benefit from a wide bandwidth, which facilitates accurate estimation of the time of arrival (ToA) of signals. Also, the multipath sparsity characteristic of millimeter wave channels, together with narrow beam antenna systems, contribute to improve angle of arrival (AoA) estimation, which can in turn be used to enhance the positioning accuracy.

Radar-like operations (motion detection, positioning, and tracking) integrated together with access point can provide wide range of services including security, medical care, and automation.

In automated factories, powerful wireless localization services are often required for low speed moving objects (including indoor and outdoor), which can be performed in millimeter wave systems. For example, on the factory floor, it is desirable to be able to locate moving objects such as forklifts, or parts to be assembled. This could be achieved with positioning and/or environmental sensing. Environmental sensing is support for radar applications identifying

objects in the environment and their respective motion. Use of millimeter wave carrier frequency may allow radar operations that may be useful for various network operations.

Indoor spaces and dense deployments will benefit from greater spatial resolution allowing operators and private networks to offer new targeted services and solutions.

5.1.13 Private Networks

Enable easy and cost-effective deployment of industrial private networks including non-public and closed group access, allowing regional deployment of closed or semi-closed access such as industrial IoT, in-building network, and factory areas.

5.1.14 Critical medical communication

As described in TR 22.826 [38], various critical medical use cases require very high data rates and very low latencies. The huge bandwidths offered by 5G NR above 52.6 GHz could prove to be essential in order to meet the required KPIs. One of the primary examples includes a wirelessly connected operating room that enables real-time streaming of lossless compressed Ultra High Definition video (from devices, such as an endoscope), and real-time streaming of uncompressed medical imaging data (from devices, such as 3D UltraSound). These streams need to be displayed on 4K/8K displays, and possibly be combined into augmented reality video streams to help a surgeon perform precise procedures. This typically requires data rates ranging from 4 Gbit/s up to 48 Gbit/s and very low latencies of preferably less than 1ms. Compression is often not allowed by medical regulations, in order to not generate any artifacts and enable the most accurate representation to be available to a surgeon.

Despite the low latency and high data rates required, medical data in general needs to be transported in a highly secure manner, including being fully integrity protected as required by medical data protection and privacy regulations. And of course, the connection has to be highly reliable and very robust.

5.2 Deployment Scenarios

This section describes deployment scenarios applicable for NR operating in between 52.6GHz and 114.25GHz. The listed deployment scenarios are indoor hotspot, dense urban, urban micro, urban macro, rural, factory hall, and indoor D2D scenario. Table 5.2-1 describes potential relationship between described use cases in Section 5.1 and listed deployment scenarios.

Table 5.2-1: Potential relationship between use cases and deployment scenarios

Deployment scenarios	Use cases
Indoor hotspot	High data rate eMBB, Mobile data offloading, Vertical industry factory application, Critical medical applications, Augmented reality/virtual reality headsets and other high-end wearables, Wireless Display Transfer, Radar/Positioning, Private Networks, Integrated access backhaul (IAB)
Dense Urban	High data rate eMBB, Mobile data offloading, Integrated access backhaul (IAB), Augmented reality/virtual reality headsets and other high-end wearables, Radar/Positioning, Private Networks
Urban Micro	High data rate eMBB, Mobile data offloading, Broadband distribution network, Integrated access backhaul (IAB)
Urban Macro	Broadband distribution network, Integrated access backhaul (IAB)
Rural	Broadband distribution network, Integrated access backhaul (IAB)
Factory Hall	Vertical industry factory application, Data center inter-rack connectivity, Factory automation/Industrial IoT (IIoT), Private Networks, Radar/Positioning, smart grid automation (note: smart grid automation use case is not limited to indoors only)
Indoor D2D	Short-range high-data rate D2D communications, Critical medical applications, Augmented reality/virtual reality headsets and other high-end wearables

5.2.1 Indoor hotspot

The indoor hotspot deployment scenario focuses on small coverage per site/TRxP (transmission and reception point) and high user throughput or user density in buildings. The key characteristics of this deployment scenario are high capacity, high user density and consistent user experience indoor. Some attributes that could be used for evaluation purposes are listed in Table 5.2.1-1.

Table 5.2.1-1: Attributes for indoor hotspot

Attributes	Values or assumptions
Aggregated system bandwidth	Up to 12 GHz
Layout	Single layer: Indoor floor (Open office) Single standalone cell operation (Smart home)
ISD	20m (Equivalent to 12TRxPs per 120m x 50m) for open office scenario
User distribution and UE speed	100% Indoor, 3km/h, 10 users per TRxP

5.2.2 Dense urban

The dense urban microcellular deployment scenario focuses on macro TRxPs with or without micro TRxPs and high user densities and traffic loads in city centres and dense urban areas. The key characteristics of this deployment scenario are high traffic loads, high user density, small coverage, and outdoor and outdoor-to-indoor coverage for mobile UEs, where UE is provided with continuous cellular connectivity using a lower frequency while being served with high traffic loads using frequencies above 52.6 GHz. Additionally, this deployment scenario can serve outdoor fixed wireless UEs or IABs with high traffic loads to mimic the last mile distribution networks. This scenario will be interference-limited, using macro TRxPs with or without micro TRxPs. A continuous cellular layout and the associated interference shall be assumed. Some attributes that could be used for evaluation purposes are listed in Table 5.2.2-1.

Table 5.2.2-1: Attributes for dense urban

Attributes	Values or assumptions
Aggregated system bandwidth	Up to 12GHz
Layout	Two layers: - Macro layer: Hex. Grid - Micro layer: Random drop
ISD	Macro layer: 200m All micro TRxPs are all outdoor
User distribution and UE speed	Uniform/macro TRxP, 10 users per TRxP Uniform/macro TRxP + Clustered/micro TRxP, 10 users per TRxP, For mobile UEs, 100% outdoor (3km/h) For fixed UE/IABs, 100% outdoor (>3km/h)

5.2.3 Urban micro

In the Urban micro deployment scenario, the sparse environment with no closely spaced high buildings are described, such as park areas, university campuses, stadiums, outdoor festivals, city squares or even rural areas, as transmitted with mostly LOS is mainly typical in the deployment scenario. Some attributes that could be used for evaluation purposes are listed in Table 5.2.3-1.

Table 5.2.3-1: Attributes for urban micro

Attributes	Values or assumptions
Aggregated system bandwidth	Up to 12GHz
Layout	Single layer: - Hex. Grid
ISD	100m
User distribution and UE speed	100% Outdoor (>3km/h), 10 users per TRxP

5.2.4 Urban macro

The urban macro deployment scenario focuses on large cells for fixed wireless UE/IABs. The key characteristics of this scenario are supporting fixed nodes in urban areas. This scenario will be interference-limited, using macro TRxPs (i.e. radio access points above rooftop level). Some attributes that could be used for evaluation purposes are listed in Table 5.2.4-1.

Table 5.2.4-1: Attributes for urban macro

Attributes	Values or assumptions
Aggregated system bandwidth	Up to 12GHz
Layout	Single layer: - Hex. Grid
ISD	500m
User distribution and UE speed	100% Outdoor (>3km/h), 10 users per TRxP

5.2.5 Rural

The rural deployment scenario focuses on larger coverage for fixed wireless UE/IABs. Although the bands above 52.6GHz have higher propagation loss, relatively long coverage can still be achieved with line-of-sight transmission condition and high gain antenna. Therefore, Rural could also be a deployment scenario for the fixed wireless access and backhaul applications, which have LOS transmission conditions. The key characteristics of this scenario are wide area coverage supporting fixed nodes. This scenario will be noise-limited and/or interference-limited, using macro TRxPs. Some attributes that could be used for evaluation purposes are listed in Table 5.2.5-1.

Table 5.2.5-1: Attributes for rural scenario

Attributes	Values or assumptions
Aggregated system bandwidth	Up to 12GHz
Layout	Single layer: - Hex. Grid
ISD	ISD 1: 1732m ISD 2: 5000m
User distribution and UE speed	100% outdoor (>3km/h), 10 users per TRxP

5.2.6 Factory Hall

Similar to the indoor hotspot deployment scenario, factory hall deployment scenario focuses on medium coverage per site/TRxP and high user throughput and high user density inside the buildings. The key characteristics of this deployment scenario are high capacity, high user density and reliable communications. Some attributes that could be used for evaluation purposes are listed in Table 5.2.6-1.

Table 5.2.6-1: Attributes for factory hall

Attributes	Values or assumptions
Aggregated system bandwidth	Up to 12GHz
Layout	Rectangular room layout with dimensions from 20m ² to 160000m ² (e.g. 100m × 100m = 10000m ²) and ceiling height from 3m to 25m.
ISD	20m
User distribution and UE speed	100% indoor (< 3 km/h), 5 ~ 40 user per TRxP.

5.2.7 Indoor D2D

In this deployment scenario, usually the low cost device is involved, so the transmit power is lower and the antenna elements is much smaller compared with regular UE. The distance between the communicating devices is likely less than 5m and the typical device is pedestrian in this deployment. The system bandwidth varies depending on the particular services/application. Some attributes that could be used for evaluation purposes are listed in Table 5.2.7-1.

Table 5.2.7-1: Attributes for Indoor D2D

Attributes	Values or assumptions
Aggregated system bandwidth	Up to 12GHz
ISD	<20m
User distribution and UE speed	100% indoor (< 3 km/h)
Operation mode	Peer to peer or point to multi-point operation modes

6 System Design Requirements

This section describe some of the system design considerations and requirements that are important for NR system operating in frequencies between 52.6 GHz and 114.25 GHz.

a) Waveform

- Power efficiency of power amplifier (PA): PA efficiency at higher frequency is expected to degrade and low PAPR waveforms designed to minimize PA backoff and maximize efficiency should be considered. At higher frequencies and especially in millimetre wave frequencies, output power per transistor as well as power added efficiency decrease. Waveform with high power back-off to support EVM and out-of-band emission requirements could dramatically reduce PA efficiency even further.
- Dynamic range of ADC and DAC: The increase in PA back-off also affects the other device requirements, for example, the dynamic range of the ADC and DAC. A higher Tx DAC effective number of bits (ENOB) is required to accommodate higher PAPR, and extra oversampling in the baseband DSP, and Tx DAC may be needed to accommodate wider channel bandwidth. All of these are impacted by waveform, and therefore should be carefully evaluated.
- Modulated signal accuracy and out-of-band emission: Power amplifier is designed and adjusted to meet RF requirements, such as spectral mask emission (SEM), adjacent channel leakage ratio (ACLR), in-band emission (IBE) and out-of-band emission (OBE) requirements, and error vector magnitude (EVM) requirements. Proper RF requirements are needed to determine appropriate in-band signal quality characteristics, minimize adjacent channel interference and impact to signals in adjacent channels. Occupied signal bandwidth and guardband for a given channel bandwidth in high carrier frequencies above 52.6 GHz require further investigation.
- Complexity and performance of waveform: Given the high data rate and high sampling rates the system is expected to operate, the complexity and performance tradeoff for waveform generation/modulation and reception/demodulation should be considered.
- Spectrum flexibility of waveform: Use cases and frequency allocations by various government bodies may require various bandwidth to be supported. Therefore, flexibility to support different system bandwidth should be considered in the design.
- Robustness to frequency offset and phase noise: Carrier frequency offset and phase noise is much higher in spectrum beyond 52.6GHz because of imperfection of PA and crystal oscillator is more severe than that of lower bands. In addition, Doppler shift/spread is also larger with the carrier frequency increasing. As a result, robustness on frequency offset and phase noise is one of the key requirements for systems operating on bands above 52.6GHz. Increasing the subcarrier spacing for CP-OFDM waveform to better cope with increased phase noise could be investigated. For other potential waveforms impact from phase noise and ability to robustly handle phase noise should be investigated.
- Feature re-usability and design commonality with existing NR specification: It would be good to be able to support features for FR1 and FR2 as defined in NR with minimal change (if possible) and support a common design structure that could support various use cases. To that extent further considerations of using an integer ratio between clock rates of NR below and NR above 52.6 GHz should be investigated. One possibility to achieve this would be to maintain the NR numerology scaling principle but extend to higher numerologies, i.e. $\Delta f = 2^\mu \times 15 \text{ kHz}$ with an appropriate range of possible integer values for μ .

b) MIMO

- Multi-antenna technology with beamforming: Depending on deploying site and also applications, various antennas can be used in millimetre communication. Concerning implementation (e.g., cost, form factor), various type of antennas can be considered for developing NR above 52.6 GHz. There are four types of antennas can be considered in this frequency range: Parabolic, lens, waveguide array, and patch array. Some examples of types of antennas are shown in Figure 6-1 and brief comparison notes are provided in Table 6-1. The design of NR above 52.6 GHz should not limit the type of antennas and corresponding beamformed channel should be considered to design physical-layers.

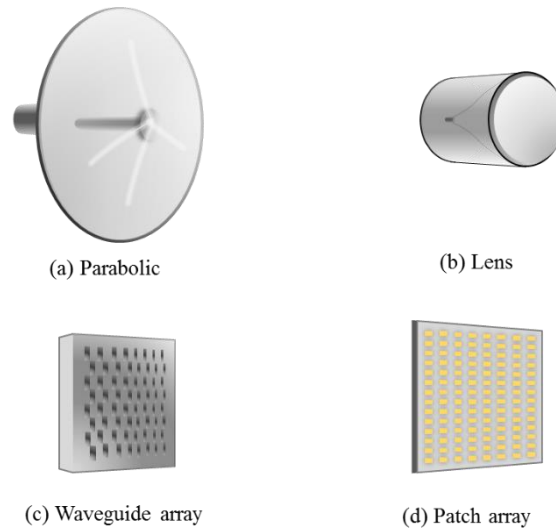


Figure 6-1: millimeter wave antennas

Table 6-1: Comparison of millimetre wave antennas

Antenna types	Applicable form factors
Parabolic	Outdoor macro for mid/long-distance PTP
Lens	Outdoor small cell AP for short/mid-distance PTP
Waveguide array	Small cell AP, indoor AP for short/mid-distance PTP
Patch array	Mobile device, small cell, indoor cell for mid-distance PTP

- Maximum supported layers: Up to two spatial layer could be supported using polarization diversity. Further study on maximum supported spatial layers taking into account support for even larger bandwidths and RF design challenges is needed.
- Enhanced beam management: Larger antenna arrays is expected to support certain link budgets in high frequencies due to poorer free space pass loss, oxygen absorption, and the obstruction loss, even from people or foliage. This results in pencil-thin beams that require improvements in beam management robustness and overhead. Methods for managing narrower beams and greater number of beams should be studied. It should be noted depending on form factor and device, number of beams supported and beam codebook space could vary. Therefore, enhancement on discovery and tracking to support various beam assumptions should be investigated.
- Enhanced path diversity: The narrow beams achieved with the larger arrays may result in a higher reliance on LOS paths. To improve coverage at these frequencies, methods for improving path diversity—increasing the probability of LOS paths—should be studied. Some examples may include collaborate MIMO techniques or same frequency multi-connectivity techniques.
- Multi-cell/panel operation for high reliability and mobility: Considering propagation characteristics, it may be beneficial to support the near-LOS condition to UEs by position and angle tracking, and point-beamforming using massive antenna arrays.

c) Power consumption

- Compared to NR FR2, operation in the bands beyond 52.6 GHz may pose even more burden on UE power consumption due to potential large number of beams, low latency and high data rate transmission/reception (i.e., continuous processing of large code block, high order modulation, and security related processing [39]), and PA efficiency losses caused by RF components.
- Power efficiency in baseband: Power consumption is one of the biggest problems in millimetre band communication. In addition to the process losses to the RF devices, the power dissipation in the ADCs is also very large. Widening the dynamic range required by the ADC when receiving high order modulation can consume high power. Therefore, power efficiency in both transmitter and receiver baseband should be considered for NR design above 52.6GHz. Improvement in uplink can be considered to reduce additional

power consumption. For example, a low-power transmit scheme, advanced DTX, and a low-power beamforming scheme can be considered.

d) Channelization and Bandwidth

- Bandwidths for the system: Different regulatory bodies already provide licensed band allocation with certain bandwidth. For example, 250MHz blocks that can be aggregated to up to 5 GHz in Europe, South Africa, and Canada, 4.75 GHz blocks in UK, up to 5 GHz and 0.9 GHz blocks in US. Additionally, 802.11ad/ay systems currently support multiple of 2.16 GHz block in unlicensed spectrum. NR system operating in above 52.6 GHz should consider the above bandwidths in the system design. Supported bandwidth should weigh in various considerations, including channelization, and hardware complexity. Wideband implementation has various implementation challenges, such as IF conversion, I/Q mismatch, increase of noise power, flatness of filter, and ADC, DAC performance.
- Support of configurable bandwidth: NR beyond 52.6 GHz is anticipated to operate in different bands with different maximum possible bandwidths. NR beyond 52.6 GHz should therefore – as NR does – support configurable transmission bandwidths. NR should also support relatively narrow bandwidth smaller than the configured transmission bandwidth to improve RF and baseband power consumption and potentially to improve coverage with peak power efficiency. Additionally, support of narrow bandwidth that is smaller than the configured transmission bandwidth in the UL would help benefit transmission of HARQ feedback and small payload sizes.
- Channelization: Supported bandwidths for the system should be considered during the channelization of NR above 52.6 GHz. The channel definitions may need to factor into account co-existence with other RAT, such as IEEE 802.11ad/ay systems, and various uses cases, such as ITS, IAB, and V2X.

e) Range, availability, and connectivity

- Use cases for NR above 52.6 GHz can be divided into three classes, a class for outdoor mid / long-distance such as backhaul or relay, a class for short / mid-distance such as indoor or outdoor small cell, and a class for adjacent, near-field device or isolated area. Long distance classes, which include backhaul, can support up to 1 to 3 km range under LOS conditions and weather conditions. The inter-cell distance for outdoor small cells is assumed to be within a few hundred meters and the size of a floor or a room is assumed to be within tens of meters. Between devices or servers, less than 5 m range would be sufficient to minimize link interference.
- Services provided by backhaul, the reliability of the wired network should be guaranteed. For indoor scenario, can guarantee higher availability as it is not effected by weather condition but it should consider the availability depending on the application services. For example, IIoT services may require URLLC-like (e.g. low BLER of 10^{-5}) availability.
- Table 6-2 show a summary of range, availability, and connectivity for NR above 52.6GHz. P-to-P in the connectivity column refers to point to point connection, and P-to-MP in the connectivity column refers to point to multi-point connection.

Table 6-2: Range, availability, and connectivity

	Target range (m)	Availability (%)	Connectivity
Backhaul/fronthaul	< 500-3000 m	99.99 – 99.999 %	P-to-P
Outdoor small cell	< 100 m	99.9 – 99.99 %	P-to-MP
Indoor hotspot/IoT	<20 m	99.9 – 99.9999 %	P-to-MP
Personal area network	< 5 m	99.9 – 99.99 %	P-to-P

f) Spectrum regime considerations

- Frequency range above 52.6 GHz covers not only unlicensed spectrum but also licensed spectrum. Additionally, ECC/CEPT has set 63- 64 GHz as harmonized implementation of ITS. The licensed spectrum in the range is often dedicated to fixed links and could be used by IAB. So spectrum for 52.6 GHz would need to support systems that enable various target use cases spanning from unlicensed operation to V2X, IAB, and eMBB. Additionally, coexistence with 802.11ad and 802.11ay on the 60GHz unlicensed spectrum may need to be considered.

- It would be preferred if similar system framework supports wide range of uses cases without significant specification effort or at the least the initial system framework support forward compatibility that allows extension to address various and different use cases.

g) Other design considerations

- Latency: For some uses cases and application services, the overall latency should be small enough to facilitate nominal operation of the application services. NR above 52.6GHz should support low latency operations.
- Mobility support: For many use cases and deployment scenarios, low mobility is common assumption. Even for ITS/V2X use cases, low relative speed between the Tx and the Rx can be expected. Support for high mobility may not need to be prioritized as high layer mobility procedures could rely on low frequency bands with CA/DC operations.
- Standalone and Non-standalone operations: Some use cases may not require standalone operation at bands beyond 52.6 GHz. For example, high data rate eMBB and mobile data offloading scenarios where wide area coverage is provided via another frequency band (e.g. lower band in FR1/FR2). Also some uses cases are suitable for standalone operations. For example, short-range high-data rate D2D communications and/or Industrial IoT. In scenarios that require standalone operations, initial access and related procedure should be studied including study on whether existing NR features and functionality are sufficient.

7 Conclusion

This study focused on three aspects, (i) survey of regulatory requirements for spectrum between 52.6 GHz and 114.25GHz, (ii) identification of deployment scenarios and uses cases for the same frequency, and (iii) identification of system requirements for the same frequency.

According to survey so far, there are minimum 5 GHz of spectrum available globally, between 57 to 64 GHz, for unlicensed operation and in some countries up to 14 GHz of spectrum, between 57 and 71 GHz, for unlicensed operation. Additionally, the survey has identified minimum of 10 GHz of spectrum available globally, between 71 to 76 GHz and 81 to 86 GHz, for licensed operation and in some countries up to 18 GHz of spectrum available, between 71 and 114.25 GHz, for licensed operation

Numerous use cases that benefit from system operating in beyond 52.6 GHz have been identified in the study. These use cases include, but not limited to, high data rate eMBB, mobile data offloading, short-range high-data rate D2D communication, vertical industry factory automation, broadband distribution network, integrated access backhauls, factory automation and industry IoT, augmented/virtual reality headsets and other high-end wearables, intelligent transport systems, V2X, data center inter-rack connectivity, smart grid automation, radar and positioning, and private networks.

The use cases span over several deployment scenarios identified in the study. The deployment scenarios include, but not limited to, indoor hotspot, dense urban, urban micro, urban macro, rural, factor hall, and indoor D2D scenarios.

Finally, the study also identified several system design requirements around waveform, MIMO operation, device power consumption, channelization, bandwidth, range, availability, connectivity, spectrum regime considerations, and others.

Annex A:

Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2018-09	RAN#81	RP-181759				Draft Skeleton TR	0.0.1
2018-09	RAN#81	RP-182065				Updated Skeleton TR	0.0.2
2018-09	RAN#81	RP-182108				Updated Skeleton TR	0.0.3
2018-09	RAN#81	RP-182147				Updated Skeleton TR	0.0.4
2019-03	RAN#83	RP-190330				Version with wrong contents	0.0.5
2019-03	RAN#83	RP-190697				Updated TR (status after RAN#83). Section 4 updated.	0.1.0
2019-06	RAN#84	RP-190330				Updated TR (status after RAN#84). Section 4, 5, and 6 updated.	0.2.0
2019-09	RAN#85	RP-192263				Updated TR (status after RAN#85). Section 4, 5, and 6 updated.	1.0.0
2019-12	RAN#86	RP-193166				Updated TR (status after RAN#86). Added new use case, critical medical communication, corrected Japanese regulatory requirement errors, added conclusion, and corrected misc. formatting errors.	2.0.0
2019-12	RP-86	-				TR 38.807 as approved by RAN #86	16.0.0