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भारतीय दूरसंचार विनियामक प्राधिकरण

Telecom Regulatory Authority of India

Consultation Paper

on

Auction of Spectrum in frequency bands identified for IMT/5G

30th November 2021

Mahanagar Doorsanchar Bhawan
Jawahar Lal Nehru Marg
New Delhi- 110002

Written Comments on the Consultation Paper are invited from the stakeholders by 28th December 2021 and counter-comments by 11th January 2022. Comments and counter-comments will be posted on TRAI's website www.trai.gov.in. The comments and counter-comments may be sent, preferably in electronic form, to Shri Syed Tausif Abbas, Advisor (Networks, Spectrum and Licensing), TRAI on the email ID advmn@trai.gov.in.

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CHAPTER–I: INTRODUCTION

1.1 The Department of Telecommunications (DoT), through its letter dated 13th September 2021 **(Annexure-1.1)**, has informed the following to the Telecom Regulatory Authority of India (TRAI):

a) Based on the TRAI recommendations dated 1st August 2018 and response dated 8th July 2019 on DoT's back-reference, Government conducted auction of spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz bands in March 2021. A total of 2,308.80 MHz spectrum worth Rs. 4,00,396.20 Crore at Reserve Price in different band-LSA[1] combinations was put to auction, out of which 855.60 MHz quantum was sold in the auction resulting in total winning bids worth Rs. 77,820.81 Crore. No bids were received in 700 MHz and 2500 MHz bands. Spectrum unsold in the auction held in March 2021 may be put to auction in the forthcoming auction.

b) In the TRAI recommendations dated 1st August 2018, spectrum in 3300-3600 MHz band was also included. However, due to certain issues, the Government decided to initiate action to auction spectrum in this band separately after resolution of these issues and, therefore, it was not a part of the auction held in March 2021. Now, as the issues have been resolved as well as the range of available frequencies in this range has slightly gone up, it has been decided by the Government that spectrum in the frequency range 3300-3670 MHz should be made available to the Telecom Service Providers for International Mobile Telecommunications (IMT)/5G through auction.

c) In addition to the above, new frequency bands (mentioned below) have also been decided to be used for IMT/5G:

[1] Licensed Service Area

- 526-582 MHz in all the LSAs in coordination with Ministry of information & Broadcasting (MIB). The use will be coordinated with minimum keep out distance from MIB transmitters.
- 582-617 MHz in all the LSAs. This band will be available for IMT/5G and rural point to point links.
- 617-698 MHz in all the LSAs except a few areas/locations.
- 24.25 to 28.5 GHz in all the LSAs except certain portion of this frequency range at 5 locations with protection distance of 2.7 km.

d) DoT has also received few requests regarding spectrum requirements for captive usage of 5G applications by some industries e.g. Industry 4.0. The Cellular Operators Association of India (COAI) has also submitted a letter regarding Private Captive Network, wherein they have inter-alia requested not to reserve any spectrum which has been identified for IMT, for Private Captive Networks.

e) Parliamentary Standing Committee on Information Technology in its report on "India's preparedness for 5G" has made certain observations on pricing of spectrum. Also, DoT has received request from COAI regarding effective spectrum pricing.

f) Department of Space (DoS) had invited comments on Draft Spacecom Policy liberalizing space segment for private sector participation to provide commercial communication services in India. This includes the Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellite constellations operational over India. In case of satellite communication, the subscriber is accessed from the satellite through "Access spectrum" similar to "Access spectrum" in terrestrial network and the demand for such spectrum will potentially increase in the future.

1.2 In view of the above, DoT through its afore-mentioned letter dated 13th September 2021, under the terms of clause 11 (1)(a) of TRAI Act, 1997 as amended by TRAI Amendment Act 2000, has requested TRAI to:

a) Provide recommendations on applicable reserve price, band plan, block size, quantum of spectrum to be auctioned and associated conditions for auction of spectrum in 526-698 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3670 MHz and 24.25-28.5 GHz bands for IMT/5G.

b) Provide recommendations on quantum of spectrum/band, if any, to be earmarked for private captive/isolated 5G networks, competitive/transparent method of allocation, and pricing, for meeting the spectrum requirements if captive 5G applications of industries for machine/plant automation purposes/Machine-to-Machine (M2M) in premises.

c) Provide recommendations on appropriate frequency band, band plan, block size, applicable reserve price, quantum of spectrum to be auctioned and associated conditions for auction of spectrum for space-based communication services.

d) Provide any other recommendations deemed fit for the purpose of spectrum auction in these frequency bands, including the regulatory/technical requirements as enunciated in the relevant provisions of the latest International Telecommunication Union (ITU)-R Radio Regulations.

1.3 Subsequently, vide its letter dated 23rd September 2021 **(Annexure-1.2)**, DoT has informed that the Government has taken the following decisions with regard to future spectrum auctions and requested TRAI to consider/factor in the same while providing recommendations in response to DoT's earlier letter dated 13th September 2021:

a) Rationalizing Bank Guarantees to securitize Deferred Annual Spectrum payment instalments in future spectrum auctions: For spectrum auctions held in the future, the requirement for the successful bidder to submit a Financial Bank Guarantee (FBG) of an amount equal to one annual instalment to securitize the instalment, and to submit Performance Bank Guarantee (PBG) for roll out obligations etc., will be dispensed with. DoT will also appropriately

address the eligibility conditions for participation in the auction, so that the participants have sufficient financial capacity.

b) Increase in duration of Spectrum Allocation: In future auctions, access spectrum will be assigned for a period of 30 years. However, since in past auctions the reserve prices and bids were corresponding to validity of 20 years, there will be no change in the tenure for spectrum acquired in past auctions.

c) Regular conduct of Spectrum Auction on annual basis: Spectrum auctions will be held normally in the last quarter of every financial year. Whenever necessary, auctions can be held at shorter intervals also.

d) Provisions for Surrender of Spectrum: In order to encourage better utilization of spectrum and to encourage business, for the auctions conducted henceforth, Telecom Service Providers (TSPs) may be permitted to surrender spectrum after a minimum period of 10 (ten) years. TSPs will have to inform one year prior to surrendering their spectrum. An appropriate surrender fee will be charged. However, the spectrum purchase dues for the remaining (post surrender) period will not be levied.

e) No Spectrum Usage Charges (SUC) for Spectrum acquired in future auctions: For spectrum acquired in future auctions no SUC will be charged. The condition of minimum 3% weighted average SUC rate and SUC floor amount will also be removed. Guidelines will be issued by DoT to operationalize this decision.

f) Sharing of Spectrum: In order to encourage spectrum sharing for better utilization and efficiency, henceforth spectrum sharing will not attract an increase in the SUC rate by 0.5%. Guidelines have already been amended by DoT to operationalize this decision.

1.4 Accordingly, DoT vide its said letter dated 23rd September 2021 has requested TRAI to provide its recommendations on the following also:

a) While undertaking auction for spectrum with validity for 30 years, recommendations on associated conditions like upfront payments,

applicable moratorium period after upfront payments, number of deferred payment instalments and other related modalities.

b) For creating provisions for surrender of spectrum, conditions and fee for such surrender of spectrum.

1.5 TRAI through its letters dated 27th September 2021 and 8th October 2021, sought certain additional information/clarifications from DoT. Response to TRAI letter dated 8th October 2021 was submitted by DoT vide its letter dated 21st October 2021. Most of the information/clarification sought vide TRAI letter dated 27th September 2021 have been provided by DoT vide its letters dated 2nd November 2021 and 27th November 2021.

1.6 Earlier, on a reference from DoT, the Authority (TRAI) had sent its recommendations on Auction of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands on 1st August 2018 and, subsequently, in response to the back reference received from DoT, the Authority sent its recommendations on 8th July 2019. Spectrum auction was held in March 2021, wherein spectrum in all the bands mentioned above except 3300-3600 MHz were put to auction. In total 2308.80 MHz spectrum was put to auction in March 2021 out of which 855.60 MHz was sold i.e., about 63% of total spectrum remained unsold. In the present reference received from DoT through its letters dated 13th September 2021 and 23rd September 2021, DoT has stated that spectrum unsold in the auction held in March 2021 along with the additional spectrum may be put to auction in the forthcoming auction. In addition, DoT has included spectrum frequencies in 526-698 MHz, 3300-3670 MHz and 24.25-28.5 GHz bands. Through its letter dated 27th November 2021, DoT has included additional spectrum in 5 LSAs in 1800 MHz band.

1.7 In this Consultation Paper, background information about spectrum frequencies 526-698 MHz, 3300-3670 MHz and 24.25-28.5 GHz (mmWave), which are proposed to be auctioned for the first time, is

given in detail. Spectrum auctions in other bands have been held earlier, detailed background information was given in earlier consultation papers issued at the relevant times. However, information mainly about present availability of spectrum in these bands is given in this paper.

BACKGROUND

Frequency ranging from 526 MHz to 698 MHz

1.8 DoT has intimated that following new frequency bands have been decided to be used for IMT/5G:

a) 526-582 MHz in all the LSAs in coordination with Ministry of information & Broadcasting. The use will be coordinated with minimum keep out distance from MIB transmitters.
b) 582-617 MHz in all the LSAs. This band will be available for IMT/5G and rural point to point links.
c) 617-698 MHz in all the LSAs except a few areas/locations

1.9 DoT has requested TRAI to provide recommendations on applicable reserve price, band plan, block size, quantum of spectrum to be auctioned and associated conditions for auction of spectrum in 526-698 MHz.

1.10 While ITU has identified spectrum in 450-698 MHz for IMT, frequency arrangement for 526-582 MHz and 582-617 MHz bands have not been defined by ITU. On examination of the band plans defined by 3GPP[2], it appears that no band plans have been defined so far for 526-582 MHz and 582-617 MHz bands. As regards 617-698 MHz band, ITU/3GPP have defined frequency arrangement in this band with Frequency Division Duplexing configuration viz. band 71/n71 also known as US 600.

[2] 3GPP: 3rd Generation Partnership Project

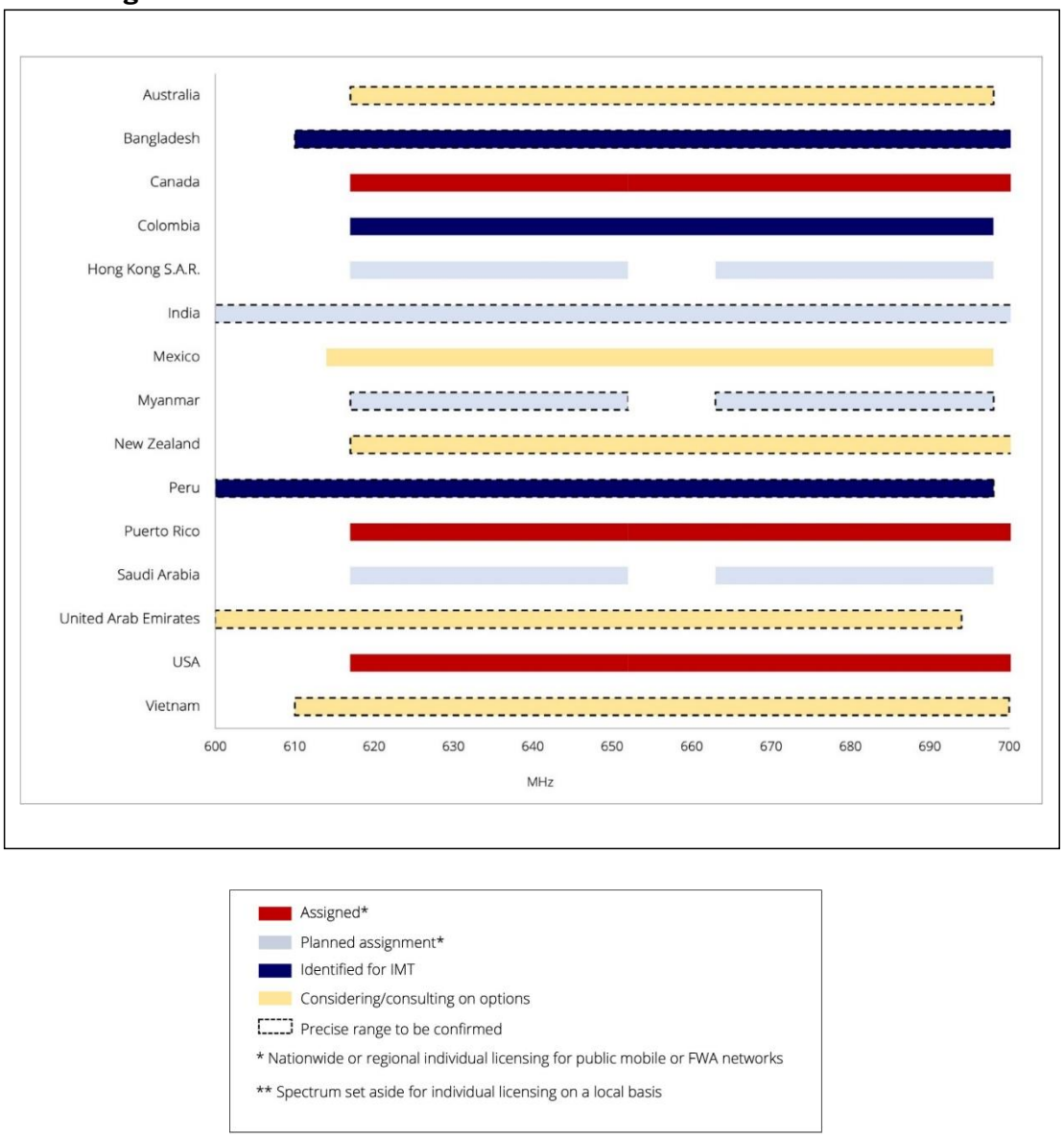
1.11 Band plan 71/n71 (US 600) is based on reverse Frequency Division Duplexing (FDD) configuration i.e. Mobile station transmitter (uplink) frequencies from 663-698 MHz and Base station transmitter (Downlink) frequencies from 617-652 MHz. In band 71/n71, reverse FDD configuration has been adopted to guarantee compatibility with adjacent spectrum band, viz. Band 28 (APT[3] 700 band) i.e. upper n71 block and lower band 28 block, both will be transmitting in uplink direction. This band plan has been adopted by some countries such as USA, Mexico, Canada[4], Hong Kong.

1.12 As per the World Radiocommunication Conference 2019 Final Acts[5] in the Bahamas, Barbados, Canada, the United States and Mexico, the frequency band 470-608 MHz, or portions thereof, is identified for IMT. In Micronesia, the Solomon Islands, Tuvalu and Vanuatu, the frequency band 470-698 MHz, or portions thereof, and in Bangladesh, Maldives and New Zealand, the frequency band 610-698 MHz, or portions thereof, are identified for implement IMT. In the Bahamas, Barbados, Belize, Canada, Colombia, the United States, Guatemala and Mexico, the frequency band 614-698 MHz, or portions thereof, is identified for IMT.

1.13 As per Global mobile Suppliers Association (GSA) report[6] on "Snapshot of National Spectrum Positions: Spectrum from 600 MHz" released in September 2021, spectrum in the 600 MHz range (617-652/663-698 MHz, including bands 71 and n71) is of interest for mobile services, and although the market is at an early stage, an increasing number of countries are considering this spectrum for IMT. According to this report, global status of spectrum licensing for mobile services in the 600 MHz range is depicted below:

[3] APT: Asia-Pacific Telecommunity
[4] https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11374.html#s3
[5] https://www.itu.int/dms_pub/itu-r/opb/act/R-ACT-WRC.14-2019-PDF-E.pdf
[6] https://gsacom.com/paper/spectrum-positions-from-600-mhz-september-2021/

Chart 1.1: Global status of spectrum licensing for mobile services in the 600 MHz range



1.14 600 MHz band (3GPP band plan 71/n71) is being adopted for Long Term Evolution (LTE)/5G deployment. As per GSA report[7] on 'Low-Band Spectrum for LTE and 5G - May 2021', in 600 MHz (Band 71), 37 operators are identified to be investing in spectrum at 600 MHz, at least three of which have launched both LTE and 5G services in the range and another two have launched 5G.

[7] https://gsacom.com/paper/low-band-spectrum-for-lte-and-5g-may-2021/

1.15 As per information published by Global System of Mobile Communiations Association (GSMA)[8], up to Q1 2021, three 4G networks and eight 5G networks were launched in 600 MHz band.

1.16 As per GSA[9], for LTE, as in May 2020, there were 141 LTE devices to support band 71 out of which 40.6% accounted for phones and in May 2021 this has increased to 375 LTE devices out of which 36.53% accounts for phones in 600 MHz band. In case of 5G, as per May 2021 report, there were 118 announced devices to support band n71 and out of which 36.40% accounts for phones.

700 MHz band (698-806 MHz)

1.17 The 700 MHz (3GPP band plan B28) band is being adopted as a prime coverage band for deployment of LTE/5G technology.

1.18 As per GSA report[10] on "Low Band Spectrum for LTE and 5G: May 2021", 205 operators were investing in LTE across the key 700 MHz bands. Among these, 145 operators have been identified as investing in APT 700 MHz spectrum (Band 28 and Band n28: 703–748 MHz/758–803 FDD), including 139 with licences, of which 66 have launched commercial LTE or 5G services in the band. Three operators have launched both, 55 have launched LTE and eight have launched 5G.

1.19 As regards device ecosystem for APT 700 (Band n28) band, as per the report published by GSA[11], as of May 2020, there were 2,531 LTE devices out of which 57.5% accounted for phones and in May 2021 this has increased to 3,463 LTE devices out of which 51.03% accounts for phones. In case of 5G, as per May 2021 report, there were 270 announced devices and out of which 58.10% accounts for phones.

[8] https://www.gsma.com/spectrum/wp-content/uploads/2021/03/Spectrum-Navigator-Q1-2021.pdf
[9] Low-Band Spectrum for LTE and 5G May 2021 (GSA)
[10] GSA - Low Band Spectrum for LTE and 5G (May 2021)
[11] GSA - Low Band Spectrum for LTE and 5G (May 2021)

Thus, it can be inferred that LTE/5G ecosystem is developing fast in this band.

1.20 As per the information published by GSMA[12], up to Q1 2021, 17 5G Networks had been launched.

1.21 In India, 700 MHz band (3GPP band B28) was opened up with FDD configuration in 2016. Since then, spectrum in 700 MHz band has been put to auction twice in October 2016 and March 2021. In October 2016, 2 x 35 MHz in each LSA was put to auction. However, the entire spectrum remained unsold. Thereafter, in October 2019, considering importance for Indian Railways to have the latest standards of Train signalling system in order to improve the passenger safety as well as to improve the operational efficiency, TRAI recommended that out of the 35 MHz (paired) spectrum available in 700 MHz band, 5 MHz (paired) spectrum may be allocated to Indian Railways for implementing European Train Control System (ETCS) Level-2, Mission-Critical Push-To-Talk (MCPTT) + Voice, Internet of Things (IoT) based asset monitoring services, passenger information display system and live feed of Video Surveillance of few coaches at a time. Accordingly, in the subsequent spectrum auction conducted in March 2021, 2 x 30 MHz spectrum in 700 MHz band was put to auction in each LSA. However, entire spectrum remained unsold. Thus, 2 x 30 MHz of spectrum in each LSA is available to be put to auction in the forthcoming auction.

800/900/1800 MHz Bands

1.22 Earlier, spectrum in 800 MHz band (band plan B5), 900 MHz band (band plan B8) and 1800 MHz band (band plan B3), was primarily being used for providing voice service (2G service) in India. Now these bands are predominantly being used to deliver high speed data services using LTE. LTE dominates global mobile telecoms. There are 807 operators

[12] GSMA - Spectrum Navigator, Q1 2021 (May 2021)

with commercially launched LTE based public mobile or broadband fixed-wireless access networks[13].

1.23 As per GSA Report[14], 67 operators have been identified that have invested in LTE Band 5 (824–849 MHz/869–894 MHz). Of these, at least 33 have launched networks, 29 others have licences to operate their networks at 850 MHz and five more have been identified as running tests/trials or planning deployment. As per GSA, two operators have launched 5G using spectrum in Band n5 (in Puerto Rico and the USA), one deploying the frequency range (in Australia) and another one testing with Band n5 (in Japan). As of May 2021, 8104 LTE devices supported Band 5, out of which, 58.29% accounts for phones and there were 201 announced 5G devices supporting this band and out of which 49.30% accounts for phones.

1.24 In 900 MHz band, GSA[15] has identified 113 operators investing in LTE in Band 8 (880–915 MHz/925–960 MHz) as of March 2021. Of those, at least 59 have launched services using the spectrum, 46 more hold licences to launch LTE at 900 MHz and a further eight are testing/trialling LTE at 900 MHz. For LTE, as of May 2021, in 900 MHz Band (Band 8) there were 7788 LTE devices out of which 55.21% accounts for phones and 170 announced 5G devices and out of which 50.60% accounts for phones.

1.25 1800 MHz band (band plan B3:1710 -1785 / 1805 – 1880 MHz) has the largest LTE user device ecosystem. 67.5% of FD-LTE devices can operate in this band. As per GSA[16], there are 19,422 FD-LTE capable user devices, out of which, 13,142 support 1800 MHz band (band B3). In case of 5G, around 15-20 operators have deployed/deploying or evaluating network in Band 3 and there are over 400 devices. As per GSA report on 'Evolution from LTE to 5G: October 2021'[17], at least 382

[13] GSA - NTS Snapshot (March 2021)
[14] GSA - Low Band Spectrum for LTE and 5G (May 2021)
[15] GSA - Low Band Spectrum for LTE and 5G (May 2021)
[16] GSA - LTE Ecosystem Status (March 2021)
[17] https://gsacom.com/paper/evolution-from-lte-to-5g-global-market-status-october-2021/

operators (around 48% of all LTE network operators with launched services) in 158 countries/territories have launched LTE services using spectrum in Band 3. Further, operators have also started to use spectrum at 1800 MHz for 5G. Eight operators have launched 5G using Band n3, three operators are deploying 5G at 1800 MHz and nine further operators have been testing/piloting/planning for 5G at 1800 MHz or licensed to launch using Band n3.

1.26 In India, spectrum assignment in 800 MHz, 900 MHz and 1800 MHz was being initially done administratively. After Hon'ble Supreme Court of India judgment dated 2nd February 2012, spectrum assignment for access services in all bands is being done through auction process. Since 2012, total six auctions have been held for assignment of spectrum in various access bands. Details of the spectrum auctioned in 800/900/1800 MHz bands since 2012 is given in the Table below:

Table 1.1
Spectrum Auctions Since 2012

Sl. No.	Year	Spectrum bands	Spectrum put to auction	Spectrum sold
1.	November 2012	1800 MHz	295 MHz	127.5 MHz
		800 MHz	95 MHz	No bidder
2.	March 2013	900 MHz	46 MHz (Delhi, Mumbai and Kolkata LSAs)	No bidder
		1800 MHz	57.5 MHz (Delhi, Mumbai, Karnataka and Rajasthan)	No bidder
		800 MHz	95 MHz	30 MHz
3.	February 2014	900 MHz	46 MHz (in 3 LSAs -Delhi, Mumbai and Kolkata)	46 MHz
		1800 MHz	385 MHz	307.2 MHz
4.	March 2015	800 MHz	108.75 MHz	86.25 MHz
		900 MHz	177.8 MHz	168 MHz
		1800 MHz	99.2 MHz	93.8 MHz
5.	October 2016	800 MHz	73.75 MHz (in 19 LSAs)	15 MHz (in 4 LSAs)
		900 MHz	9.4 MHz (4 LSAs-Bihar, Gujarat, UP(E), UP(W))	No bidder
		1800 MHz	221.6 MHz (in all LSAs except Tamilnadu)	174.8 MHz (in 19 LSAs)
6.	March 2021	800 MHz	230 MHz (in all LSAs)	150 MHz (in 19 LSAs)
		900 MHz	98.8 MHz (in 19 LSAs)	38.4 MHz (in 9 LSAs)
		1800 MHz	355 MHz (in all LSAs)	152.2 MHz (in 21 LSAs)

1.27 The spectrum that remained unsold in the previous spectrum Auction held in March 2021 along with some additional spectrum in 800 MHz, 900 MHz, and 1800 MHz bands is available for the forthcoming auction.

2100 MHz Band (1920-1980 MHz/2110-2170 MHz)

1.28 2100 MHz spectrum band (3GPP band B1) was opened up in India for deploying 3G networks. With the introduction of LTE services in India, 3G services started to fade away and TSPs started to migrate from 3G services to LTE services. Similar trend has been seen in other countries also. In some of the countries, the TSPs have closed down 3G services and refarmed this band for deploying 5G services. Indian TSPs have also closed down /closing down 3G services in the country on geographic area basis.

1.29 As per GSMA[18] 2100 MHz is the most refarmed band for 5G; 6 out of the 58 new 5G network launches in the previous six months up to Q1 2021 were supported by spectrum in the 2100 MHz band. Up to Q1 2021, 18 numbers of 5G Networks and 106 4G networks were launched in 2100 MHz band.

1.30 As per GSA[19], there are over 40 operators deployed/deploying or evaluating 5G in 2100 MHz (Band 1). As regards device ecosystem, as per GSA[20], there are 11,226 devices supporting 2100 MHz (Band 1) and represents 57.8% of all LTE devices. For 5G, over 80 devices support 2100 MHz (band 1).

1.31 In India, first auction for spectrum in 2100 MHz band was held in 2010. In that auction, three blocks (each block of 2x5 MHz) in 17 LSAs and four blocks in the remaining 5 LSAs were awarded. In addition, the Government allocated one block of 2x5MHz spectrum in Delhi and Mumbai to MTNL and in the remaining 20 service areas to BSNL at the winning price achieved in the respective LSAs.

[18] https://www.gsma.com/spectrum/wp-content/uploads/2021/03/Spectrum-Navigator-Q1-2021.pdf
[19] GSA - 5G Market Snapshot (August 2021)
[20] GSA - LTE Ecosystem Status (March 2021)

1.32 Second auction in 2100 MHz band was held in March 2015 along with other spectrum bands. Only one block (2x5 MHz) was put to auction in the 17 LSAs. The spectrum remained unsold in 3 LSAs viz Delhi, Mumbai and Andhra Pradesh. Meanwhile, Defence agreed, in principle, for swapping of 15 MHz spectrum in 2100 MHz band with 1900 MHz band in all LSAs. Therefore, additional 3 slots of 2x5 MHz in 2100 MHz became available for commercial assignment, which were put to auction in October 2016 along with unsold spectrum of 2015 auction. However, only 85 MHz spectrum in 12 LSAs was sold and 275 MHz spectrum in 21 LSAs remained unsold. In the last spectrum auction conducted in March 2021, 175 MHz of spectrum was put to auction; out of which, 15 MHz was sold and remaining 160 MHz is available for the forthcoming auction. Summary of the spectrum awarded in 2100 MHz spectrum through various auctions held so far is given in the table given below:

Table 1.2
Spectrum Auctions in 2100 MHz band

Sl. No.	Year	Spectrum put to auction	Spectrum sold
1	2010	355 MHz (15 MHz in 17 LSAs, 20 MHz in 4 LSAs)	355 MHz
2	2015	85 MHz (5 MHz in 17 LSAs)	70 MHz
3	2016	360 MHz (in 22 LSAs)	85 MHz (in 12 LSAs)
4	March 2021	175 MHz (in 19 LSAs)	15 MHz (in 3 LSAs)

2300 MHz band (2300-2400 MHz)

1.33 In India, for spectrum in 2300 MHz band 3GPP band B40 has been adopted and is being used to offer high speed data services using TD-LTE technology. The TD-LTE ecosystem is well established with 8,744 user devices as of March 2021. Amongst Time Division Duplexing (TDD) bands, 2300 MHz band supports maximum number of devices (79% of TDD devices)[21]. As per GSMA[22], up to Q1 2021, one number of 5G

[21] GSA - LTE Ecosystem Status (March 2021)
[22] GSMA - Spectrum Navigator, Q1 2021 (May 2021)

Network and 54 number of 4G networks were launched in 2300 MHz band.

1.34 Spectrum in the 2300 MHz band was first time assigned for commercial use through an auction conducted in the year 2010. In that auction, the Government put to auction two blocks (each of 20 MHz unpaired) in this band in each of the 22 LSAs and entire spectrum was sold. The spectrum in this band was auctioned again in the auction held in October 2016. Two blocks, each of 10 MHz unpaired were put to auction in 16 LSAs and again the entire spectrum was sold. In the recent auction held in March 2021, a total of 560 MHz spectrum was put to auction. Out of this, 500 MHz was sold and remaining 60 MHz of spectrum is available for the forthcoming auction. Summary of the spectrum awarded in 2300 MHz spectrum through various auctions held so far is given in the table given below:

Table 1.3

Spectrum Auctions in 2300 MHz band

Sl. No.	Year	Spectrum put to auction	Spectrum sold
1	2010	880 MHz (40 MHz in each LSA)	880 MHz
2	2016	320 MHz (20 MHz in 16 LSAs)	320 MHz
3	2021	560 MHz (40 MHz in 6 LSAs, 20 MHz in 16 LSAs)	500 MHz (in 22 LSAs)

2500 MHz band (2500-2690 MHz)

1.35 In the year 2009, the Government allocated one block of 20 MHz spectrum in 2500 MHz band in Delhi and Mumbai to MTNL and in the remaining 20 service areas to BSNL at the winning price achieved in respect of 2300 MHz band in the 2010 auctions. Later on, MTNL surrendered its spectrum in this band in both Delhi and Mumbai while BSNL surrendered it in 6 LSAs (Kolkata, Maharashtra, Gujarat, Andhra Pradesh, Tamil Nadu and Karnataka). Spectrum in this band was put to auction for the first time in auction held October 2016. In that auction,

a total of 600 MHz in the 2500 MHz band was put to auction in all the 22 LSAs, out of which, 370 MHz spectrum was sold in the 20 LSAs. Subsequently, this 230 MHz of unsold spectrum was put to auction in the last spectrum auction held in March 2021. However, entire 230 MHz of spectrum remained unsold.

1.36 Spectrum in 2500 MHz band (3GPP band B41) is being used to offer high speed data services using TD-LTE technology. As of March 2021, out of the total 8,744 TD-LTE user devices, 65% of the devices support 2500 MHz band (B41)[23], which is second highest in TD-LTE devices, after 2300 MHz band. As per GSMA[24], up to Q1 2021, two 5G Networks and nine 4G networks have been launched in 2500 MHz (band 41).

3300-3670 MHz band

1.37 In the TRAI recommendations dated 1st August 2018, recommendations relating to spectrum in 3300-3600 MHz band were also included. However, due to certain issues, the Government decided to initiate action to auction spectrum in this band separately after resolution of such issues and, therefore, it was not a part of the auction held in March 2021. Now, as the issues have been resolved by the Government as well as the range of available frequencies in this range has slightly gone up, it has been decided by the Government that spectrum in the frequency range 3300-3670 MHz should be made available to the Telecom Service Providers for IMT/5G through auction.

1.38 3GPP 5G NR (New Radio) bands n77 (3300-4200 MHz) and n78 (3300-3800 MHz), support the frequency range mentioned in the DoT reference for IMT services. Spectrum in 3300-3670 MHz band will be put to auction for IMT services for the first time in India in the forthcoming auction. This band has emerged as a prime band for deploying 5G services.

[23] GSA - LTE Ecosystem Status (March 2021)
[24] GSMA - Spectrum Navigator, Q1 2021 (May 2021)

1.39 As per GSA[25], there are over 250 operators deployed/deploying or evaluating 5G in n77, and n78 bands. As per GSMA[26], up to Q1 2021, there were 4, 70, and 34 numbers of 5G network launched in 3300 MHz, 3500 MHz, and 3700 MHz respectively. Up to Q1 2021, there were 34, 1 and 11 number of 4G networks launched in 3500 MHz, 3600 MHz, and 3700 MHz respectively.

1.40 In its reference, DoT has mentioned that 3400-3425 MHz spectrum would be made available for IMT throughout the country except in 6 locations namely Thiruvananthapuram, Hassan, Bhopal, Jodhpur, Shillong and Andaman & Nicobar Islands where the keep off distance of 40 to 130 km shall be maintained.

24.25 to 28.5 GHz band

1.41 In the World Radiocommunications Conference 2019 (WRC-19), additional globally harmonized frequency bands were identified for IMT, including IMT-2020, facilitating diverse usage scenarios for enhanced mobile broadband, massive machine-type communications, and ultrareliable and low-latency communications. New Resolutions approved at WRC-19 pointed out that ultra-low latency and very high bit-rate applications of IMT will require larger contiguous blocks of spectrum than those available in frequency bands that had previously been identified for use by administrations wishing to implement IMT.

1.42 In accordance with the Resolutions 241-244 of WRC-19[27], frequency bands 24.25 – 27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2–48.2, and 66–71 GHz, have been identified for IMT. Out of these, 26 GHz band (24.25 -27.5 GHz) is one of the globally harmonised bands.

1.43 While in WRC-19, 26 GHz band (24.25 – 27.5 GHz) has been identified for IMT, some of the countries such as USA, Japan, Korea have also opened up 28 GHz band (26.5 – 29.5 GHz) for IMT/5G. However, Europe

[25] GSA - 5G Market Snapshot (August 2021)
[26] GSMA - Spectrum Navigator, Q1 2021 (May 2021)
[27] https://www.itu.int/en/ITU-R/conferences/wrc/2019/Documents/PFA-WRC19-E.pdf

has decided to go for 26 GHz band. Therefore, ecosystem is getting developed in both these bands.

1.44 DoT through its reference dated 13h September 2021 has, for the first time proposed to include 24.25 – 28.5 GHz band amongst the bands to be auctioned in the forthcoming auction and has sought TRAI's recommendations on the reserve price and other related issues for this band. DoT has also informed that 24.25 to 28.5 GHz band will be used exclusively for IMT/5G except certain portion of this frequency range at 5 locations at Delhi, Shadnagar (Hyderabad), Khambaliya (Gujarat), Hut Bay (A&N Islands) and Tirunelveli (Tamilnadu) with protection distance of 2.7 Km.

1.45 DoT has informed that 24.25-28.5 GHz has been identified for IMT in India. As per band plans identified by 3GPP, there is no single band plan, which covers the entire frequency range identified by India. However, there are three band plans i.e. n257 (26.5 to 29.5 GHz), n258 (24.25 to 27.50 GHz) and n261 (27.50 to 28.35 GHz), which cover part of the frequency range identified by India and there are some overlap of frequencies in these band plans. Having said that, it is understood that the mmWave devices will support the entire frequency range.

1.46 As per GSA report[28], 108 operators in 45 countries/territories are investing in mmWave in the form of tests/trials, acquisition of licences, planning deployments or engaging in deployments. 133 operators in 22 countries/territories have been assigned mmWave spectrum enabling operation of 5G networks. 28 operators in 16 countries/territories are known to be already deploying 5G networks using mmWave spectrum. 19 countries/territories have announced formal plans for assigning frequencies above 24 GHz by the end-2022. 112 announced 5G devices explicitly support one or more of the 5G spectrum bands above 24 GHz. 70 of these devices are understood to be commercially available.

[28] https://gsacom.com/paper/mmwave-bands-24-25-ghz-may-2021-member-report/

Spectrum for Private Cellular Networks

1.47 A Private Cellular Network (PCN) is basically a local area network (LAN) that uses mobile cellular technologies to create a dedicated network with unified connectivity, optimised services and a secure means of communication within a specific geographic area. Newer cellular technologies such as LTE and 5G, are capable of providing very high capacity and low latency, which has enabled the use of cellular technologies for industrial automation. Considering the capabilities of 5G technology, it is being projected as a catalyst for 4th Industrial Revolution and thereby one of its the prominent use case is 'Industry 4.0'.

1.48 In its reference, DoT has informed about receiving few requests regarding spectrum requirements for captive usage of 5G applications by some industries e.g. Industry 4.0. DoT has also informed that COAI has submitted a letter regarding Private Captive Network, wherein they have, inter-alia, requested not to reserve any spectrum which has been identified for IMT, for Private Captive Networks.

1.49 DoT has requested TRAI to provide recommendations on quantum of spectrum/band, if any, to be earmarked for private captive/isolated 5G networks, competitive/transparent method of allocation, and pricing, for meeting the spectrum requirements for captive 5G applications of industries for machine/plant automation purposes/M2M in premises.

1.50 5G will potentially be used in all the economic verticals; however, initial demand for private networks is likely to arise from the Automotive, Industries, Ports, Mines, Aerospace etc. The requirement of private networks could be catered in multiple ways such as TSPs could provide them services using network slicing, TSPs could be permitted to lease the spectrum to industries to build their own private network, some spectrum could be set aside for private networks etc. Globally, different models are being adopted. As regards setting aside dedicated spectrum for private networks, as per GSA reports on Spectrum positions in different bands, some of the countries such as Germany, Finland, UK,

Brazil, Australia, Hong Kong, Japan, have decided to set aside some spectrum in mmWave band for private networks or local use. Some other countries such as Slovenia, Sweden, Republic of Korea are planning to set-aside some spectrum in different bands (mid-band /mmWave) for private networks.

Spectrum for Space-based communication

1.51 DoT in its reference letter dated 13th September 2021, has mentioned that the Department of Space (DoS) had invited comments on Draft Spacecom Policy liberalizing space segment for private sector participation to provide commercial communication services in India. This includes the Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellite constellations operational over India. In case of satellite communication, the subscriber is accessed from the satellite through "Access spectrum" similar to "Access spectrum" in terrestrial network and the demand for such spectrum will potentially increase in the future. In view of this, DoT requested TRAI to provide its recommendations on appropriate frequency bands, band plan, block size, applicable reserve price, quantum of spectrum to be auctioned and associated conditions for auction of spectrum for space-based communication services.

1.52 TRAI through its letters dated 27th September 2021 and 23rd November 2021 requested DoT to furnish the details of the frequency bands and quantum of spectrum available in each band required to be put to auction and associated information in respect of space-based communication.

1.53 Through its letter dated 27th November 2021, DoT has informed that *"…information in respect of space-based communication services sought by TRAI vide letter dated 23.11.2021, the same will take some time. Therefore, to avoid delay in 5G roll-out, TRAI may go ahead with consultations/recommendations on issues excluding space-based communication services referred in DoT's reference dated 13.09.2021 and 23.09.2021. Issues related to space-based communication services*

may be taken up separately on receipt of information from DoT". Therefore, a separate consultation process on the issue of spectrum for space-based communication services will be taken up by TRAI after receipt of requisite information from DoT.

STRUCTURE OF THE CONSULTATION PAPER

1.54 The paper is divided into four Chapters. This Chapter provides background to the subject. Chapter-II discusses the availability of spectrum in the 500 MHz, 600 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3670 MHz and 24.25 to 28.5 GHz bands for IMT. It also deals with policy issues such as band plan, block-size, roll-out obligations, spectrum cap, etc. Chapter-III discusses the different alternative approaches to valuation of spectrum in the 526-698 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3670 and 24.25 to 28.5 GHz bands and fixation of reserve price, Chapter-IV deals with the issues related to spectrum for private cellular networks. The issues for consultation have been listed in Chapter-V.

CHAPTER-II: AUCTION RELATED ISSUES

A. SPECTRUM AVAILABILITY AND BAND PLAN

2.1 Availability of spectrum in the various spectrum bands viz. 526-698 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3670 MHz and 24.25-28.5 GHz bands has been discussed below.

i) Frequency ranging from 526 MHz to 698 MHz

2.2 As informed by DoT, in the frequency range 526-698 MHz, the following new frequency bands have been decided to be used for IMT/5G:

d) 526-582 MHz in all the LSAs in coordination with Ministry of information & Broadcasting. The use will be coordinated with minimum keep out distance from MIB transmitters.

e) 582-617 MHz in all the LSAs. This band will be available for IMT/5G and rural point to point links.

f) 617-698 MHz in all the LSAs; except for a few areas/locations

2.3 TRAI through its letters 27th September 2021 and 8th October 2021, had sought following additional information/clarifications from DoT:

a) **526-582 MHz**: Exact details of the MIB transmitters, their locations, and coordinates (latitude-longitude), exact keep out distance required to be maintained at each location and any other relevant information.

b) **582-617 MHz**: it has been mentioned that this band will be available for IMT/5G and rural point to point links. DoT has been requested to clarify whether these two use cases are going to coexist. If yes, the coexistence/interference studies and any other relevant information in this regard have been sought.

c) Information on India proposal to ITU/APT on these bands.

2.4 DoT has clarified that in case of auction of spectrum in this band, right to use spectrum should be assigned to the successful bidder for

exclusive use. Rest of the information sought by TRAI, has not been received from DoT.

2.5 While ITU has identified spectrum in 470-698 MHz as an IMT band in Region 2 & Region 3, frequency arrangement for 526-582 MHz and 582-617 MHz bands have not been defined by ITU. On examination of the band plans defined by 3GPP, it appears that no band plans have been defined so far for 526-582 MHz and 582-617 MHz bands. Thus, ecosystem for IMT is not available in these bands.

2.6 In view of the above, the very first issue which needs to be deliberated is whether it will be appropriate to include 526-582 MHz and 582-617 MHz bands in the forthcoming auction.

Issues for consultation

Q.1 Whether spectrum bands in the frequency range 526-617 MHz, should be put to auction in the forthcoming auction? Kindly justify your response.

Q.2 If your answer to Q1 above is in affirmative, which band plans and duplexing configuration should be adopted in India? Kindly justify your response.

Q.3 In case your answer to Q1 is in negative, what should be the timelines for adoption of these bands for IMT? Suggestions to make these bands ready for adoption for IMT may also be made along with proper justification.

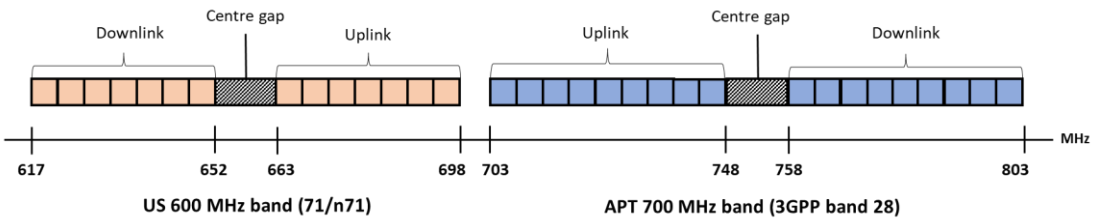
2.7 As regards 617-698 MHz band, ITU/3GPP have defined frequency arrangement with FDD configuration viz. band 71/n71 also known as US 600.

2.8 Band plan 71/n71 is based on reverse FDD configuration i.e. Mobile station transmitter (uplink) frequencies from 663-698 MHz and Base

station transmitter (Downlink) frequencies from 617-652 MHz. In band 71/n71, reverse FDD configuration has been adopted to guarantee compatibility with adjacent spectrum band, viz. Band 28 (APT 700 band) i.e. upper n71 block and lower B28 block will be both transmitting in uplink direction. This band plan has been adopted by some countries such as USA, Mexico, Canada[29], Hong Kong.

2.9 As mentioned above, band plan n71 is based on reverse FDD configuration to ensure that there is no interference with the adjacent band i.e. Band 28. Therefore, it may be appropriate to examine these bands together. The frequency arrangement of these band plans is shown below:

Chart 2.1: frequency arrangement of US 600 MHz band (n71) and 3GPP band 28

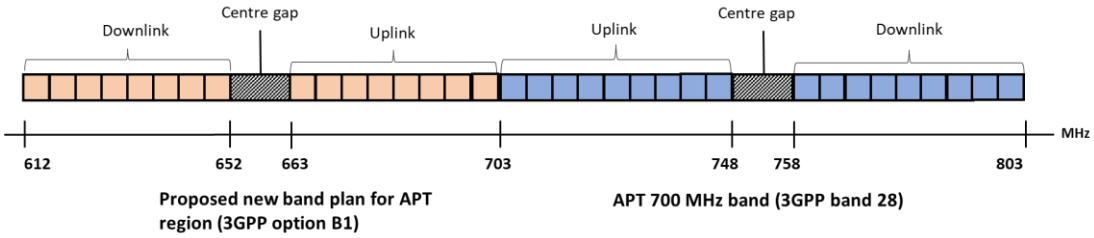


2.10 As can be seen from the Chart 2.1 above, between these two band plans (i.e. n71 & Band 28), there is an inter-band gap of 5 MHz. Inter-band gap is kept to ensure interference free utilization of two different band plans. However, since band n71 works on reverse FDD configuration, need for the band gap of 5 MHz may not be technically required. The ITU-APT Foundation of India (IAFI) [30] has proposed the creation of a new 600 MHz spectrum band plan for 4G and 5G networks in the Asia Pacific region to the 28th annual meeting of APT Wireless Group (AWG). As per the proposal submitted by IAFI, the new 2 x 40 MHz band plan will provide 80 MHz of spectrum as against 70 MHz (2 x 35 MHz) as per

[29] https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11374.html#s3
[30] https://www.communicationstoday.co.in/itu-apt-foundation-proposes-600-mhz-4g-5g-spectrum-band-in-asia-pacific/

band n71. In the 3GPP TR 38.860 V17.0.0 (2021-09) Technical Report[31] on 'Study on Extended 600 MHz NR band (Release 17)', one of the options for band plan is B1, wherein it has been proposed that the band gap between band n71 and Band 28 may be removed and additional 5 MHz from the lower frequencies may be included in this band. Accordingly, the proposed band plan is based on reverse Frequency Division Duplexing (FDD) configuration i.e. Mobile station transmitter (uplink) frequencies from 663-703 MHz and Base station transmitter (Downlink) frequencies from 612-652 MHz. However, the centre gap remains the same i.e. 652-663 MHz as that in band plan n71. Frequency arrangement for proposed new band plan is shown below:

Chart 2.2: Frequency arrangement of proposed new band plan for 600 MHz (3GPP option B1) and 3GPP band 28



2.11 A harmonised frequency arrangement facilitates economies of scale resulting in the availability of affordable equipment. Therefore, it is essential to follow an internationally harmonised band plan in each of the frequency bands. In case it is decided to adopt the above-mentioned proposed new band plan (3GPP option B1) for 600 MHz band, it will result in better utilization of available spectrum; on the other hand, benefit of the existing ecosystem for 71/n71 band, will not be derived. Having said that, if APT region decides to go with the proposed new band plan (3GPP option B1), ecosystem in the proposed new band plan is likely to get developed very fast.

[31] https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3893

2.12 Lower frequency bands provide wider coverage because they can penetrate objects effectively and thus travel farther, including inside buildings. Therefore, this band has a potential to enhance terrestrial mobile coverage, particularly in rural and far-flung areas and also to fill the in-building coverage gaps in urban areas. Thus, opening up of this band could be beneficial for the TSPs as well as the consumers.

2.13 In view of the foregoing discussion, the stakeholders are requested to provide their comments on the following questions:

Issues for consultation

Q.4 Do you agree that 600 MHz spectrum band should be put to auction in the forthcoming auction? If yes, which band plan and duplexing configuration should be adopted in India? Kindly justify your response.

ii) 700 MHz (UL: 703-748 MHz/DL: 758-803 MHz)

2.14 India has adopted FDD configuration-based Band 28 or APT 700 band for 700 MHz spectrum. 700 MHz spectrum band is also emerging as a prime coverage band for 5G. Corresponding 5G band defined by 3GPP is n28, which uses the similar frequency arrangement as that of Band 28.

2.15 As per the 3GPP band plan B28, 45 MHz (paired) spectrum can be utilised in this band. However, in India, 30 MHz (paired) spectrum is available for commercial purpose in each of the 22 LSAs in this band. The entire available spectrum (2 x 30 MHz in each LSA) was put to auction in March 2021. However, there was no bid received in any of the LSAs. Therefore, 30 MHz (paired) in each LSA totalling 660 MHz on pan-India is available for commercial use that can be put to auction.

iii) 800 MHz Band (UL: 824-844 MHz/DL: 869-889 MHz)

2.16 India has adopted FDD configuration based 3GPP band 5 for 800 MHz spectrum band. Considering that the telecom operators, already utilizing this band for other older mobile technologies, may like to refarm it for deploying latest mobile technologies, 3GPP has defined corresponding 5G band with the similar frequency arrangement, as band n5.

2.17 In the last spectrum auction held in March 2021, a total of 230 MHz (paired) spectrum was put to auction in the 800 MHz band in all 22 LSAs, out of that 150 MHz (paired) was sold in 19 LSAs. The remaining unsold 80 MHz spectrum (paired) is available for the forthcoming auction. In addition, 1 more carrier of 1.25 MHz has been made available in WB LSA. Details of spectrum availability, as provided by DoT, are given in Table 2.1 below:

Table 2.1

Spectrum availability (paired in MHz) in 800 MHz Band

LSA	Total spectrum put in March 2021 auction	Spectrum sold	Spectrum that remained unsold	Additional spectrum available for Auction	Total spectrum available for auction
	A	B	C=A-B	D	E=C+D
DEL	12.50	8.75	3.75	-	3.75
MUM	10.00	7.50	2.50	-	2.50
KOL	12.50	10.00	2.50	-	2.50
MH	15.00	12.50	2.50	-	2.50
GUJ	6.25	5.00	1.25	-	1.25
AP	13.75	6.25	7.50	-	7.50
KTK	13.75	10.00	3.75	-	3.75
TN	13.75	10.00	3.75	-	3.75
KL	13.75	10.00	3.75	-	3.75
PB	11.25	6.25	5.00	-	5.00
HR	10.00	8.75	1.25	-	1.25
UP (W)	12.50	10.00	2.50	-	2.50
UP (E)	12.50	5.00	7.50	-	7.50
RAJ	7.50	5.00	2.50	-	2.50
MP	12.50	10.00	2.50	-	2.50
WB	11.25	10.00	1.25	1.25	2.50
HP	10.00	5.00	5.00	-	5.00

LSA	Total spectrum put in March 2021 auction	Spectrum sold	Spectrum that remained unsold	Additional spectrum available for Auction	Total spectrum available for auction
	A	B	C=A-B	D	E=C+D
BH	12.50	5.00	7.50	-	7.50
OD	11.25	5.00	6.25	-	6.25
AS	2.50	-	2.50	-	2.50
NE	2.50	-	2.50	-	2.50
J&K	2.50	-	2.50	-	2.50
TOTAL	**230.00**	**150.00**	**80.00**	**1.25**	**81.25**

2.18 On examination of the information provided by DoT on frequency-wise spectrum allocation in 800 MHz band, it is observed that a total of 1.8 MHz of spectrum (available in disjoint small chunks less than the carrier size of 1.25 MHz individually), has been marked as guard band. If harmonization exercise is carried out and these are made contiguous, additional spectrum can be made available in all the LSAs.

iv) 900 MHz Band (UL: 890-915 MHz/DL: 935-960 MHz)

2.19 India has adopted FDD configuration based 3GPP band 8 for 900 MHz spectrum band. Corresponding 5G band defined by 3GPP is band n8.

2.20 In the last spectrum auction held in March 2021, a total of 98.8 MHz (paired) spectrum was put to auction in the 900 MHz band in 19 LSAs. Out of this, 38.4 MHz (paired) spectrum in 9 LSAs was sold, and 60.4 MHz (paired) spectrum remained unsold. Therefore, entire unsold spectrum (60.4 MHz) is available for auction. Further, some additional spectrum has been made available in Punjab, Rajasthan and J&K LSAs. Details of spectrum availability are given in Table 2.2 below:

Table 2.2

Spectrum availability (paired in MHz) in 900 MHz Band

LSA	Total spectrum put in March 2021 auction	Spectrum sold	Spectrum that remained unsold	Additional spectrum available for Auction	Total spectrum available for auction
	A	B	C=A-B	D	E=C+D
DEL	2.20	-	2.20	-	2.20
MUM	2.20	-	2.20	-	2.20
KOL	4.20	-	4.20	-	4.20
MH	4.20	-	4.20	-	4.20
GUJ	4.20	4.20	-	-	-
AP	3.60	-	3.60	-	3.60
KTK	3.80	-	3.80	-	3.80
TN	17.60	10.00	7.60	-	7.60
KL	4.60	4.60	-	-	-
PB	-	-	-	1.20	1.20
HR	0.80	-	0.80	-	0.80
UP (W)	2.40	-	2.40	-	2.40
UP (E)	6.40	5.00	1.40	-	1.40
RAJ	-	-	-	0.60	0.60
MP	5.80	-	5.80	-	5.80
WB	5.20	3.60	1.60	-	1.60
HP	5.20	2.60	2.60	-	2.60
BH	10.40	3.40	7.00	-	7.00
OD	5.20	3.80	1.40	-	1.40
AS	5.80	-	5.80	-	5.80
NE	5.00	1.20	3.80	-	3.80
J&K	-	-	-	3.00	3.00
TOTAL	**98.80**	**38.40**	**60.40**	**4.80**	**65.20**

2.21 On examination of the information provided by DoT on frequency-wise spectrum allocation in 900 MHz band, it is observed that in some of the LSAs, vacant spectrum is not available in contiguous manner. It is observed that if harmonization exercise is carried out, spectrum efficiency can be improved by making spectrum assigned to each TSP as well as the vacant spectrum, contiguous.

v) 1800 MHz Band (UL: 1710-1785 MHz/DL: 1805-1880 MHz)

2.22 India has adopted FDD configuration based 3GPP band 3 for 1800 MHz spectrum band. Band 3 consist of 2 x 75 MHz of spectrum; however, 2

x 55 MHz has been earmarked for IMT services in India. This band has emerged as one of the most preferred bands for LTE. Corresponding 5G band defined by 3GPP is band n3.

2.23 In the spectrum auction held in March 2021, a total of 355 MHz (paired) spectrum was put to auction in the 1800 MHz band in all the LSAs. Out of which, 152.2 MHz (paired) spectrum was sold in 21 LSAs. The remaining unsold 202.8 MHz (paired) spectrum in 21 LSAs is available for the forthcoming auction. Details of spectrum availability are given in Table 2.3 below:

Table 2.3
Spectrum availability (paired in MHz) in 1800 MHz Band

LSA	Total spectrum put in March 2021 auction	Spectrum sold	Spectrum that remained unsold	Additional spectrum available for Auction	Total spectrum available for auction
	A	B	C=A-B	D	E=C+D
DEL	15.40	4.60	10.80	-	10.80
MUM	15.60	3.40	12.20	10	22.20
KOL	14.40	1.00	13.40	10	23.40
MH	22.20	5.00	17.20	-	17.20
GUJ	17.80	4.00	13.80	-	13.80
AP	16.40	4.20	12.20	-	12.20
KTK	24.80	20.20	4.60	-	4.60
TN	19.40	18.20	1.20	-	1.20
KL	18.20	10.00	8.20	15	23.20
PB	19.40	9.80	9.60	-	9.60
HR	23.20	5.00	18.20	10	28.20
UP (W)	23.20	8.60	14.60	-	14.60
UP (E)	18.80	8.20	10.60	-	10.60
RAJ	16.80	-	16.80	-	16.80
MP	18.80	7.80	11.00	-	11.00
WB	7.00	3.80	3.20	-	3.20
HP	22.80	4.80	18.00	-	18.00
BH	8.60	7.80	0.80	-	0.80
OD	7.60	7.60	-	15	15
AS	6.80	4.60	2.20	-	2.20
NE	3.80	3.60	0.20	-	0.20
J&K	14.00	10.00	4.00	-	4.00
TOTAL	**355.00**	**152.20**	**202.80**	**60.00**	**262.80**

2.24 On examination of the information provided by DoT on frequency-wise spectrum allocation in 1800 MHz band, it is observed that in all the LSAs, 0.2 MHz of spectrum has been shown as guard band, which has not been included in the spectrum available for auction. Since block size for 1800 MHz band is 0.2 MHz, the spectrum availability can go up by 0.2 MHz in each LSA.

vi) 2100 MHz Band (UL: 1920-1980 MHz/DL: 2110-2170 MHz)

2.25 India has adopted FDD configuration based 3GPP band 1 for 2100 MHz spectrum band. Band 1 consist of 2 x 60 MHz of spectrum; however, 2 x 40 MHz has been earmarked for IMT services in India. This band was initially being used for provision of 3G services, however; lately trend of migrating from 3G to LTE/5G has been seen in this band. Corresponding 5G band defined by 3GPP is band n1.

2.26 In the spectrum auction held in March 2021, a total of 175 MHz (paired) spectrum was put to auction in the 2100 MHz band in 19 LSAs. Out of which, 15 MHz spectrum was sold in 3 LSAs. The remaining unsold 160 MHz (paired) spectrum in 19 LSAs is available for the forthcoming auction as given below:

Table 2.4

Spectrum availability (paired in MHz) in 2100 MHz Band

LSA	Total spectrum put in March 2021 auction	Spectrum sold	Spectrum that remained unsold	Total spectrum available for auction
	A	B	C=A-B	D=C
DEL	15.00	-	15.00	15.00
MUM	10.00	-	10.00	10.00
KOL	10.00	-	10.00	10.00
MH	5.00	-	5.00	5.00
GUJ	10.00	-	10.00	10.00
AP	15.00	-	15.00	15.00
KTK	10.00	-	10.00	10.00
TN	-	-	-	-
KL	5.00	-	5.00	5.00
PB	5.00	-	5.00	5.00

LSA	Total spectrum put in March 2021 auction	Spectrum sold	Spectrum that remained unsold	Total spectrum available for auction
	A	B	C=A-B	D=C
HR	5.00	-	5.00	5.00
UP (W)	10.00	-	10.00	10.00
UP (E)	-	-	-	-
RAJ	-	-	-	-
MP	10.00	-	10.00	10.00
WB	10.00	5.00	5.00	5.00
HP	15.00	-	15.00	15.00
BH	5.00	-	5.00	5.00
OD	10.00	-	10.00	10.00
AS	10.00	5.00	5.00	5.00
NE	10.00	5.00	5.00	5.00
J&K	5.00	-	5.00	5.00
TOTAL	**175.00**	**15.00**	**160.00**	**160.00**

vii) 2300 MHz Band (2300-2400 MHz)

2.27 India has adopted TDD configuration based 3GPP band 40 for 2300 MHz spectrum band. Band 40 consist of 100 MHz of spectrum; however, 80 MHz has been earmarked for IMT services in India. This band is the most preferred TD-LTE band. Corresponding 5G band defined by 3GPP is band n40.

2.28 In the spectrum auction held in March 2021, a total of 560 MHz (unpaired) spectrum was put to auction in the 2300 MHz band in all the 22 LSAs. Out of this, 500 MHz (unpaired) spectrum was sold. The remaining unsold 60 MHz (unpaired) spectrum in 6 LSAs is available for the forthcoming auction as given below:

Table 2.5

Spectrum availability (unpaired in MHz) in 2300 MHz Band

LSA	Total spectrum put in March 2021 auction	Spectrum sold	Spectrum that remained unsold	Total spectrum available for auction
	A	B	C=A-B	D=C
DEL	20.00	10.00	10.00	10.00
MUM	20.00	10.00	10.00	10.00
KOL	20.00	10.00	10.00	10.00
MH	20.00	20.00	-	-
GUJ	20.00	20.00	-	-
AP	20.00	10.00	10.00	10.00
KTK	20.00	10.00	10.00	10.00
TN	20.00	10.00	10.00	10.00
KL	20.00	20.00	-	-
PB	40.00	40.00	-	-
HR	40.00	40.00	-	-
UP (W)	40.00	40.00	-	-
UP (E)	40.00	40.00	-	-
RAJ	40.00	40.00	-	-
MP	20.00	20.00	-	-
WB	20.00	20.00	-	-
HP	20.00	20.00	-	-
BH	20.00	20.00	-	-
OD	20.00	20.00	-	-
AS	20.00	20.00	-	-
NE	20.00	20.00	-	-
J&K	40.00	40.00	-	-
TOTAL	**560.00**	**500.00**	**60.00**	**60.00**

viii) 2500 MHz Band (2500-2690 MHz)

2.29 India has adopted TDD configuration based 3GPP band 41 for 2500 MHz spectrum band. Band 41 consist of 190 MHz of spectrum; however, only 40 MHz has been made available for IMT services in India. Corresponding 5G band defined by 3GPP is band n41.

2.30 In the last spectrum auction held in March 2021, a total of 230 MHz (unpaired) spectrum in 12 LSAs was put to auction in the 2500 MHz band. However, no bids were received. Therefore, entire spectrum, which was put to auction in March 2021, is available for the

forthcoming auction. Details of the LSA-wise spectrum availability is given below:

Table 2.6

Spectrum availability (unpaired in MHz) in 2500 MHz Band

LSA	Total spectrum available for auction
DEL	20.00
MUM	20.00
KOL	20.00
MH	10.00
GUJ	10.00
AP	30.00
KTK	40.00
TN	40.00
KL	-
PB	10.00
HR	-
UP (W)	-
UP (E)	-
RAJ	-
MP	-
WB	-
HP	10.00
BH	10.00
OD	-
AS	-
NE	-
J&K	10.00
TOTAL	**230.00**

ix) 3300-3670 MHz Band

2.31 In the last TRAI recommendations on Auction of Spectrum, dated 1st August 2018, recommendations relating to spectrum in 3300-3600 MHz band were also included. However, due to certain issues, the Government decided to initiate action to auction spectrum in this band separately after resolution of these issues and, therefore, it was not a part of the auction held in March 2021. Now, as the issues have been resolved as well as the range of available frequencies in this range has slightly gone up, it has been decided by the Government that spectrum

in the frequency range 3300-3670 MHz should be made available to the Telecom Service Providers for IMT/5G through auction. In its reference, DoT has mentioned that 3400-3425 MHz spectrum would be made available for IMT throughout the country except in 6 locations namely Thiruvananthapuram, Hassan, Bhopal, Jodhpur, Shillong and Andaman & Nicobar Islands where the keep off distance of 40 to 130 km shall be maintained. Subject to the above exceptions, 370 MHz of unpaired spectrum is available in each LSA for forthcoming auction.

2.32 Considering the global trend, TRAI in its recommendations on Auction of Spectrum dated 1st August 2018, had recommended that 3300-3600 MHz should be auctioned as a single band and TDD band frequency arrangement should be adopted for this band. As regards band plan, it observed that in the given frequency range, TDD configuration-based band plans have been defined for both LTE and 5G. The details are given below:

Chart-2.3: 3GPP Channel arrangements for LTE

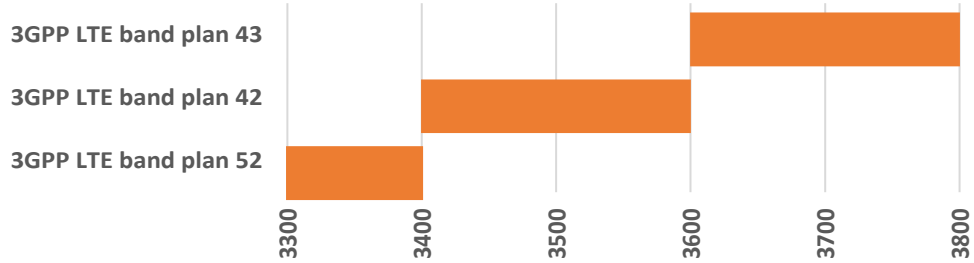
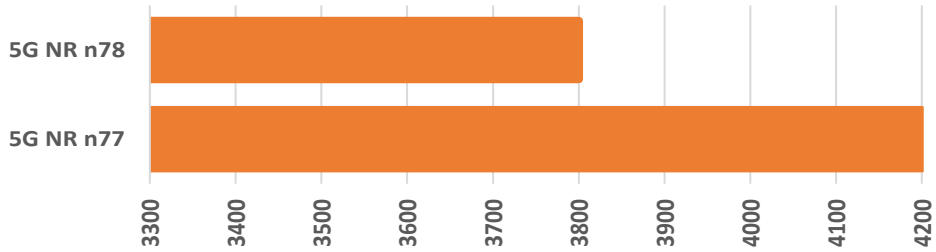


Chart-2.4: 3GPP Channel arrangements for 5G-NR



2.33 The given frequency range i.e, 3300-3670 MHz has emerged as the prime spectrum for 5G. Considering the global trends, this spectrum is

likely to be used for deploying 5G in India. Both the 5G band plans defined by 3GPP i.e. n77 & n78, support the frequency range earmarked by India for IMT. One view could be that the spectrum band covering the larger range i.e. n77, could be adopted. This would also take care of a future situation, where some more spectrum in this band could be made available for IMT.

Issues for consultation

Q.5 For 3300-3670 MHz frequency range, which band plan should be adopted in India? Kindly justify your response.

x) 24.25 to 28.5 GHz band

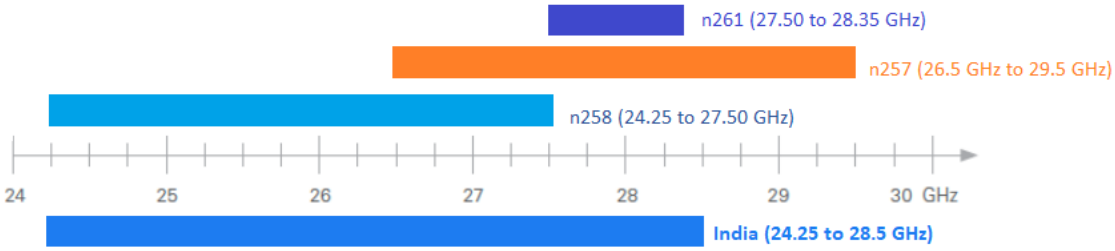
2.34 DoT through its reference dated 13th September 2021 has, for the first time proposed to include 24.25 – 28.5 GHz band amongst the bands to be auctioned in the forthcoming auction. DoT has also informed that 24.25 to 28.5 GHz band will be used exclusively for IMT/5G except certain portion of this frequency range at 5 locations at Delhi, Shadnagar (Hyderabad), Khambaliya (Gujarat), Hut Bay (A&N Islands) and Tirunelveli (Tamilnadu) with protection distance of 2.7 Km.

2.35 While in WRC-19, 24.25 – 27.5 GHz has been identified for IMT, some of the countries such as USA, Japan, Korea have also opened up 28 GHz band (26.5 – 29.5 GHz) for IMT/5G. However, Europe has decided to go for 26 GHz band. Therefore, ecosystem is getting developed in both these bands.

2.36 Both the bands i.e. 26 GHz and 28 GHz bands are TDD configuration-based. Higher frequency bands are generally used for enhancing capacity and lowering latency. Therefore, TDD based configuration is desirable. 3GPP has defined this band only for TDD configuration based band plans in mmWave spectrum bands.

2.37 As informed by DoT, 24.25-28.5 GHz has been identified for IMT in India. As per band plans identified by 3GPP, there is no single band plan, which covers the entire frequency range identified by India. However, there are three band plans i.e. n257 (26.5 GHz to 29.5 GHz), n258 (24.25 to 27.50 GHz) and n261 (27.50 to 28.35 GHz), which cover part of the frequency range identified by India and there are some overlap of frequencies in these band plans. Frequency arrangement of these band plans are depicted below:

Chart 2.5: Frequency arrangement of n257, n258 and n261



2.38 As can be seen from the above chart, band n261 is a subset of band n257. Therefore, for India, the band plans of interest would be n258 and n257.

2.39 As per a report on "The Impacts of mmWave 5G in India" published by GSMA in October 2020, mmWave spectrum in particular will play a crucial role in enabling the high-speed and ultra-low-latency features required by many 5G applications. India will benefit significantly from mmWave-enabled 5G. Over the period 2025–2040, it has been estimated that mmWave-enabled 5G will deliver $150 billion in additional GDP for India.

2.40 As already mentioned, ecosystem is developing fast in 26 GHz band (n258) as well as 28 GHz band (n257). As per GSA report on '5G Spectrum, Networks and Devices' dated 24 June 2021, in mmWave (26/28 GHz bands), 112 licences have been issued and out of them, 27 operators have either deployed or deploying mmWave spectrum. As

regards device ecosystem, 122 devices supporting high 'mmWave' spectrum [band n257 (26.5-29.5 GHz), n258 (24.25-27.5 GHz), n261 (27.5-28.35 GHz) and n260 (37.0-40.0 GHz)] have been announced and out of which, 77 are commercially available. Charts given below presents band-wise details of the count of operators investing in key 5G spectrum bands as of mid-August 2021 and number of announced device models known to support 5G bands as of end of July 2021, as published by GSA.

Chart 2.6: Count of operators investing in key 5G spectrum bands (mid-August 2021)

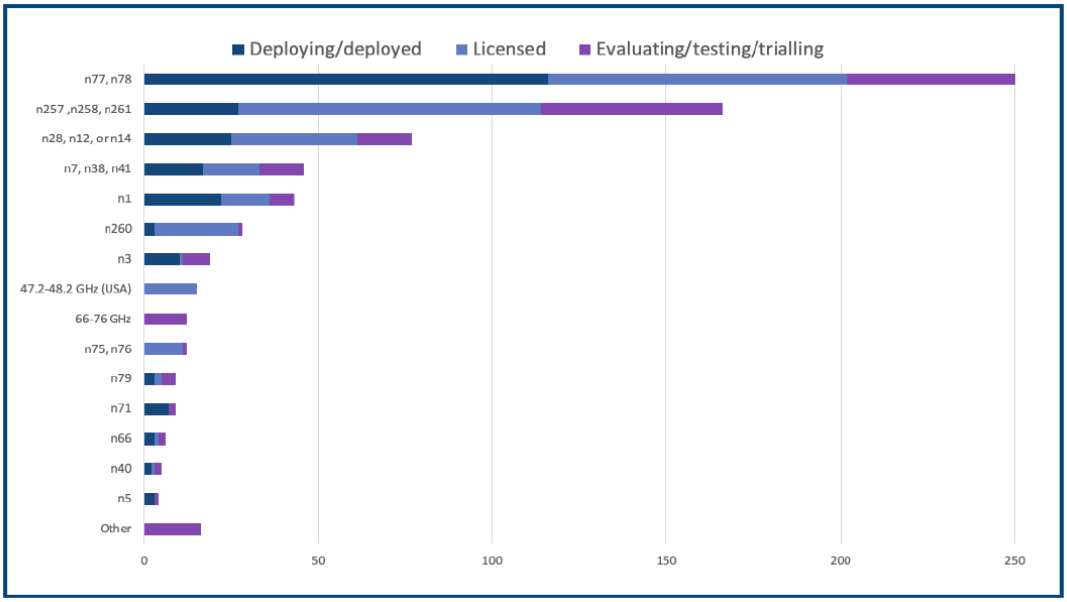
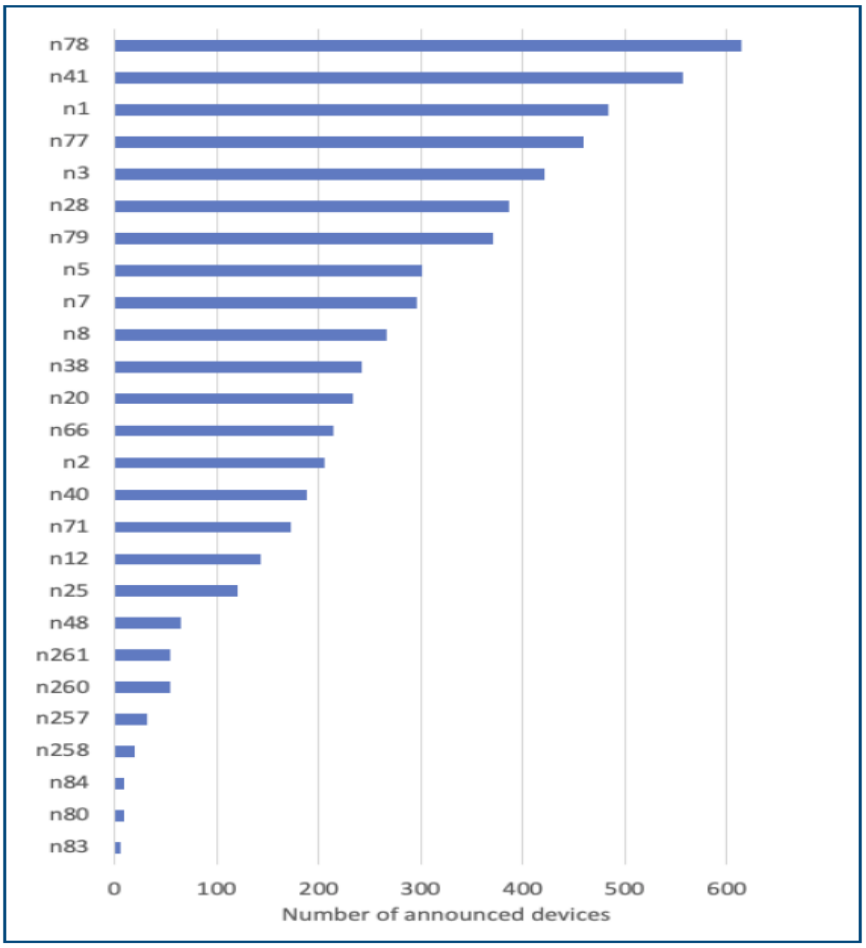


Chart 2.7: Number of announced device models known to support 5G bands (end of July 2021)



Issues for consideration

Q.6 Do you agree that TDD based configuration should be adopted for 24.25 to 28.5 GHz frequency range? Kindly justify your response

Q.7 In case your response to Q6 is in affirmative, considering that there is an overlap of frequencies in the band plans n257 and n258, how should the band plan(s) along with its frequency range be adopted? Kindly justify your response.

Q.8 Whether entire available spectrum referred by DoT in each band should be put to auction in the forthcoming auction? Kindly justify your response.

B. Block Size

2.41 The Block size and the minimum quantity of spectrum to be bid for by Existing Licensee/ New Entrant, in various bands, as per the Notice Inviting Applications (NIA) for spectrum auction conducted in March 2021, is given in Table given below:

Table 2.8

Block size and minimum quantity for bidding as per NIA for spectrum auction conducted in March 2021

Spectrum Band	Block Size (MHz)	Minimum amount of spectrum that a bidder is required to bid for	
		Existing licensees (MHz)	New Entrants (MHz)
700 MHz	5 (paired)	NA	5
800 MHz	1.25 (Paired)	1.25	5, 3.75 (where only 3.75 MHz is available), 2.5 (where only 2.5 is available). 1.25 (where only 1.25 is available)
900MHz	0.20 (paired)	0.2	5, 0.2 (where less than 5 MHz is available)
1800 MHz	0.20 (paired)	0.2	5, 0.2 (where less than 5 MHz is available)
2100 MHz	5 (paired)	5	5
2300 MHz	10 (unpaired)	10	10
2500 MHz	10 (unpaired)	10	10

2.42 Initially, 800 MHz spectrum band was assigned for deployment of Code Division Multiple Access (CDMA) technology. Therefore, a carrier size of 1.25 MHz was prescribed. CDMA services required a guard band between the spectrum frequencies allocated to different operators. Therefore, in the carrier size of 1.25, the TSP were actually assigned 1.23 MHz, rest was provisioned for guard band at both sides. However, with changing times, spectrum has been liberalized (technology neutral). Spectrum assigned through auction is treated as liberalized

and for any existing spectrum holding which was assigned through administrative allocation, the TSPs have been given a choice to get it liberalized after paying differential between the entry fee and the market determined price for the remaining validity of spectrum. It is observed that presently, no TSP is offering CDMA based services and 800 MHz band is being used by the TSPs for provision of LTE based services, wherein requirement of guard band does not exist. Further, LTE employ OFDM modulation with flexible contiguous component carriers from 1.4, 3, 5, 10, 15 and 20 MHz. As mentioned in the earlier section, additional 1.8 MHz spectrum (in small disjoint chunks) is available in 800 MHz band in each LSA, which has so far been marked as guard band by DoT. Even if harmonization exercise is carried out by DoT, entire 1.8 MHz additional spectrum will not be able to be utilized with the existing carrier size. Therefore, the question arises whether there is a need to change the block size for 800 MHz band and to revisit the existing provision for guard band. To better utilize the available spectrum, one option could be to keep the block size of 800 MHz same as that for 900 MHz band.

2.43 For 700 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz bands, same block sizes as mentioned in the Table 2.8 above are proposed for the upcoming auction.

Issues for consultation

Q.9 Since upon closure of commercial CDMA services in the country, 800 MHz band is being used for provision of LTE services,

a. Whether provision for guard band in 800 MHz band needs to be revisited?

b. Whether there is a need to change the block size for 800 MHz band? If yes, what should be the block size for 800 MHz band and the minimum number of blocks for bidding for existing and new entrants?

(Kindly justify your response)

Q.10 Do you agree that in the upcoming auction, block sizes and minimum quantity for bidding in 700 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands, be kept same as in the last auction? If not, what should be the band-wise block sizes and minimum quantity for bidding? Kindly justify your response.

526-698 MHz bands

2.44 As already discussed, technical characteristics of the lower frequency bands are such that provide better coverage and in-building penetration. While no band plans could be found for 526-617 MHz, band plan 71/n71 exist for 617-698 MHz band. Band 71/n71 is being used for provision of LTE/5G services. US, Canada and Hong Kong decided to auction this band in the block size of 5 MHz (paired).

2.45 The existing 3GPP band plan Band 71/n71 (617-698 MHz) consist of 2 x 35 MHz of spectrum. In case India decides to adopt the proposed new band (3GPP option B1 from 612-703 MHz), spectrum availability would

be 2 x 40 MHz. In any case, block size of 5 MHz would ensure that entire available spectrum is put to auction. Further, it is observed that there is a global trend of keeping a block size of 5 MHz in this band.

Issues for consultation

Q.11 In case it is decided to put to auction spectrum in 526-698 MHz bands, what should be the optimal block size and minimum quantity for bidding? Kindly justify your response.

3300-3670 MHz band and 24.25-28.5 GHz bands

2.46 For 3300-3600 MHz band, TRAI in its recommendations on Auction of Spectrum dated 1st August 2018, had noted that for 5G NR bands n77(3300-4200 MHz) and n78 (3300-3800 MHz), the supported channel bandwidth is 10 MHz, 15 MHz, 20 MHz, 30 MHz, 40 MHz, 50 MHz, 60 MHz, 70 MHz, 80 MHz, 90 MHz, and 100 MHz. Further, in the same recommendations, TRAI had recommended that barring the specific locations or districts where ISRO is using the 25 MHz (3400 MHz - 3425 MHz) of spectrum, the entire spectrum from 3300 MHz to 3600 MHz should be made available for access services and should be included in the forthcoming auction. Considering (i) total 300 MHz spectrum would be available for access services, (ii) the supported channel bandwidth as per 3GPP standards, (iii) to provide flexibility and at the same time to attain greater efficiency, and (iv) to avoid the fragmentation of these bands, TRAI had recommended that spectrum in 3300-3600 MHz band should be put to auction in the block size of 20 MHz.

2.47 However, upon receipt of back-reference from DoT, wherein it was informed that ISRO has requested for leaving 25 MHz (from 3400 MHz to 3425 MHz) untouched for NavIC constellation maintenance. In its

response to back reference, TRAI recommended that in case DoT decides to reserve 25 MHz (3400-3425 MHz) for ISRO i.e. this 25 MHz cannot be assigned to the TSPs because of potential interference, the spectrum available for auction will be 275 MHz (one chunk of 100 MHz from 3300-3400 MHz and other of 175 MHz from 3425-3600 MHz). It was further noted that if 20 MHz block size is retained, 15 MHz will remain unsold as it cannot be put to auction. Thus, to ensure that all available spectrum is put to auction, the Authority viewed that block size may be kept as 5 MHz. The Authority felt that while bidding for multiple blocks of 5 MHz each, the TSPs will be able to use any of the supported channel bandwidth as per 3GPP standards and it will also ensure auction and utilization of entire available spectrum.

2.48 In the current reference, a total of 370 MHz of spectrum from 3300-3670 MHz, is available. For 5G NR bands n77(3300-4200 MHz) and n78(3300-3800 MHz), the supported channel bandwidth is 10 MHz, 15 MHz, 20 MHz, 25 MHz, 30 MHz, 40 MHz, 50 MHz, 60 MHz, 70 MHz, 80 MHz, 90 MHz, and 100 MHz. To ensure that entire spectrum is put to auction, block size of 5 MHz or 10 MHz can be specified. However, considering that this band is likely to be used for 5G, wherein larger chunk of spectrum may be required, minimum number of blocks for bidder can be kept in a manner to ensure that bidder bids for at least 40 MHz or 50 MHz.

2.49 As regards 24.25 – 28.5 GHz (mmWave) band, the spectrum is likely to be used for provision of 5G use cases/applications requiring very high data rates and ultra-low latency. High frequency spectrum bands provide more capacity and therefore, for such bands, TDD based frequency configuration is adopted as TDD networks offers more flexibility as can easily adapt between uplink and downlink traffic.

2.50 As per the standard frozen by 3GPP[32] [ETSI TS 138 104 V16.6.0 (2021-01)], for 5G NR bands n257 and n258, the supported channel

[32] https://www.etsi.org/deliver/etsi_ts/138100_138199/13814102/16.06.00_60/ts_13814102v160600p.pdf

bandwidth is 50 MHz, 100 MHz, 200 MHz and 400 MHz. Considering the different 5G use cases, several countries have opened up mmWave spectrum. In Frequency Range 2 (FR2: 24.25 GHz to 52.6 GHz) for 5G NR, maximum carrier bandwidth is up to 400 MHz and at present, that can be aggregated with a maximum bandwidth of 800 MHz. However, it is likely to go up to 1000 MHz in near future.

2.51 Since the last recommendations were made by TRAI in August 2018, several countries have auctioned spectrum in mid-band and mmWave bands. It has been observed that while UK and Australia auctioned mid-band spectrum in block size of 5 MHz, some countries like South Korea, US, Italy, Spain have specified block size as 10/20 MHz. As regards mmWave, it is observed that US and South Korea auctioned mmWave spectrum in block size of 100 MHz, whereas Australia and Italy kept a block size of 200 MHz. Country wise details are provided in Annexure-2.1

Issues for Consultation

Q.12 What should be optimal block size and minimum quantity for bidding in 3300-3670 MHz band? Kindly justify your response.

Q.13 What should be optimal block size and minimum quantity for bidding in 24.25-28.5 GHz? Kindly justify your response.

C. Eligibility Conditions for Participation in Auction

2.52 Eligibility conditions for participation in Auction are specified in the relevant NIA. Eligibility conditions for the last auction held in March 2021 for 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz were prescribed in the NIA[33]. In the present

[33] https://dot.gov.in/sites/default/files/AmendedNoticeInvitingApplications28-01-2021.pdf

reference, DoT has proposed to include the following spectrum bands in the forthcoming auction:

a) 526-698 MHz
b) 3300-3670 MHz
c) 24.25-28.5 GHz

Issues for consultation

Q.14 Whether any change is required to be made in the existing eligibility conditions for participation in Auction as specified in the NIA for the spectrum Auction held in March 2021, for the forthcoming auction? If yes, suggestions may be made in detail with justification.

Q.15 In your opinion, should the suggested/existing eligibility conditions for participation in Auction, be made applicable for the new spectrum bands proposed to be auctioned? If not, what should be the eligibility conditions for participating in Auction? Kindly justify your response.

D. Interference mitigation in TDD bands

2.53 It is a well-known fact that when more than one TDD networks operate in the same band and same geographic area, severe interference may happen if the networks are uncoordinated i.e., if some base stations (BSs) are transmitting while others are receiving. Synchronization is one of the techniques to avoid Uplink/Downlink interference without losing spectrum in guard bands. Synchronized Operation of TDD networks prevents simultaneous uplink and downlink. It can be implemented by means of (a) Starting the frame in the same time and (b) Configuring compatible frame structures (length of the frame, and uplink/downlink ratio) so that all transmitter stop before any receiver starts.

2.54 Earlier, the issue of interference in the TDD networks was analysed by the Authority in 2016, when the unpaired spectrum in the 2300 MHz and 2500 MHz bands was put to auction. The Authority had recommended[34] that:

> *"…. the operation of adjacent LTE TDD networks in 2300/2500 MHz bands shall be time-synchronised and TSPs shall use the same frame structure with DL/ UL configuration of 3:1. Other technical aspects such as clock source, requirement to be fulfilled by Wi-MAX networks for co-existence at LSA border areas etc can be finalised by TEC. These provisions may be mandated in the NIA for auctioning of spectrum in this band. It can also be mandated that this provision can be reviewed later on as and when need arises. …… DoT should carry out carrier frequency re-assignment to make uniform carrier frequency assignment though out the country to the TSPs without any inter-operator guard band in the 2300 MHz band. It will result in additional spectrum for commercial use. The Authority also recommends if TSPs acquires additional block of 10MHz, it should be ensured that all its carriers are contiguous."*

2.55 In the recommendations on "Auction of spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands" dated 1st August 2018, the Authority had noted that use of compatible frame structures is not always feasible. The relevant extract is reproduced below:

> "2.68 *Use of compatible frame structures is not always feasible. For instance, if two different technologies, say LTE & 5G, are deployed in the same band, compatible frame structures may not be possible. If the large contiguous blocks of spectrum are assigned to TSPs, they can manage the interference by mutual coordination and provisioning of guard bands. However, assignment of non-contiguous blocks would lead to fragmentation, necessitating increased provisioning of guard bands, which may lead to a situation that the spectrum assigned may not remain suitable for implementation of 5G technology. To reap the real advantage of 5G technology, it is important that the larger contiguous chunk of spectrum is available with the TSPs. Therefore, the Authority is of the view that while assigning spectrum blocks, contiguity of spectrum blocks*

[34] Authority's recommendation on "Valuation and Reserve Price of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz Bands" dated 27th January 2016.

should be ensured. In case a TSP is able to win more than two blocks of spectrum in the upcoming auctions, it should be allocated spectrum in contiguous blocks.

2.69 Further, possibility of interference may exist between far-off BTSs due to time-lag involved in the transmission of signal. In the 2300 MHz band, the interference issues have been reported in the neighboring LSAs if the overlapping frequency bands have been assigned to different TSPs in neighboring LSAs. This requires coordination amongst BTS sites which can be easily carried out if the TSP has been assigned same frequency spots across different LSAs."

2.56 In view of the above, the Authority had recommended that (a) in case a TSP acquires more than one block in 3300-3600 MHz band, the entire spectrum should be assigned to it in contiguous form and (b) In case a TSP acquires spectrum in 3300-3600 MHz band in more than one LSA, same frequency spots should be assigned to it in all those LSAs.

2.57 Considering that there could be a situation where a TSP wins some spectrum in an auction and later on decides to increase its spectrum holding in that band. In such a case, it may be difficult to assign additional spectrum in contiguity with the existing spectrum holding and also to ensure that same frequency spots are assigned in each LSA.

2.58 Further, with introduction of 5G, the TSPs may like to implement Dynamic TDD, wherein each cell in the network can adapt its uplink-downlink ratio depending on the traffic. Prescribing a frame structure with a downlink and uplink configuration could come in way of implementation of dynamic TDD. Having said that, in case of multiple service providers environment, where spectrum licenses are allocated in the same band and need to co-exist with each other, possibility of interference cannot be ruled out. Therefore, there may be a need to synchronize outdoor networks or adjacent frequencies of different TSPs.

2.59 In view of the forgoing the issues for consultation are:

Issues for Consultation

Q.16 Is there a need to prescribe any measure to mitigate possible interference issues in 3300-3670 MHz and 24.25-28.5 GHz TDD bands or it should be left to the TSPs to manage the interference by mutual coordination and provisioning of guard bands? Kindly provide justification to your response.

Q.17 In case your response to the above question is in affirmative,

a. whether there is a need to prescribe provisions such as clock synchronization and frame structure to mitigate interference issues, as prescribed for existing TDD bands, for entire frequency holding or adjacent frequencies of different TSPs? If yes, what should be the frame structure? Kindly justify your response.

b. Any other measures to mitigate interference related issues may be made along with detailed justification.

E. Roll-out Obligations

2.60 Given the fact that spectrum is a limited resource and should be used in an effective and efficient manner, roll-out obligations are mandated for the spectrum assigned to the TSPs. Roll-out obligations mandated in the NIA for Auction conducted in March 2021 are discussed below.

a) 700 MHz, 800 MHz, 900 MHz, 1800 MHz bands

Roll out Phase	**Roll Out Requirement**	**Time Period***
Metro LSAs	Coverage of 90% of the LSA	by the end of one year
Non-Metro LSAs		
Phase 1	Coverage of 10% DHQs/ Towns	by the end of one year

Phase 2	Coverage of 50% DHQs/ Towns	by the end of three years
Phase 3	Coverage of 10% BHQs	by the end of three years
Phase 4	Coverage of additional 10% BHQs (Cumulative 20% BHQs)	by the end of four years
Phase 5	Coverage of additional 10% BHQs (Cumulative 30% BHQs)	by the end of five years
Notes: ***** From effective date of license or date of assignment of spectrum won in this auction process, whichever is later. For this purpose, 900 & 1800MHz bands are treated as the same band.		

b) 2100 MHz Band

The Licensee shall be required to provide street level coverage as prescribed in the Test Schedule as detailed below:

Roll out Phase	**Roll Out Requirement**	**Time Period***
Metro LSAs	Street level coverage using the spectrum in 2100 MHz in at least 90% of the LSA	by the end of five years
Non-Metro LSAs		
Phase 1	50% of DHQs in the LSA out of which 15% of DHQs should be in rural SDCA	by the end of three years
Phase 2	Additional 10% of DHQs in the LSA	by the end of four years
Phase 3	Additional 10% of DHQs	by the end of five years
Notes: ***** From effective date of license or date of assignment of spectrum won in this auction process, whichever is later.		

c) 2300 MHz & 2500 MHz bands

Roll out Phase	**Roll Out Requirement**	**Time Period***
Metro LSAs	street level coverage as prescribed in the test schedule in at least 90% of the LSA	by the end of five years
Non-Metro LSAs	At least 50% of the rural SDCAs are covered using 2300/ 2500 MHz band Coverage of a rural SDCA would mean that at least 90% of the area bounded by the municipal/ local body limits	by the end of five years

	should get the required street level coverage.	

Notes:

***** From effective date of license or date of assignment of spectrum won in this auction process, whichever is later.

2.61 As per the NIA provisions, the requirement of rollout obligation shall be treated as fulfilled once the required number of district headquarters or block headquarters or rural SDCAs are covered by use of any technology in any band by a licensee. Therefore, the licensee is not required to fulfil these roll-out obligations separately in respect of each of these bands. However, for 2100 MHz (Metro LSAs) and 2300/2500 MHz (non-Metro LSAs), the prescribed coverage targets are specific to the use of respective bands, which may need to be corrected.

2.62 In the frequency range 526-698 MHz, ITU/3GPP band plan and ecosystem for IMT are available only in 617-698 MHz band. Lower frequency bands provide wider coverage because they can penetrate objects effectively and thus travel farther, including inside buildings. Therefore, this band has a potential to enhance terrestrial mobile coverage, particularly in rural and far-flung areas.

2.63 Keeping in mind the primary objective of increasing broadband penetration in rural areas and reducing the urban-rural divide, the special focus should be given for the coverage in smaller towns and villages. With this view, TRAI in its recommendations dated 27th January 2016, had recommended the following roll-out obligations for 700 MHz band:

"*The Authority recommends that the following roll-out obligations should be imposed for licensees who acquire access spectrum in 700 MHz band:*

- *All towns/villages having population of 15,000 or more but less than 50,000 to be covered within 5 years of effective date of allocation of spectrum for access services and all villages having population of 10,000or more but less than 15,000 to be covered within 7 years of effective date of allocation of spectrum.*

- *To prevent, duplication of infrastructure, a TSP should also be permitted to fulfil the obligations by sharing network of other operator to the extent permissible as per guidelines/instructions applicable from time to time. A licensee should be allowed to cover any town/village as part of roll-out obligations using intra-service area roaming amongst TSPs having 700 MHz band spectrum, subject to the condition that at least one-third of the towns/villages shall be covered without intra-circle roaming.*
- *.....”*

(Para 2.97 of the Recommendations dated 27th January 2016)

2.64 Considering the foregoing discussion, one view could be that both for 526-698 MHz and 700 MHz bands, the roll-out obligations may be prescribed in a manner that so far uncovered areas are provided with mobile coverage. Another view could be that both these bands are likely to be used as 5G coverage bands and 5G services will be rollout by the TSPs in different areas based on its commercial viability; therefore, rural based coverage may not be advisable. Another option could be to extend the rollout obligations prescribed for 700 MHz band as specified in the NIA for the Auctions held in March 2021 to 526-698 MHz band also.

2.65 For 3300-3600 MHz band, in the recommendations on “Auction of spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz band” dated 1st August 2018, TRAI had recommended that no roll out obligations should be mandated for 3300-3600 MHz band. Reasons for recommending no rollout obligations were:

a) the high frequency waves do not travel longer due to higher propagation loses, these are not suitable for extending mobile coverage to uncovered/remote areas,
b) this band is likely to be used for 5G and the TSPs will decide 5G rollout based on demand and affordability,
c) the standards of IMT 2020 are still in development stage and the maturing of technology/device eco-system will take even more time.

2.66 Upon study of the practice adopted in other countries, it is observed that generally, countries have prescribed some rollout obligations for mid-band spectrum. For instance, in April 2021, OFCOM, UK Regulator, conducted auction for 3.6-3.8 GHz spectrum band, wherein no coverage obligations were prescribed because the Mobile Network Operators (MNOs) had committed to achieve more comprehensive mobile coverage in the Shared Rural Network programme than they would be able to require through coverage obligations in this award. Their commitments, now agreed with the Government, are included in their current spectrum licences and are legally binding. In South Korea for 3.5 GHz band, deployment of 150,000 base stations were obligated, out of which, 22,500 (15%) to be deployed in three years. Details of the roll-out obligations imposed by other countries are available in the Annexure-2.1.

2.67 24.25 – 28.5 GHz (mmWave) spectrum is likely to be used for provision of 5G use cases/applications requiring very high data rates and ultra-low latency. Therefore, the TSPs would be deploying it selectively in the areas where the demand for such use cases/applications exists. Further, the technical characteristics of high band are such that it cannot be used for meeting coverage requirement. Therefore, prescribing coverage related rollout obligations may not be feasible. However, on examination of the practice adopted in other countries, it is observed that generally, certain obligations have been imposed. For instance, in South Korea, for 28 GHz spectrum band, the licensees are mandated that 100,000 base stations are to be deployed, of which 15 percent or more were obligated to be completed in the nationwide network within three years. Details of the roll-out obligations imposed by other countries are available in the Annexure-2.1.

2.68 In addition to the above, it is observed that Virtual Network Operator (VNO) regime was introduced in India in 2016 and as per the provisions of the license, VNOs are permitted to set up their own network equipment viz., BTS, BSC, MSC, RSU, DSLAMs, LAN switches, if

required, where there is no requirement of interconnection with other Network Service Operator(s). TRAI, through its recommendations on 'Enabling Unbundling of Different Layers Through Differential Licensing' dated 19th August 2021, has inter-alia, recommended that:

> *"A separate authorization under Unified License should be created for Access Network Provider (network layer) to provide network services on wholesale basis. Under this authorization for Network layer only, the Access network provider shall not be permitted to directly provide services to the end customers under the authorization.*
>
> *Scope of the Access Network Provider shall be to establish and maintain access network, including wireless and wireline access network, and selling the network services (capable of carrying voice and non-voice messages and data) on a wholesale basis to VNOs (service delivery operators) for retailing purpose."*

2.69 In the said recommendations on 'Enabling Unbundling of Different Layers Through Differential Licensing' dated 19th August 2021, it was also mentioned that:

> *"if a separate category of License for Access Network Provider is created the Access Network Provider could build Core network, Radio Access Network (RAN) and team up with VNOs for provision of services. Since the VNOs are also permitted to set up their own network equipment viz., BTS, BSC, MSC, RSU, DSLAMs, LAN switches, if required, where there is no requirement of interconnection with other Network Service Operator(s), it could create a win-win environment where it is possible for the VNO licensee to support the regime by investing in Radio Access Network. In such a situation, since both the operators have invested for provision of service, the network provider will not perceive the service delivery operator (VNO) as a competitor but as a service delivery partner. Thus, introduction of separate license for Access Network provider could also attract investment and strengthen the service delivery segment."*

2.70 To actualize the above-mentioned scenario, it may be necessary that while assessing fulfilment of the rollout obligations of the relevant Network Operator (Unified licensee with access service authorization and Access Network Provider-as recommended by TRAI), the network elements such BTS, BSC etc. created by the attached VNO, may also be included.

Issues for Consultation

Q.18 Whether the roll-out obligations for 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz as stipulated in the NIA for last auctions held in March 2021 are appropriate? If no, what changes should be made in the roll out obligations for these bands?

Q.19 What should be associated roll-out obligations for the allocation of spectrum in 526-698 MHz frequency bands? Should it be focused to enhance rural coverage? Kindly justify your response.

Q.20 What should be associated roll-out obligations for the allocation of spectrum in 3300-3670 MHz frequency band? Kindly justify your response.

Q.21 What should be associated roll-out conditions for the allocation of spectrum in 24.25 to 28.5 GHz frequency range? Kindly justify your response.

Q.22 While assessing fulfilment of roll out obligations of a network operator, should the network elements (such BTS, BSC etc.), created by the attached VNO, be included? If yes, kindly suggest the detailed mechanism for the same. Kindly justify your response.

F. Spectrum Cap

2.71 The spectrum cap is the limit of access spectrum a telecom operator can hold for providing wireless services. The objective of prescribing spectrum cap is to prevent large holdings of spectrum by one or a few TSPs which otherwise may create concerns for the competition in the market. As per the NIA provisions of the recent auction, the overall spectrum cap for each of the service areas is calculated as under:

> *"The sub-1 GHz cap is 50% of the combined spectrum available in sub-1 GHz bands (i.e. 700 MHz, 800 MHz, 900 MHz bands) for an LSA and the over-all cap is 35% of the total spectrum available for assignment across all the bands in an LSA.*
>
> *Note: It may be noted that the blocks/spectrum that are being put to auction (including those which are not available for assignment immediately after the auction but at a later date) were not to be included in the spectrum holding of the existing licensees, for the purpose of spectrum holding cap rules.*
>
> *The government has decided to follow the following principles for the calculation of overall and band wise caps for an LSA.*
>
> *i) All spectrum assigned to TSPs, including quantity of spectrum whose rights to use were put to auction but remained unsold, spectrum whose rights to use were assigned but subsequently surrendered by the TSPs or taken back by the licensor and quantity of spectrum whose rights to use are being put to auction would be counted for the purpose of the spectrum cap.*
>
> *ii) The spectrum which may become available to DoT for commercial use after its refarming from other uses (such as defence) at different points of time would not be counted for determining the spectrum caps until its rights to use are put to auction.*
>
> *iii) In case a situation arises where due to any subsequent assignment of spectrum to defence/ non-commercial usage, spectrum cap is affected adversely, no TSP would be asked to surrender right to use of any*

spectrum which it already holds. For the sake of level playing field among Telecom Service Providers (TSPs), the same spectrum cap shall be made applicable for all the telecom service providers in that Licensed Service Area."

2.72 It is clear that the above definition does not include 526-698 MHz, 3300-3690 MHz and 24.25-28.5 GHz bands as these were never put to auction. Now, since these bands are also proposed to be auctioned, above provision of spectrum cap needs to be reviewed. Having said that, in the last TRAI recommendations on Auction of spectrum dated 1st August 2018, 3300-3600 MHz band was also included, and the following recommendations w.r.t. spectrum cap, were made for this band:

"- The existing provisions of spectrum cap (i.e. 35% Overall cap) should be extended to 3300-3600 MHz band also.

- To avoid monopolization of this band, there should be limit of 100 MHz per bidder in this band."

2.73 DoT has informed that spectrum availability in mid band has gone up by 70 MHz (3300-3670 MHz). In addition, the following new frequency bands have also been decided to be used for IMT/5G:

a) 526-582 MHz
b) 582-617 MHz
c) 617-698 MHz
d) 24.25 to 28.5 GHz

2.74 From the above, it can be observed that in sub-1-GHz bands, spectrum availability has gone by substantially. Presently, there is a combined spectrum cap of 50% on all sub-1 GHz bands. If such spectrum cap is also extended to the new sub-1 GHz bands, it may create concerns for the competition in the market. Therefore, there may be a need to review this cap.

2.75 Further, the high frequency bands such as 3300-3670 MHz and 24.25-28.5 GHz, together, come with a huge quantum of spectrum. In case the overall spectrum cap is extended to these bands as well, the denominator for computation of spectrum cap will increase to an extent that the overall spectrum cap of 35% may lose its significance. One view could be that separate spectrum caps may be defined for different group of spectrum bands viz. sub-1 GHz, 1-2 GHz, 3300-3670 MHz and 24.25-28.5 GHz bands.

2.76 Considering the global trend, 3300-3670 MHz and 24.25-28.5 GHz bands are likely to be used for 5G in India. Therefore, to ensure competition in 5G segment, whether intra-band spectrum cap for these bands should be put in place. TRAI in its last recommendations on Auction of Spectrum dated 1st August 2018, had recommended a spectrum cap of 100 MHz per operator in 3300-3600 MHz band. The global practice also shows that some countries have prescribed a spectrum cap of 100 MHz for mid-band.

2.77 As regards 24.25-28.5 GHz band, the study of other countries show that some countries have prescribed a spectrum cap of 800/1000 MHz. As per 3GPP[35], in frequency range 2 (FR2: 24.25 GHz to 52.6 GHz) for 5G NR, maximum carrier bandwidth is up to 400 MHz and at present, that can be aggregated with a maximum bandwidth of 800 MHz. However, it is likely to go up to 1000 MHz in near future.

Issues for Consultation

Q.23 Whether there is a need to review the spectrum cap for sub-1 GHz bands? If yes, what should be the spectrum cap for sub-1 GHz bands. Kindly justify your response.

Q.24 Keeping in mind the importance of 3300-3670 MHz and 24.25-28.5 GHz bands for 5G, whether spectrum cap per operator

[35] https://www.etsi.org/deliver/etsi_ts/138100_138199/13814102/16.06.00_60/ts_13814102v160600p.pdf

specific to each of these bands should be prescribed? If yes, what should be the cap? Kindly justify your response.

Q.25 Whether there should be separate spectrum cap for group of bands comprising of 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands together? If yes, kindly suggest the cap along with detailed justification.

Q.26 Whether overall spectrum cap of 35% requires any change to be made? If yes, kindly suggest the changes along with detailed justification.

Q.27 For computation of overall spectrum cap of 35%, should the spectrum in 3300-3670 MHz and 24.25-28.5 GHz bands be included? Kindly justify your response.

Q.28 Any other suggestion regarding spectrum cap may also be made with detailed justification.

G. Surrender of Spectrum

2.78 DoT through its letter dated 23rd September 2021 has, inter-alia, communicated recent Telecom Reforms and requested TRAI to consider / factor in the decisions announced in Telecom Reforms, while providing recommendations. One such decision is regarding provision for surrender of spectrum, wherein it has been informed that "in order to encourage better utilization of spectrum and to encourage business, for the auctions conducted henceforth, TSPs may be permitted to surrender spectrum after a minimum period of 10 (ten) years. TSPs will have to inform one year prior to surrendering their spectrum. The spectrum purchase dues for the remaining (post surrender) period will not be levied. However, an appropriate surrender fee will be charged". TRAI recommendations have been sought on the conditions and fee for such surrender.

2.79 In this regard, it is noted that provision for surrender of spectrum has been created by the Government as part of the Telecom Reforms. Provision for surrender of spectrum was one part of structural reforms. In this regard the relevant extract of the press note dated 15th September 2021, providing the objective of the telecom reforms is reproduced below:

> *"The Union Cabinet, chaired by the Prime Minister Shri Narendra Modi, today approved a number of structural and process reforms in the Telecom sector. These are expected to protect and generate employment opportunities, promote healthy competition, protect interests of consumers, infuse liquidity, encourage investment and reduce regulatory burden on Telecom Service Providers (TSPs). The package is also expected to boost 4G proliferation, infuse liquidity and create an enabling environment for investment in 5G networks."*

2.80 So far, to shed the excess spectrum (if any), the only practical option available with TSPs is spectrum trading. As per the spectrum trading guidelines, the TSPs are permitted to trade their partial/entire spectrum holding to another TSP after a lock in period of 2 years post assignment of such spectrum.

2.81 The Government has decided to create a provision for surrender of spectrum after a period of 10 years from date of allocation of such spectrum. To surrender the spectrum, TSPs will be required to inform about its decision to surrender the spectrum to the Government one year prior to surrendering such spectrum. The question arises that what should be the process and associated terms and conditions for surrender of spectrum. Further, what provisions may be created in the spectrum surrender framework so that any possible misuse by the licensees, could be avoided.

2.82 It is understood that the period of 10 years would be counted from the date of assignment of such spectrum. However, in case a TSP acquires spectrum through trading, should the period of 10 years be counted

from the date of original assignment of spectrum or from the date of spectrum trading.

2.83 Considering the backdrop of the telecom reforms, the issue that also needs deliberation is on need to charge a spectrum surrender fee. One could argue that the right to use the spectrum has been bought by a TSP for a contracted number of years and through surrender provisions, the TSP may surrender it prematurely. Therefore, for dilution of spectrum license, some fee may be charged. Another view could be that if a TSP is surrendering spectrum, the Government can very well put to auction such surrendered spectrum in a timely manner as the TSP is required to inform one year in advance; thus, there may be no need for any fee to be charged.

2.84 Further, DoT has informed that for the auctions conducted henceforth, TSPs may be permitted to surrender spectrum after a minimum period of 10 (ten) years. Therefore, the issue needs deliberation is whether provision for surrender of spectrum should also be made available for the existing spectrum holding of the TSPs. In case such a provision needs to be created, what should be the process and associated terms and conditions.

2.85 In view of the above discussion, the following issues arise for consultation:

Issues for Consultation

Q.29 What should be the process and associated terms and conditions for permitting surrender of spectrum for future auctions? Kindly justify your response.

Q.30 What provisions may be created in the spectrum surrender framework so that any possible misuse by the licensees, could be avoided? Kindly justify your response.

Q.31 In case a TSP acquires spectrum through trading, should the period of 10 years to become eligible for surrender of spectrum, be counted from the date of original assignment of spectrum or from the date of acquisition through spectrum trading? Kindly justify your response.

Q.32 Whether provision for surrender of spectrum should also be made available for the existing spectrum holding of the TSPs? If yes, what should be the process and associated terms and conditions? Kindly justify your response.

Q.33 Whether spectrum surrender fee be charged from TSPs? If yes, what amount be levied as surrender fee? Kindly justify your response.

CHAPTER–III: VALUATION AND RESERVE PRICE OF SPECTRUM

3.1 Spectrum refers to the radio frequencies allocated to various sectors viz. telecom, space, defence, railways etc. for communication over airwaves. It plays a pivotal role in the functioning of these sectors and is used as factor input for provisioning for various telecom services making it an indispensable resource for telecommunication. The high utility of spectrum in various sectors leads to composite demand for spectrum and given that spectrum is both rivalrous and largely excludable, its composite demand limits its supply available for the telecom sector. Pricing of spectrum is, therefore, essential to avoid free riding and *tragedy of the commons*. Thus, besides ensuring intersectoral coordination for efficient allocation and utilization of the spectrum, the control on supply and pricing of various spectrum bands lies in the hands of the Government (i.e. the Licensor).

3.2 It is a known fact that the demand for spectrum is a derived demand. It depends on the demand for telecom services. Thus, the demand for spectrum is influenced by a number of factors which have a bearing on the demand for telecom services, which include prevailing market conditions such as tele-density, internet penetration and techno-economic factors like investment in infrastructure. Other economic variables like geographies, population demographics, living standards etc. influence the preferences and demand for telecom services. Similarly, macroeconomic variables like Gross Domestic Product (GDP), per capita income, inequality of income, unemployment rate and inflation etc., affect the demand for telecom services.

3.3 The supply of spectrum is relatively inelastic as the Government controls when the right to use of spectrum held by the incumbents will expire to make it available for re-auction and when new spectrum will be released and in what quantities. Along with control on supply, reserve prices are also decided by the Government. The reserve price

has a significant effect on the demand for spectrum. During spectrum valuation exercises, the Authority has taken a consistent view that a reserve price, that is set too high may discourage participation and restrict competition whereas a reserve price that is set too low may lead to cartelization thereby affecting competition. Spectrum acts as a valuable input in provisioning of telecommunication services. The telecom sector, through its backward and forward linkages, leads to large scale economic impacts such as affecting growth, employment, citizen participation etc. Hence, any policy decision which affects the prices of spectrum is reflected in the prices of telecommunication services. The interests of the public, at large, are linked with spectrum pricing. Effective spectrum pricing based on a sound rationale is a prerequisite to ensure that this valuable resource is utilized in an optimal manner to serve the public interest in the best possible manner.

3.4 In the instant Reference, DoT stated that a request has been received from COAI regarding effective spectrum pricing. Further, DoT mentioned that the Parliamentary Standing Committee on Information Technology in its report on 'India's preparedness for 5G' has made certain observations on the pricing of spectrum. In this context, TRAI sought the views of DoT on pricing of spectrum. In response, DoT informed, *inter-alia*, that:

> *"There is a need to strike balance between revenue generation from the auction on one hand, long term growth/ sustainability of the telecom sector, introduction of new services/ technologies, on the other.*
>
> *The Government's intent is to protect direct and indirect employment, promote healthy competition, protect consumer interests, infuse liquidity encourage investment and reduce unnecessary regulation in the sector. Telecommunications sector provides the basic backbone and infrastructure for digital connectivity and broadband. The sector has direct and indirect linkage in advancing growth, employment, ease of living, empowering citizens, enhancing transparency in governance etc. Advanced technology*

and applications envisaged in Industry 4.0 rely heavily on robust and state-of-the-art telecommunication networks.

In this context, for transitioning to 5G technology, proliferation and penetration of optical fibre networks and providing reliable high-speed broadband at affordable prices, the telecom service providers need to be in good health with sufficient capacities to make regular and substantial capital expenditure.

In the recently concluded spectrum auction 2021, only 37.1% of spectrum put up to auction was acquired by TSPs.

Government of India has recently approved for an option of 4-year moratorium on spectrum auction instalments as well as AGR instalments for TSPs, to ensure healthy cash flow situation in the sector.

Further, spectrum lying idle is a waste for the economy."

3.5 On 15.09.2021, the Union cabinet approved structural and procedural reforms in the telecom sector with a view to protect and generate employment opportunities, promote healthy competition, protect interests of consumers, infuse liquidity, encourage investment and reduce regulatory burden on TSPs. The reforms are expected to provide financial and economic benefits to the telecom sector. For instance, the increase in moratorium period for repayment of liabilities will tend to improve the cash flow position of the TSPs. Further, waiving off of penalties along with interest payments, removal of Spectrum Usage Charges (SUC), reduction in penal interest rates and rationalization of Adjusted Gross Revenue (AGR) definition, are expected to reduce present as well as future liabilities of TSPs, and positively impact the availability of funds to them. Reduction in bank guarantee can enable the TSPs to fully utilize their fund capacity. The increase in moratorium period prior to the first instalment will lower the present liability of TSPs. The 100% foreign direct investment (FDI) under automatic route permitted in the telecom sector is expected to promote healthy competition and attract further investment in the sector.

3.6 There are certain spectrum and auction related reforms such as removal of the requirement of bank guarantees to secure instalment payments, which may lead to increased participation in auctions as it will increase financial headroom for the potential bidders. The increased tenure of the spectrum allotment from the existing 20 years to 30 years will enable TSPs to exploit spectrum benefits by using it for a longer period. The elimination of spectrum usage charge on spectrum acquired in future auctions will result in the direct financial benefits by lowering the regulatory expenditure on account of acquiring a certain quantum of spectrum. It may result in reduction in spectrum usage charges for the incumbents once they acquire new spectrum.

Issues for consultation

Q.34 Which factors are relevant in the spectrum valuation exercise and in what manner should these factors be reflected in the valuation of spectrum? Please give your inputs with detailed reasoning.

Q.35 In what manner, should the extended tenure of spectrum allotment from the existing 20 years to 30 years be accounted for in the spectrum valuation exercise? Please support your response with detailed rationale/ inputs.

Q.36 What could be the likely impact of the following auction related telecom reforms announced by the Government in September 2021 on the valuation of various spectrum bands?

(a) Rationalization of Bank Guarantees to securitize deferred annual spectrum payment instalments in future auctions

(b) No spectrum usage charges (SUC) for spectrum acquired in future auctions

(c) Removal of additional SUC of 0.5% for spectrum sharing

(d) Provision for surrender of spectrum

In what manner, should the above provisions be accounted for in the valuation of spectrum? Please support your response with detailed justification.

Need for fresh exercise of valuation versus use of March 2021 auction determined prices in 800 MHz/900 MHz/1800 MHz/2100 MHz/2300 MHz bands

3.7 DoT, through the instant Reference, has sought recommendations on applicable reserve price of spectrum in 526-698 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3670 MHz and 24.25 – 28.5 GHz bands for IMT/ 5G.

3.8 Since the year 2013, the Authority has been furnishing its recommendations on valuation and reserve price of various spectrum bands following a bottom-up approach (LSA-wise valuation using LSA-specific inputs) using several valuation methodologies. Through the latest recommendations, which were furnished in the August 2018, the Authority recommended reserve price of spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands.

3.9 About 9 months have elapsed since the last spectrum auction was held in the month of March 2021 wherein spectrum in 700 MHz (in 22 LSAs), 800 MHz (in 22 LSAs), 900 MHz (in 19 LSAs), 1800 MHz (in 22 LSAs), 2100 MHz (in 19 LSAs), 2300 MHz (in 22 LSAs) and 2500 MHz (in 12 LSAs) was put to auction. In this regard, the Authority requested DoT to provide the rationale for seeking fresh recommendations for auction of spectrum in 800 MHz, 900 MHz, 1800 MHz, 2300 MHz bands. DoT was also requested to provide reasons for seeking fresh recommendations in respect of 700 MHz, 2500 MHz and 3300-3600

MHz band. It is pertinent to mention that in the spectrum auction held in March 2021, no bids were received for spectrum in 700 MHz and 2500 MHz bands while spectrum in 3300-3600 MHz band was not put to auction. In response to the Authority's request, DoT conveyed that there are apparently changes in the context and timing of auction, and may be changes in various factors that may have a bearing on the reserve prices etc. DoT also stated that further, the Government has decided that tenure of the spectrum assigned through auction will be 30 years, and also that for spectrum auctioned in future, there will be no Spectrum Usage Charges (SUC). DoT has stated that TRAI may like to consider all these while making recommendations.

3.10 A comparative statement of the reserve prices recommended by TRAI, the reserve prices fixed by DoT and the auction determined prices of different spectrum bands during the spectrum auction held in March 2021 has been depicted in **Annexure 3.1**. The band-wise summary of quantity of spectrum put on auction and quantum of spectrum sold in the auction held in March 2021, is being presented in the following table:

Quantity of spectrum put to auction vis-à-vis quantity of spectrum sold				
Spectrum Band	**Quantity put on auction (in MHz) / (LSAs)**	**Quantity sold in Auction (MHz)/LSAs**	**Quantity sold (%)**	**Number of LSAs where no bid was received**
1800 MHz	355.00 (22 LSAs)	152.2 (21 LSAs)	43	1
800 MHz	230.00 (22 LSAs)	150 (19 LSAs)	65	3
900 MHz	98.80 (19 LSAs)	38.4 (9 LSAs)	39	10
700 MHz	660 (22 LSAs)	0	0	22
2100 MHz	175 (19 LSAs)	15 (3 LSAs)	9	18
2300 MHz	560 (22 LSAs)	500 (22 LSAs)	89	0
2500 MHz	230 (12 LSAs)	0	0	12
Total	**2303.8**	**855.6**	**37.1**	**-**

3.11 The spectrum auction of March 2021 started on March 1, 2021 and spanned for six rounds across two days, with four rounds of bidding on day-1 and two rounds on day-2. Unlike previous auctions, in which more number of TSPs had participated, only three TSPs participated in the spectrum auction of March 2021. The auction determined price was equal to the reserve price set by DoT across various spectrum bands and across various LSAs.

3.12 In the spectrum auction of March 2021, a total of 2308.8 MHz spectrum was put to auction, out of which, 855.6 MHz spectrum was sold. The spectrum in 700 MHz and 2500 MHz bands, which together comprised 38.55% of the total quantity, remained entirely unsold. Out of the remaining five bands (viz. 800 MHz, 900 MHz, 1800 MHz, 2100 MHz and 2300 MHz) comprising 1418.8 MHz spectrum, 60.3% of the quantity put to auction was sold.

3.13 The status of sale of spectrum in terms of demand (D) and supply (S) for the various spectrum bands in the spectrum auction of March 2021 has been given in **Annexure 3.2**. From the annexure, it may be inferred that in the LSAs for a particular band, where entire quantity on offer was sold at the reserve price, it was the market clearing price; on the other hand, for the LSAs for a particular band, where there was not enough demand, the realized price was not the market clearing price, though it was still the 'auction determined price'. The Authority has, in the past, taken a view that auction determined price achieved as an outcome of an auction is the best available indicator of the valuation of spectrum by the market. Further, in its previous recommendations, the Authority took a view that it would be reasonable to consider the auction determined prices of the preceding two years for the purpose of valuation of spectrum. Accordingly, the Authority, in 2018, recommended that the prices revealed in the auction held in October 2016 should be taken as one of the possible values of spectrum in the respective bands for the forthcoming auction, duly indexed, if these are more than one year old.

3.14 In this context, the Notice Inviting Applications (NIA) of 25th February 2010 for 'Auction of 3G and BWA Spectrum' includes the following clause:

> *"Para 4.7: If a further round of auction for 3G spectrum or BWA spectrum takes place within 12 months from the date of completion of the current round or the relevant Auction, the Reserve Price in such a round will be the same as the Successful Bid Amount in the current round of the relevant Auction for the respective service area."*

3.15 Further, the Authority, through the Recommendations on 'Spectrum Management and Licensing Framework' dated 11.05.2010 stated, *inter-alia*, as below:

> *"Para 3.50: The Authority recommends that Government should bring additional blocks into 3G services at the earliest and offer the same at the highest price being discovered through the present auction to the remaining bidders in the order of bids. If, however, more than a year lapses from now for this exercise, a fresh auction needs to be conducted."*

3.16 The NIAs of 28th September 2012 (for 1800 MHz and 800 MHz) and 30th January 2013 (for 1800 MHz, 900 MHz and 800 MHz) for auction of spectrum included a clause which states that:

> *"Para 2.3: Existing CMTS/UAS/UL(AS) licensees can liberalise their existing spectrum holding in 1800 MHz band after payment of auction determined price."*

3.17 Further, the NIA dated 12th December 2013 for 'Auction of Spectrum in 1800 MHz and 900 MHz band' and NIA dated 9th January 2015 for 'Auction of Spectrum in 2100 MHz, 1800 MHz, 900 MHz and 800 MHz Bands' stated that:

> *"Para 2.3: … Existing CMTS/UAS/UL licensees can liberalise their existing spectrum holding in 1800 MHz band for the balance validity period of spectrum assignment after payment of auction determined price prorated for the balance validity period of the Spectrum Assignment.*

In case more than one set of auction determined prices are available, the latest auction determined prices available at the time when the TSP wants to liberalise its spectrum holding, would be applied.

If the auction determined price is more than one year old then the prevailing market rates would be determined by indexing the last auction price at the rate of SBI PLR.…".

3.18 Further, the Guidelines for 'Liberalisation of Administratively allotted Spectrum in 800 MHz and 1800 MHz frequency bands' dated 5th November, 2015 states that:

"Para 7: In case more than one set of auction determined prices are available, the latest auction determined prices for the respective frequency band as available at the time of calculation of charges/ amount payable for liberalisation of spectrum, would be applied.

Para 8: If the auction determined price is more than one year old then the prevailing market rates would be determined by indexing the last auction price at the rate of SBI PLR."

3.19 The NIA dated 6th January, 2021 for 'Auction of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz & 2500 MHz Bands' stated that:

"Para 9.1.3: …if a licensee also holds administratively assigned spectrum which is non-contiguous to the spectrum held by him through auctions conducted in 2010, 2012, 2013, 2014, 2015, 2016 and the present auction, contiguity of the administratively held spectrum with any of the spectrum acquired by him through auctions will not be permitted unless such licensee liberalises his entire administratively held spectrum in that band by paying the latest market price in accordance with the relevant guideline(s) issued for liberalisation of spectrum from time to time."

3.20 From the above, it can be seen that apart from the NIA dated 25th February 2010, none of the NIAs contain any explicit clause that if auction of spectrum takes place in a particular band within less than

one year of the previous auction in the same spectrum band, the auction determined price in a spectrum band shall be the reserve price for the next round of spectrum auction. However, considering the fact that macro/microeconomic variables influencing the demand for spectrum may not vary significantly within a span of just one year it is possible to take the view that there may not be a need for a fresh exercise for valuation or indexation of auction price for that spectrum band for each round of auction, if the period between auctions is less than one year.

3.21 It may be noted that in the recently announced reform package, an annual calendar has been fixed wherein spectrum auctions will normally be held in the last quarter of every financial year.

Issues for consultation

Q.37 Whether the auction determined prices of March 2021 auction be taken as the value of spectrum in the respective band for the forthcoming auction in the individual LSA? Should the prices be indexed for the time gap (even if less than one year or just short of one year)? If yes, please indicate the basis/ rate at which the indexation should be done, with reasons.

Q.38 If the answer to the above question is in negative, whether the valuation for respective spectrum bands be estimated on the basis of the various valuation approaches/methodologies being followed by the Authority in the previous recommendations, including for those bands (in an LSA) for which either no bids were received, or spectrum was not offered for auction?

Q.39 Whether the method followed by the Authority in the Recommendations dated 01.08.2018 of considering auction determined prices of the auctions held in the previous two years be continued, or the prices revealed in spectrum auctions

conducted earlier than two years may also be taken into account? Kindly justify your response.

Q.40 Whether the valuation exercise be done every year in view of the Government's intention to have an annual calendar for auction of spectrum? Please support your response with detailed justification.

Valuation of spectrum in 800 MHz/ 900 MHz/ 1800 MHz/ 2100 MHz bands

3.22 Beginning from the Authority's recommendations on valuation and spectrum pricing dated 09.09.2013, the valuation of spectrum in various bands has been estimated on the basis of several valuation approaches/methodologies adopted by the Authority. The details of the valuation methodologies/ approaches followed by the Authority for the valuation of various spectrum bands has been given as **Annexure 3.3**.

3.23 The valuation methodologies/approaches followed by the Authority for the valuation of various spectrum bands rely on the availability of technologically segregated financial and non-financial data in addition to certain assumptions. However, nowadays the industry is moving towards technology neutral usage of spectrum enabling the TSPs to deploy new services/ multiple technologies within the same spectrum band. Essentially, the TSPs are free to provide access services using any technology in any of the spectrum bands acquired by them through auction. Therefore, technological segregation of financial and non-financial data is presently a constraint.

Issue for consultation

Q.41 Whether there is a need to bring any change in the valuation approaches/ methodologies followed by the Authority for spectrum valuation exercises in view of the changing dynamics in the telecom sector largely due to the usage of various spectrum bands by the TSPs in a technologically neutral manner? If yes, please provide suggestions along with a detailed justification about the methodology.

Valuation of spectrum in 2300 MHz and 2500 MHz bands

3.24 Like other spectrum bands, valuation of 2300 MHz (unpaired) spectrum is also dependent on the availability of data related to cost, revenue and other information pertaining to this band. However, such band specific data is not available in the case of the 2300 MHz spectrum.

3.25 Therefore, due to limited availability of information, in the year 2018, the Authority recommended the reserve price of 2300 MHz spectrum band by using the auction determined prices of the last auction (October 2016) duly indexed with Marginal Cost of Funds based Lending Rates (MCLR) for LSAs where auction had taken place, and the last recommended reserve price in the LSAs where spectrum was put to auction but could not be sold in October 2016 auction.

3.26 The spectrum in 2500 MHz band was auctioned for the first time in October 2016. The paucity of dataset due to unavailability of information in segregated form exists in this band as well. Previously, in 2016 recommendations, the Authority recommended the reserve price of the spectrum in 2500 MHz band equal to the spectrum in 2300MHz band. Further, in 2018 recommendations, the Authority made use of 2016 recommended reserve prices in case spectrum was

offered but could not be sold in October 2016 auction, and the auction determined prices revealed in October 2016 auction, duly indexed for LSAs where auction took place.

3.27 Further, during the previous recommendations the Authority took a view that the auction revealed prices in the preceding two years would be reasonable to be considered for the purpose of valuation in the present exercise. In case of 2500 MHz band, the spectrum was put to auction in 12 LSAs in March 2021 auction but it remained entirely unsold. In this situation, question arises as to whether the auction determined prices of previous auction i.e. October 2016 should be used for the determination of value of spectrum in 2500 MHz band.

3.28 Another way of valuing the spectrum in 2300 MHz or 2500 MHz bands could be to establish relative technical efficiency with other spectrum bands, as was done earlier for the valuation of 800 MHz/ 900 MHz/ 2100 MHz/ 700 MHz/ 3300-3600 MHz spectrum bands.

Issues for consultation

Q.42 In your opinion, what could be the possible reasons for the relative lack of interest for the spectrum in the 2500 MHz band? Could this be attributed to technological reason(s) such as development of network/device ecosystem or availability of substitute spectrum bands or any other reasons(s)? Please support your response with detailed justification.

Q.43 Whether the March 2021 auction determined prices be used as one possible valuation for the spectrum in 2300 MHz band for the current valuation exercise? If yes, should these prices be indexed for the time gap and at what rate? Please justify your response.

Q.44 Whether auction determined prices of October 2016 (i.e. for the auction held earlier than two years) be used as one possible valuation for the spectrum in 2500 MHz band for the current valuation exercise? If yes, should these prices be indexed for the time gap and at what rate? Please justify.

Q.45 Whether the value of the spectrum in 2300 MHz/ 2500 MHz bands should be derived by relating it to the value of spectrum in any other band by using technical efficiency factor? If yes, which band and what rate of efficiency factor should be used? If no, then which alternative method should be used for its valuation? Please justify your response with rationale and supporting studies, if any.

Valuation of spectrum in 700 MHz Band

3.29 The 700 MHz spectrum band is a relatively low frequency band amongst the commercially exploited frequency bands for providing access services. This band provides better indoor and outdoor coverage as compared to the bands which are currently in use. The report[36]by ZTE on "APT 700 MHz Best Choice for Nationwide Coverage" provides a comparative uplink edge rate from dense urban to rural environments and the coverage radius of a single site utilizing 700 MHz spectrum and 1800 MHz spectrum. The finding of the report indicates that 700 MHz spectrum band has comparative advantage over 1800 MHz band both in terms of uplink cell range as well as coverage area. Therefore, 700 MHz band has an advantage over other existing bands in terms of deployment.

[36]http://www.gsma.com/spectrum/wp-content/uploads/2013/07/ZTE-LTE-APT-700MHz-Network-White-Paper-ZTE-June-2013.pdf

3.30 This spectrum band was put to auction in India for the first time in October 2016 and thereafter in March 2021. However, no bids were received in either of the auctions.

3.31 The Authority in its recommendation dated 23.04.2012 had used international benchmarking for the purpose of valuation of this band wherein the ratio of auction price per MHz per population of similarly placed band in other countries with the corresponding price in 1800 MHz band was used to arrive at the valuation.

3.32 In the 2018 recommendations, the valuation of this spectrum band was done by the Authority based on the technical efficiency factor approach taking 1800 MHz as the reference band.

Issue for consultation

Q.46 In your opinion, what could be the possible reasons for the relative lack of interest for the spectrum in the 700 MHz band? Could this be attributed to technological reason(s) such as development of network/device ecosystem or availability of substitute spectrum bands or any other reasons(s)?

Q.47 Whether the value of spectrum in 700 MHz band be derived by relating it to the value of other spectrum bands by using a technical efficiency factor? If yes, with which spectrum band, should this band be related and what efficiency factor or formula should be used? Please justify your views with rationale and supporting studies, if any.

Q.48 If your response to the above question is in negative, what other valuation approach(es) be adopted for the valuation of 700 MHz spectrum band? Please support your response with detailed methodology.

Valuation of spectrum in 3300-3670 MHz (Mid-Band)

3.33 Frequencies in the Mid-Band (3300-3670 MHz) are considered ideal for 5th Generation (5G) networks because of its dual potential in terms of carrying large volume of data along with propagation over significant distances. This band provides balance in coverage and capacity and supports a wide range of 5G use cases. Internationally, the Mid- band, is emerging as the primary frequency bands for the introduction of 5G.

3.34 In response to a query raised by the authority to DoT in respect of the instant reference in respect of the reserve price in 3300-3670 MHz band, DoT has stated that TRAI recommended reserve price of spectrum in 3300-3600 MHz band of the TRAI recommendation dated 01.08.2018 was accepted by the Digital Communication Commission (DCC) in its meeting held in December 2109; however, the auction of spectrum in 3300-3600 MHz band could not be held due to certain issues with other Government Departments; subsequently, the concerns of different Ministries/Departments in the bands identified for IMT/5G including 3300-3600 MHz band were addressed and an additional 70 MHz (3600-3670 MHz) has become available; the increase in supply of spectrum in the Mid-Band, increase in spectrum allotment tenure from 20 to 30 years, removal of spectrum usage charges, changes in the context and timing of the auction, are all variations from the situation prevailing at the time of 2018 recommendations; the Authority may like to consider all these factors while making recommendations.

3.35 In the 2018 recommendations, the Authority recommended the reserve price of 3300-3600 MHz band equal to 30% of the reserve price of 1800 MHz FDD band keeping in view the coverage analysis according to which, 3300-3600 MHz spectrum band TDD coverage will be around 30% of the 1800 MHz FDD coverage.

Issue for consultation

Q.49 Whether the valuation of the 3300-3670 MHz spectrum band should be derived from value of any other spectrum band by using technical efficiency factor? If yes, what rate of efficiency factor should be used? If no, which other method(s) should be used for its valuation? Please justify your response with rationale and supporting documents, if any.

Valuation of spectrum in 526-698 MHz bands

3.36 These bands provide enhanced coverage, carries excellent penetration potential enabling the wireless signal to penetrate windows and walls.

3.37 These bands are to be put to auction for the first time. Globally also, only a few jurisdictions have concluded spectrum auctions for wireless services in this band. Thus, there is a constraint of both national and international level data for this band.

3.38 Considering the fact that all sub-1 GHz bands, which are currently planned for IMT, share common characteristics of enhanced coverage and penetration accompanied with low capacity, there exists the possibility of applying a common technical factor related to a particular band for all sub-1 GHz bands.

Issues for consultation

Q.50 In case you are of the opinion that frequencies in the range 526-698 MHz should be put to auction in the forthcoming spectrum auction, whether the value of 526-698 MHz be derived by using technical efficiency factor? If yes, with which spectrum band, should this band be related and what efficiency factor or formula should be used? Please justify your suggestions.

Q.51 If your response to the above question is in negative, which other valuation approach(es) should be adopted for the valuation of these spectrum bands? Please support your suggestions with detailed methodology, related assumptions and any other relevant factors.

Valuation of 24.25 GHz – 28.5 GHz (mmWave band)

3.39 The millimetre Wave (mmWave) band is currently under use largely by the satellite ecosystem, as a primary user under the International Telecommunication Union (ITU) regime. Satellite users in such bands (mmWave) use applications ranging from enterprise and government networks for broadband delivery, consumer broadband delivery, cellular backhauls, and broadcasting.

3.40 The frequencies in the mmWave Band can travel only small distances and are subject to rapid attenuation and thus their signal can be interrupted by objects. However, what makes this spectrum band a valuable resource for mobile networks is the amount of spectrum available in it. Thus, though the band lacks in terms of coverage, it carries an edge in terms of capacity and speed.

3.41 In the World Radiocommunication Conference, 2019 (WRC-19) organized by the ITU, 24.25-27.5 GHz band was globally identified for IMT. Many countries have already concluded auction in these bands.

3.42 The 24.25 – 28.5 GHz spectrum is being contemplated for auction in India for the first time. There is no historical auction data available to conduct comparative analysis involving auction determined prices in India. Thus, alternative approaches for valuation of this band could be based on comparative values that can be achieved by using relative technical efficiency factor of some other spectrum bands. The possibility of using international benchmarking can also be explored in this band.

Issues for consultation

Q.52 Whether the value of spectrum in 24.25 - 28.5 GHz band be derived by relating it to the value of other bands by using technical efficiency factor? If yes, with which spectrum band, should this band be related and what efficiency factor or formula should be used? Please justify your suggestions.

Q.53 If your response to the above question is in negative, which other valuation approaches should be adopted for the valuation of these spectrum bands? Please support your suggestions with detailed methodology, related assumptions and other relevant factors.

International benchmarking for new bands

3.43 Since the spectrum in 526-698 MHz and 24.25-28.5 GHz bands is being contemplated for auction for the first time, the non-availability of data acts as a constraint for valuation of these bands. The deficiency of band specific data imposes the necessity to opt for alternative methods such as international benchmarking. The details of auctions held in these two bands internationally are given at **Annexure 3.4**.

3.44 The Authority had followed a similar approach in previous spectrum valuation exercise. In 2012, international trends in the auction price of similar spectrum band were used to arrive at reserve price of 700 MHz band.

3.45 Similarly, in 2008, international average auction determined price in countries comparable to India, was used to arrive at the reserve price for 2300-2400, 2500-2690 and 3300-3400 MHz bands.

3.46 The advantage of using this approach is that it is based on revealed willingness to pay (WTP) i.e. it is based on prices that have actually been paid by specific buyers for a certain amount of spectrum in a particular country. However, countries are not strictly comparable. There may be differences in other factors such as population, subscriber base, demographics, license duration of spectrum offered etc. In order to arrive at the valuation, there may be a need to apply some normalization technique in order to obtain a comparable spectrum valuation.

Issues for consultation

Q.54 Whether international benchmarking by comparing the auction determined price in countries where auctions have been concluded be used for arriving at the value of these new bands? If yes, then what methodology can be followed in this regard? Please explain.

Q.55 For international benchmarking, whether normalization techniques be used for arriving at the valuation of these new bands in the Indian context? If yes, please justify your response with rationale /literature, if any.

Use of technical efficiency factor

3.47 Under this approach, the coverage/ propagation characteristic of a particular band is compared with the coverage of 1800 MHz band and a technical efficiency factor is derived based on the ratio of the two bands.

3.48 This method has been used in the past recommendations for valuation of 800 MHz, 900 MHz, 2100 MHz bands. The approach was also used in the valuation of 700 MHz and 3300-3600 MHz band in the recent recommendations.

3.49 The sub-1 GHz bands may be considered to be similar in terms of their technical characteristics. These bands provide enhanced coverage enabling the TSPs to serve a vast customer base spread over a large area. These bands carry excellent penetration potential enabling the wireless signal to penetrate through walls and obstructions.

3.50 The Authority in the past recommendations have used distinct technical efficiency factor for these bands. Given the similarity in the technical characteristics of these bands, applying a methodology of a uniform technical factor, with reference to a similar band, can also be considered.

Issues for consultation

Q.56 Whether a common methodology/ approach should be used for valuation of all sub-1 GHz bands, which are currently planned for IMT? If yes, suggest which methodology/ approach should be used. Please give your views along with supporting reasoning and documents/ literature, if any.

Use of trend-line approach for valuation of spectrum

3.51 The 1800 MHz band has received significant bids in various auctions and there is sufficient data on auction determined price in this band. In 18 out of 22 LSAs, there are at-least four auction determined prices discovered in last five auctions concluded since 2012. In Delhi, Mumbai, Karnataka and Rajasthan, three auction determined prices (ADP) are available along with reserve prices.

3.52 Since ADPs have been consistently considered by the Authority as the best indicator of valuation, using the available information on ADPs, a trend line may be established for each LSA predicting expected ADP in the future auctions using extrapolation.

3.53 Using this method, ADP may be expressed as a function of time wherein a linear relationship may be established between ADP and time by expressing ADP as a linear function of time as follows:

ADP = a + b * t

where a is constant and b is coefficient of time (t).

3.54 Based on the above equation, ADP for future auctions can be predicted at different point of time (t). The extrapolated ADP may be assumed as the present valuation of 1800 MHz in each LSA at that time (auction year).

Issue for consultation

Q.57 Whether the extrapolated ADP based on a time-series analysis, may be considered as the valuation itself or some normalization may be performed taking into account the financial, economic and other parameters pertaining to a particular auction? If yes, which factors should be considered and what methodology should be followed?

Valuation of Spectrum: Single Approach -Versus- Multiple Approaches

3.55 The Authority, since September 2013, has taken a consistent view that instead of depending on the valuation arrived at using any single approach, it would be better to rely on a number of such approaches to arrive at a final reasonable valuation and then determine reserve price based on such valuation. Accordingly, the Authority has been using various approaches to arrive at the valuation of different spectrums bands and to determine the reserve price of different spectrum bands for the auction of various bands of spectrum from time to time. All of these valuation approaches have their merits as well as demerits and it would be appropriate to rely on a number of such approaches to arrive

at a final reasonable valuation rather than depending on the valuation arrived at using any one approach.

3.56 The Authority in its spectrum valuation exercises has used probabilistic average valuation (simple mean) of the valuations obtained through the different approaches attempted for valuation of a particular spectrum band and the same has been accepted by the Government. Taking into account the principle of equal probability of occurrence of each valuation, will it be appropriate to take the average valuation (simple mean) of the valuations obtained through the different approaches attempted for valuation of a particular spectrum band, as adopted by the Authority since September 2013 recommendations or some other methodology be used for valuation exercise.

Issues for Consultation

Q.58 Whether the value arrived at by using any single valuation approach for a particular spectrum band should be taken as the appropriate value of that band? If yes, please suggest which single approach/ method should be used. Please justify your response.

Q.59 In case your response to the above question is negative, will it be appropriate to take the average valuation (simple mean) of the valuations obtained through the different approaches attempted for valuation of a particular spectrum band, or some other approach like taking weighted mean, median etc. should be followed? Please justify your response.

Other possible valuation approaches

3.57 In addition to the various valuation approaches discussed above in respect of various spectrum bands under reference, there could be other suitable approaches.

Issue for Consultation

Q.60 Is there any valuation approach other than those discussed above or any international auction experience/ approach that could be used for arriving at the valuation of spectrum for 700 MHz/ 800 MHz/ 900 MHz/ 1800 MHz/ 2100 MHz/ 2300 MHz/ 2500 MHz/ 3300-3670 MHz/ 24.25 - 28.5 GHz/ 526 - 698 MHz bands? Please support your suggestions with a detailed methodology and related assumptions.

Reserve Price Estimation

3.58 A reserve price refers to the lower bound on the bid below which the item up for sale cannot be acquired through an auction. The reserve price ensures a minimum guaranteed amount for the owner/seller of goods. It prevents excessive bargaining in an auction process.

3.59 Reserve price should be set at an optimal level to ensure efficiency of the auction process. A high reserve price may discourage participation and the competitiveness of the auction. Low participation leads to low sales and revenue. On the other hand, too low a reserve price hampers the realisation of the true value of the underlying asset by incentivizing collusive behaviour among participants. Thus, a balanced intermediate reserve price satisfies the basic objectives of reserve price setting viz. ensuring appropriate revenue and deterring collusion.

3.60 In order to ensure competitive bidding and price discovery, the reserve price should not be too close to the expected/predicted valuation of the object put up for auction.

3.61 In its past valuation exercises, the authority estimated the value of spectrum using various valuation models and taking a mean of value derived from all approaches. The reserve price is set at 80% of the

valuation and is compared with the price discovered in previous auctions to arrive at final reserve price.

Issues for consultation

Q.61 Should the reserve price be taken as 80% of the valuation of spectrum? If not, then what ratio should be adopted between the reserve price for the auction and the valuation of the spectrum in different spectrum bands and why?

Q.62 Whether the realized/ auction determined prices achieved in the March 2021 auction for various spectrum bands can be directly adopted as the reserve price in respective spectrum bands for the forthcoming auction? If yes, should these prices be indexed for the time gap since the auction held in March 2021 and at which rate the indexation should be done?

Calculation of bid amount to be paid by the bidder in case spectrum is not available in a part of LSA

3.62 Through the instant reference, DoT has informed, *inter-alia*, that the Government has decided to make available the spectrum in 3300 - 3670 MHz, 526 - 698 MHz and 24.25 - 28.5 GHz bands to the TSPs for IMT/ 5G through auction except in a few areas/ locations. In this regard, the details given in Chapter-I may please be referred to.

3.63 In the Notice Inviting Applications (NIA) dated 6th January, 2021 for 'Auction of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz & 2500 MHz Bands', DoT included, *inter-alia*, the following provision in respect of spectrum allotment in a part of LSA:

> *"For the LSAs (For Territorial Jurisdiction of LSAs, please see Annexure G of Section 12.7) where the spectrum is not available in some of the districts, while the bids will be sought for spectrum in entire LSA, the bid amount will be collected only for the spectrum available and the balance*

collected as and when spectrum is made available in each District, the amount being pro-rated to the population of that district(s) (as of census of 2011) and the balance period (of the 20 years). Bid amount as mentioned above will be collected subject to the condition that the amount to be collected in future at the time of providing balance spectrum would be the balance prorated bid amount indexed on the SBI PLR prevalent for the period between finalisation of bid price and actual assignment made. In all partial assignment cases where the successful bidders are more than one, the post auction assignment of balance spectrum will be made to all the successful bidders, district wise based on auction date and rank."

Issue for consultation

Q.63 Should the method followed by DoT in the previous auction in respect of collecting bid amount from the successful bidder in case spectrum is not available in a part of the LSA be followed in the forthcoming auction? Please justify your response in detail.

Associated conditions

3.64 Through the letter dated 23.09.2021, DoT conveyed to the Authority that the Government has recently taken the following decisions with regard to future spectrum auctions:

(a) Rationalization of Bank Guarantees to securitize deferred annual spectrum payment instalments
(b) Increase in duration of spectrum allocation
(c) Regular conduct of spectrum auction on annual basis
(d) Provision for surrender of spectrum
(e) No spectrum usage charges (SUC) for spectrum acquired in future auctions

(f) Removal of additional SUC of 0.5% for spectrum sharing

3.65 Through the above letter, DoT also mentioned that while undertaking auction of spectrum with validity for 30 years, TRAI recommendations will also be sought for associated conditions like upfront payment requirements, applicable moratorium period after upfront payments, number of deferred payment instalments and other related modalities.

Payment Terms

3.66 Broadly, the payment terms issued by DoT through its Notice Inviting Applications (NIA) fall in the following categories:

(a) Upfront Payment
(b) Moratorium
(c) Number of annual instalments

Upfront Payments

3.67 As per NIA dated 6th January, 2021 for 'Auction of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz & 2500 MHz Bands', upfront payment of 50% was fixed in the case of 1800 MHz, 2100 MHz, 2300 MHz & 2500 MHz bands. This was same in the NIA dated 8th August, 2016. However, for the preceding years (viz. the years 2015, 2013 and 2012), the upfront payment rate in case of above 1 GHz spectrum bands was fixed at 33%. On the other hand, in case of sub-1 GHz bands viz. 700 MHz, 800 MHz and 900 MHz, the upfront payment rate was fixed at 25% and upfront payment criteria remained consistent in earlier NIAs also.

Prepayment option

3.68 As per prepayment option given in the NIA 2021: -

> *"Prepayment of one or more instalments will be allowed on each annual anniversary date of the first upfront payment, based upon the principle that the Net Present Value (NPV) of the payment is protected."*

Moratorium Period

3.69 The prevailing moratorium period of two years for payment of balance amount of one-time charges for the spectrum has remained consistent throughout. In the recent reform package, Government has announced a moratorium/ deferment for upto four years on the dues for the spectrum purchased in past auctions (excluding 2021 auction).

No. of instalments

3.70 As per NIA 2021, for the case of deferred payments, the outstanding amount subsequent to the upfront payments shall be recovered in 16 equal annual instalments. However, in the earlier NIAs, the number of equal annual instalment stood at 10.

Extending the validity

3.71 In the recently announced reform package for telecom sector, the validity period of the right to use spectrum acquired in the future auctions has been extended from the existing 20 years to 30 years. This will enable the TSPs to reap benefits from the spectrum usage over an increased time horizon, thereby increasing the value of spectrum from the perspective of spectrum user.

Issues for consultation

Q.64 What percentage rate of upfront payment should be fixed in case of each spectrum band?

Q.65 What should be the applicable period of moratorium for deferred payment option?

Q.66 How many instalments should be fixed to recover the deferred payment?

Q.67 What rate of discount should be used while exercising pre-payment/deferred payment option, in order to ensure that the net present value of payment/ bid amount is protected?

Please support your suggestions for Q64 to Q67 with proper justifications.

CHAPTER–IV: SPECTRUM FOR PRIVATE CELLULAR NETWORKS

A. About Private Cellular Network

4.1 A Private Cellular Network is basically a local area network (LAN) that uses cellular technologies to create a dedicated network with unified connectivity, optimized services and a secure means of communication within a specific geographic area. Newer cellular technologies such as LTE and 5G, are capable of providing very high capacity and low latency, which has enabled the use of cellular technologies for industrial automation. Considering the capabilities of 5G technology, it is being projected as a catalyst for 4th Industrial Revolution and thereby one of its the prominent use case is 'Industry 4.0'.

4.2 3GPP has referred a private network as a Non-Public Network (NPN) which has been defined by it as "*a network that is intended for non-public use*". According to 3GPP [3GPP TS 22.261],

> '*Non-public networks are intended for the sole use of a private entity such as an enterprise, and may be deployed in a variety of configurations, utilising both virtual and physical elements. Specifically, they may be deployed as completely standalone networks, they may be hosted by a Public Land Mobile Network (PLMN), or they may be offered as a slice of a PLMN.*
>
> *In any of these deployment options, it is expected that unauthorized UEs, those that are not associated with the enterprise, will not attempt to access the non-public network, which could result in resources being used to reject that UE and thereby not be available for the UEs of the enterprise. It is also expected that UEs of the enterprise will not attempt to access a network they are not authorized to access. For example, some enterprise UEs may be restricted to only access the non-public network of the enterprise, even if PLMN coverage is available in the same*

geographic area. Other enterprise UEs may be able to access both a non-public network and a PLMN where specifically allowed.'

4.3 GSA defines Private Mobile Network as a 3GPP-based 4G/LTE-5G private mobile network intended for the sole use of private entities such as enterprises, industries or governments, that is not offered to the general public and uses spectrum defined in 3GPP[37].

4.4 The private cellular networks are suitable for different groups of applications, with specific architectures applicable to building various types of private networks[38]. They can be used by industries for automate manufacturing lines, reduce security risks, protect employees from dangerous environments, monitoring and control of assets, predictive performance and condition-based maintenance, digital assistance, etc[39]. They can be useful in a wide variety of venue environments, healthcare, education etc. Enterprises have used the private network to improved productivity, efficiency, flexibility, quality, security, and competitiveness.

4.5 The newer cellular technologies such as LTE and 5G have enabled private networks to go wireless which gives them additional benefits such as use of robots, software driven controls, remote location monitoring & control, ease in detection & resolution of issues, lower operational cost etc.

4.6 According to GSA[40], the demand for private mobile networks based on LTE (and increasingly 5G) technologies is being driven by the spiralling data, security, digitization and enterprise mobility requirements of modern business and government entities. Organizations of all types are combining connected systems with big data and analytics to transform operations, increase automation and efficiency or deliver new

[37] GSA: https://gsacom.com/press-release/gsa-catalogues-370-private-mobile-networks/
[38] 5G Americas: Whitepaper on 5G Technologies in Private Networks (October 2020)
[39] Capgemini: The Adoption of Private Networks for Enterprises (March 2021)
[40] GSA: Private Mobile Networks (September 2021)

services to their users. Wireless networking with LTE or 5G enables these transformations to take place even in the most dynamic, remote, or highly secure environments, while offering the scale benefits of a technology that has already been deployed worldwide.

4.7 In a white paper[41] published by Ericsson on '5G spectrum for local industrial networks', the likely benefits of Industry 4.0 have been elaborated, citing certain examples. Some of the excerpts are as follows:

a) Taking manufacturing, with its estimated 1 million factories (with more than 100 employees), as an example, typical business cases revolve around controlling the production process, improving material management, improving safety, and introducing new tools. Typical revenue increases come from increased throughput and quality (2–3 percent), while typical cost savings stem from improved capital efficiency (5–10 percent) and decreased manufacturing costs (4–8 percent).

b) ABI Research has shown that manufacturers can expect to see a tenfold increase in their returns on investment (ROIs) for cellular Industry 4.0 solutions, while warehouse owners can expect a staggering fourteenfold increase in ROI.

c) In Boliden's open-pit Aitik mine, for example, drilling productivity could be increased by 40 percent through automation of its drills alone. Additional savings from increased usage of equipment could also lead to lower capital expenditures for mines (CapEx) as well as a better safety and working environments for their personnel.

d) One case study examining the private 5G network trial for the automation of China's Port of Qingdao indicated that a 70-percent labor cost savings could be achieved if 5G automation were to be fully implemented. In Italy's Port of Livorno suggest much the same, with the potential for significant savings in port and quay operations

[41] https://www.ericsson.com/en/reports-and-papers/white-papers/5g-spectrum-for-local-industrial-networks

as well as reduced berthing times for vessels and shortened cargo release times.

B. Technologies for Private Network:

4.8 The arrival of LTE-Advanced systems delivered a step change in network capacity and throughput, while 5G networks have brought improved density, support for larger numbers of users or devices, even greater capacity, as well as dramatic improvements to latency that enable use of mobile technology for time-critical applications[42].

4.9 The private LTE market is robust, with deployment activity across many sectors globally. Private LTE systems take advantage of the global LTE ecosystem, which benefits from high volume, standardized technology, and well-established suppliers able to design and deploy networks. The scale economics and interoperability benefits of global 3GPP technologies also apply to sector-specific equipment, and well-developed supply chains and established best practices are now in place in many sectors. For example, devices such as sensors, automated guided vehicles (AGVs), security cameras, safety equipment, etc. are now available with integrated LTE[43].

4.10 5G technologies are increasingly delivering enhanced networking speed, latency, bandwidth, privacy, and other benefits supporting emerging applications that are built on the proven technology of private LTE networks. A private 5G network is a local area network that provides all the features of a 5G network including reduced latency, higher speeds and all the advantages in terms of efficiency and security[44].

4.11 Private 5G is arriving with a lot of promise about enabling new, innovative use cases that will bring great value to enterprises across different industries such as manufacturing, mining, logistics,

[42] GSA: Private Mobile Networks (September 2021)
[43] Qualcomm: Private 5G Networks for Industrial IoT (July 2019)
[44] 5G Americas: Whitepaper on 5G Technologies in Private Networks (October 2020)

transport, healthcare, agriculture, education, entertainment etc. With the advent of Private 5G solutions, there is a new alternative to Wi-Fi or Private LTE for businesses looking at wireless networking solutions. Each form of connectivity, whether that be Wi-Fi or industrial ethernet or private 5G, has its own capabilities that is suited to support different types of use cases[45].

4.12 Though many industrial applications can be supported on LTE, users may have more demanding performance requirements, in terms of availability, reliability, latency, jitter, device density, throughput, etc. 5G is better suited to their needs than LTE. 5G includes innovations in the radio domain and system architecture that make it better able to meet the requirements of high-performance industrial applications. Private 5G trials and commercial pilots are already underway, and adoption will scale rapidly as 3GPP Release 16 capabilities and ecosystem support are now available[46].

4.13 Comparing the different capabilities of wireless networking solutions is given in table below:

	Security	Mobility & off-site	Bandwidth	Ability to synch.	Outdoor suitability	Latency	Layout flexibility	Reliable coverage
Wi-Fi	×	×	✓	×	×	×	✓✓	✓
Private LTE	✓	✓✓	✓	✓	✓✓	✓	✓✓	✓✓
Private 5G	✓	✓✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓

Other alternatives that we have not covered include industrial ethernet, Bluetooth, public cellular etc.

Source: STL Partners

4.14 There are some key features in the 5G system that make it very appealing for private network deployments. 3GPP Release 16 aims to

[45] https://stlpartners.com/telco_cloud/private-5g-vs-wi-fi-vs-private-lte/
[46] Qualcomm: Private 5G Networks for Industrial IoT (July 2019)

enable 5G to substitute for private wired Ethernet, Wi-Fi, and LTE networks, and includes multiple capabilities designed specifically for industrial environments[47].

C. Benefits of private LTE and 5G networks for enterprises[48]

4.15 More and more enterprises are realizing that the conventional choices for deploying wireless broadband connectivity i.e. Wi-Fi or public cellular networks, are not delivering the efficiency, control and security they need to satisfy the demands of their business operations. In contrast, private LTE and 5G networks for enterprises bring distinct benefits especially for business critical and security critical applications:

- Superior service security based on SIM-based authentication
- Improved control and management of connectivity with better reliability, resiliency and predictability
- Increased availability and coverage due to new spectrum bands that became available specifically for private cellular networks
- Full control over the enterprise's own operating processes as the enterprise itself operates the mobile network infrastructure.
- Enhanced data security as data segregated and processed locally and separately from public 5G networks
- Controlled latency enables near real-time communication, a crucial factor in applications such as public safety or robotic motion control.
- Network slicing allows the network to be optimised for the needs of specific user groups, devices or applications over the same infrastructure.

[47] Deloitte: Technology, Media, and Telecommunications Predictions 2020
[48] https://zeetta.com/solutions/private-cellular-networks-for-enterprises/

D. International Scenario on deployment of Private Cellular Networks

4.16 GSA in one of its report[49] has mentioned that exact number of existing private mobile network deployments is hard to determine, as details are not often made public. GSA has identified 55 countries/territories with private network deployments based on LTE or 5G or LTE or where 5G-suitable private network spectrum licenses have been assigned. In addition, there are private mobile network installations in various offshore locations serving the oil and gas industries, as well as on ships.

4.17 In their report, it has been mentioned that GSA has collated information about 626 organizations known to be deploying LTE or 5G private mobile networks or known to have been granted a license suitable for the deployment of a private LTE or 5G network (but excluding those that have deployed alternative technologies) – up from 370 catalogued organizations in the last issue. Within this count there are 528 organizations catalogued to have deployed, or to be deploying private mobile networks based on LTE or 5G. According to GSA, LTE is used in 75% of the 528 catalogued private mobile network deployments, while 5G is also being deployed (or planned for deployment) in 29% of those networks.

E. DoT Reference

4.18 DoT, through its reference vide letter dated 13th September 2021 has requested TRAI to provide recommendation on quantum of spectrum / bands, if any, to be earmarked for private captive / isolated 5G networks, competitive / transparent method of allocation, and pricing, for meeting the spectrum requirements for captive 5G applications of industries for machine / plant automation purposes / M2M in premises.

[49] https://gsacom.com/paper/private-mobile-networks-member-report-september-2021/

4.19 In the reference, it has been mentioned that DoT has received few requests for spectrum requirements for captive usage for 5G applications by some industries e.g., Industry 4.0 and COAI has also submitted a letter regarding Private Captive Networks wherein they have inter alia requested not to reserve any spectrum which has been identified for IMT, for Private Captive Networks.

F. Models for meeting the needs of industries/enterprises

4.20 Considering the benefits of LTE and 5G based private networks, wireless connectivity is increasingly becoming a necessity for business-critical services in industrial processes, such as those related to assembly lines and other modes of production.

4.21 Different enterprises can have different strategies regarding connectivity for their core operations. For some Industries, such as manufacturers producing high-quantity and high-value products, even a few minutes of assembly line downtime could potentially mean severe revenue losses; such industries may like to own and operate their network equipment themselves. For many industries, service-level agreements (SLAs) will satisfy and regulate such needs for guaranteed network uptime and quality. As discussed, the requirement of the industries can broadly be met in two ways either by using services of the TSPs or by deploying own private network, which are discussed in detail in subsequent sections.

a) Meeting the demand for private network through TSPs

4.22 TSPs have skill and experience in designing, building, managing, and maintaining cellular networks. Further, wide range of spectrum availability with TSPs enable them to address needs of the different enterprises. This is true even in countries with locally licensed spectrum for enterprises, as different frequency bands have complementary characteristics, with low bands provide better coverage and availability and having the most diverse device support but

typically smaller bandwidth, mid bands offer significantly improved capacity with a good balance of coverage, and high bands such as mmWave bands provide a major capacity boost but have limited coverage.

4.23 One way, a TSP could provide private network as a service to an enterprise, is by using network slicing over its public network. 5G technology has the capability to offer different service profiles using network slicing feature and each created slice can have attributes or combination of attributes such as low latency, high bandwidth, support for huge number of devices etc. The advantage of network slicing is that the TSPs can create and use different slices to serve different use cases/applications/user groups, according to the specific need, over the same infrastructure.

4.24 Another way, a TSP could provide private network service, is by building a separate private network for an enterprise/industry using its own existing spectrum holding. As already mentioned, wide range of spectrum availability with TSPs (in different spectrum bands) could enable them to address industry needs in the best possible ways. This option may also be used in cases where security and control are the key concerns of the enterprises. As the spectrum is assigned to the Access Service Licensee for establishing a Public Land Mobile Network (PLMN), a question arises that whether an explicit enabling clause is needed in the license to permit the Access Service licensee to set-up private network (isolated from public network), using the spectrum assigned for PLMN.

4.25 In view of the foregoing discussion, to meet the industrial demand through TSPs, the first issue that needs deliberation is that whether the licensing/policy framework require any facilitation or changes.

Issue for Consultation

Q.68 To facilitate the TSPs to meet the demand for Private Cellular Networks, whether any change(s) in the licensing/policy framework, are required to be made. If yes, what changes are required to be made? Kindly justify your response.

b) Meeting the demand for private networks through geography based (localized) private captive cellular networks

4.26 In cases, where an enterprise wishes to deploy and maintain its own private cellular network, one of the most important inputs is availability of access spectrum in globally harmonized IMT bands. The need for spectrum for private networks can be met in many ways, such as, using unlicensed spectrum, leasing of spectrum by TSPs to the private entities and earmarking some dedicated spectrum for private captive networks. These options are discussed below.

i) Unlicensed Spectrum

4.27 Unlicensed spectrum can be used by an organization to operate private network, subject to regulatory conditions. Though these spectrums are widely available and easy to access but there could be a possibility of interference from other users, making organizations reluctant to rely on it for production-critical networks. However, 5G radio innovations such as Coordinated MultiPoint (CoMP) combined with good network design may help in achieving consistent and reliable performance in shared frequency bands.

4.28 Currently, in India 2.4 GHz and 5 GHz bands are unlicensed. USA adopted rules that make 1.2 GHz of spectrum in the 6 GHz band available for unlicensed use. It authorizes indoor low-power operations. An automated frequency coordination system will prevent standard

power access points from operating where they could cause interference to incumbent services[50].

4.29 In Europe, the European Commission approved regulations to allow the deployment of the lower 6 GHz band (5945-6425 MHz)[51] for Wi-Fi use, releasing 480 MHz spectrum for the same[52].

4.30 With 3GPP Release 16, the foundation has been laid for deploying 5G New radio in unlicensed spectrum (referred as NR-U) in the license exempt 5 GHz and 6 GHz bands. Having said that, use of unlicensed band may not be preferred by some enterprises which require high grade network in terms of reliability, data rate or latency.

ii) Leasing of spectrum by TSPs to enterprises for private captive networks

4.31 In Spectrum leasing option, a TSP having exclusive spectrum usage rights, leases part of or entire spectrum holding to an enterprise (for localized captive use), for a specified period and geography. For such specified time and specified geography, the rights get transferred to the transferee entity and reverts to the transferor after expiry of such leasing period. So far, leasing of spectrum is not permitted in India.

4.32 Option of spectrum leasing has been opened in many countries such as Australia, Denmark, Finland, France, Germany, Malaysia, UK, USA etc.

4.33 Leasing of spectrum could result in efficient utilization of spectrum as the TSPs will be utilizing the access spectrum for provision of mobile services in majority of the geography, and same spectrum will be utilized by the enterprise in its limited geography for their private captive network. This option will enable TSPs to better monetize the spectrum, as additional revenue stream could be created. Further, the TSP will be in a better position to manage the interference issues, which

[50] https://www.fcc.gov/document/fcc-opens-6-ghz-band-wi-fi-and-other-unlicensed-uses
[51] Wi Fi Alliance: Wi-Fi 6E Insights Newsletter (July 2021)
[52] https://www.eetimes.eu/eu-boosts-6ghz-spectrum-for-wi-fi-use/

may arise due to captive usage of spectrum by the enterprise. While, this option appears to be a good option, it may have some practical issues such as, (i) it may be difficult for industries to get spectrum from TSPs, (ii) the price charged by the TSPs may work as a deterrent, (iii) certainty on continuity of operations could become an issue, (iv) high order dependence on the TSPs, etc. Having said that, permitting of leasing of spectrum may create an alternate option for the enterprises. In case leasing of spectrum to enterprises for private captive networks is permitted, the following issues need to be deliberated:

Issues for Consultation

Q.69 To meet the demand for spectrum in globally harmonized IMT bands for private captive networks, whether the TSPs should be permitted to give access spectrum on lease to an enterprise (for localized captive use), for a specific duration and geographic location? Kindly justify your response.

Q.70 In case spectrum leasing is permitted,

i. Whether the enterprise be permitted to take spectrum on lease from more than one TSPs?

ii. What mechanism may be prescribed to keep the Government informed about such spectrum leasing i.e., prior approval or prior intimation?

iii. What timeline should be prescribed (in number of days) before the tentative date of leasing for submitting a joint request by the TSPs along with the enterprise, for approval/intimation from/to the Government?

iv. Whether the spectrum leasing guidelines should prescribe duration of lease, charges for leasing,

adherence of spectrum cap provisions, roll out obligations, compliance obligations. If yes, what terms and conditions should be prescribed?

v. **What other associated terms and conditions may be prescribed?**

vi. **Any other suggestion relevant to leasing of spectrum may also be made in detail.**

(Kindly justify your response)

iii) Earmarking spectrum for private captive networks

4.34 Under this option, the Regulators earmark some quantum of spectrum in harmonized IMT bands for private captive networks. Such spectrum, assigned to enterprises, is utilized within a limited geographic area; therefore, it is also referred as spectrum for localized or local use. Spectrum assigned for localized private captive networks is used in such a manner that the signals are restricted within its geographic area and do not cause interference to other outside systems. Considering the need for spectrum for private networks, Regulators in many countries have allocated spectrum specifically for local use.

4.35 In the global scenario, most of the countries have considered the mid-band and/or the mmWave spectrum for private network licenses. Some of the countries which have either earmarked or are planning to earmark spectrum in mid-band for local use are US, France, Slovenia, Poland, Denmark, Czech Republic, Netherlands, and Norway. In case mmWave bands, Australia, Hong Kong, Malaysia, Italy, and Russia have earmarked or are planning spectrum allocation for local use. On the other hand, Germany, Finland, UK, Sweden, South Korea, and Japan have opened or are planning to open both the bands.

4.36 The method of allocation is administrative in most cases, whereby interested parties directly apply for licenses to the national regulator. This holds true for Germany, UK, France, Finland, Sweden, Australia, South Korea, Hong Kong, Malaysia, etc. The General Authorized Access (GAA) in US is an exception, which is open to the widest possible group of users for free, without the need of a license from FCC. In Germany, the entire 3.7-3.8 GHz range is intended for vertical uses only, while the 26 GHz band is open to MNOs and regional operators as well. Countries such as UK, Finland, Australia, South Korea, Hong Kong and Malaysia have decided upon fragmented use of certain bands for public and private use.

4.37 Some countries have earmarked frequency range for private networks in global IMT frequency bands which are currently being used for other services also and therefore, it is offered on a shared use basis. OFCOM, UK[53] in its publication on 'Enabling wireless innovation through local licensing - Shared access to spectrum supporting mobile technology' has mentioned that "*We want to support innovation and enable new uses of spectrum, and we recognize there is growing interest in the use of mobile technology, including 5G, to develop solutions to meet local wireless connectivity needs. To ensure that lack of access to the radio spectrum does not prevent innovation, we are introducing a new licensing approach to provide localised access to spectrum bands that can support mobile technology.*" The decisions taken by OFCOM are reproduced below:

> "*We are making spectrum in the 3.8-4.2 GHz, 1800 MHz and 2300 MHz spectrum bands available through local licences. People can apply to Ofcom for coordinated access (this ensures they won't cause interference) to these bands on a first come, first served basis and will pay a licence fee that reflects Ofcom's cost of issuing the licence. To achieve a simple process across the shared access bands, we will also align the authorisation approach for existing licensees in the 1800 MHz shared spectrum with the*

[53] https://www.ofcom.org.uk/__data/assets/pdf_file/0033/157884/enabling-wireless-innovation-through-local-licensing.pdf

authorisation approach for the shared access bands confirmed in this statement.

We are introducing a new way to access spectrum that is already licensed to mobile operators but which is not being used or planned for use in a particular area within the next three years. People can apply to Ofcom for a licence and, if the application is successful, will pay £950 per license, which allows them to use the spectrum for three years unless they ask for a different period and this can be agreed with the existing licensees.

We have added the 24.25-26.5 GHz band to our spectrum sharing framework for indoor-only deployment. This is part of the 26 GHz band, identified as a European pioneer 5G band, and could provide additional spectrum options for new applications."

4.38 It is noted that some countries such as Australia, UK, US, Germany, Canada, have allowed assignment of spectrum for local use by private networks in the frequency range already being used by other users whose spectrum use is in specific geographies, such as Fixed Satellite Service (FSS). For instance, Germany[54] has prescribed the following:

i) In 3.7-3.8 GHz band for local licenses, local users must ensure interference-free use, including by coordinating with other geographically near local users and protecting existing users in the band (e.g., FSS earth stations).

ii) In 26 GHz (24.25 – 27.5 GHz) for local licenses, local users must operate on a non-interference basis and protect existing services for example, fixed point-to-point links in 24.25-26.5 GHz, Earth-Exploration Satellite (EESS) Service in 25.5-27 GHz.

4.39 Details of the global scenario on spectrum for private networks are available in **Annexure 4.1**.

4.40 Considering that the economic benefits from next industrial revolution i.e., Industry 4.0 could be many folds and it could prove to be a catalyst in the overall growth of the country, there is a need to explore how best the private cellular networks be implemented and promoted in India.

[54] https://digitalregulation.org/spectrum-licensing-local-and-private-networks-in-germany/

Further, there is also a need to explore the spectrum for local use on location-specific basis in those globally harmonized IMT spectrum bands which are currently being used for non-IMT services and can coexist with local use of spectrum. For instance, in India, spectrum range from 3670-4200 MHz in mid-band and spectrum range 28.5-29.5 GHz in mmWave band which are currently being used for satellite communications could also be explored for local use by private captive networks without causing any interference.

4.41 In case some quantum of spectrum is earmarked for private captive networks, the same spectrum can be utilized by various enterprises in different geographic locations. Considering the availability of spectrum for IMT services in different bands, in some of these bands, it may be difficult to dedicate some quantum of spectrum for private captive networks as reduced spectrum availability for IMT may impact 5G services for the public at large. However, in case spectrum frequencies are made available for local use on shared basis with other services/users, which operates in geographically distinct locations, spectrum utilization will enhance. Further, DoT through its reference, has sought TRAI recommendations on quantum of spectrum/bands, if any to be earmarked for private captive networks. Therefore, the issue needs to be deliberated that whether some spectrum should be earmarked for localized private captive networks in India and in case it is decided to earmark some spectrum for localized private captive networks, then in which band(s) the spectrum be earmarked for private captive networks and what should be the associated terms and conditions.

4.42 Another issue that needs to be deliberated is about the eligibility of entities for assignment of spectrum for private captive networks and what should be the process of assignment. To ensure that the spectrum earmarked for local use by private captive networks, is not exploited, some countries have prescribed that the allocation must be to the landowner or tenant. For instance, South Korea has prescribed that the

applicant for allocation must be the land/building owner, lessee, or a third party entrusted by the owner, and the lessee and entrusted third party require the consent of the owner. Companies that directly build private 5G networks designate frequencies through interference analysis according to the current wireless station establishment permit procedure[55].

4.43 Ericsson in its white paper has proposed that if countries decide to dedicate locally licensed spectrum, an idea defined as the "real estate principle" should be the preferred principle to apply when doing so. In short, this refers to linking a priority right to acquire a local license to the real estate ownership (or tenant, depending on national prerequisites). This simple principle meets the three requirements of having predictable spectrum access, avoiding rewarding first movers, and ensuring availability of unused local spectrum.

a. In view of the above, the issue needs to be deliberated is what should be the eligibility criteria for applying for spectrum for private captive networks.
b. To ensure that the spectrum is put to use, some countries, such as Germany, have prescribed obligations such as "use it or lose it". As regards assignment of spectrum, it is generally assigned on first come first serve basis and the charging is on a formula basis, with area, bandwidth, type of area, etc. as factors. For instance, Germany has prescribed an annual fee for the use of the spectrum apply and are calculated according to the amount of bandwidth, the size and location of the coverage area requested, and the duration of the spectrum license.[56] The fee is calculated in each individual case using the following fee formula:

[55] https://www.netmanias.com/en/?m=view&id=blog&no=15139
[56] https://digitalregulation.org/spectrum-licensing-local-and-private-networks-in-germany/

Fee = 1000 + B * t * 5 * (6a1 + a2), where

- 1,000 indicates the basic amount in €,
- B denotes the bandwidth in MHz (min. 10 to max. 100 MHz),
- t the duration of the allocation in years (e.g., 10 years),
- a is the area in km² with a differentiation between the settlement and traffic area (a1) and other areas (a2).[57]

4.44 In Germany[58], several industrial players have already applied for local licenses, including Bosch, Siemens, BMW, Volkswagen, BASE SE, and Deutsche Lufthansa. As per Qualcomm[59] some of the enterprise groups who have gone for 5G based private networks are Verizon, Lufthansa, Ford, Toyota, Yangquan Coal Industry, Group ADP, Hub One & Air France. Qualcomm has also mentioned that there is a growing momentum in 5G private networks because of the following reasons:

i) early commercial deployments,
ii) a vibrant, global ecosystem led by 5G-ACIA, ready to scale
iii) comprehensive support for 5G private networks in 3GPP Rel-16

4.45 In case it is decided to earmark some quantum of spectrum for private captive networks, broad framework for process of filing application, payment of spectrum charges, assignment of frequencies, monitoring of spectrum utilization etc. may be required. One view could be that the entire process be made system driven and web-based online portal may be created for the same. However, this option could have some practical issues. Another view could be that the enterprise may be required to submit their detailed application while applying for frequencies and some guidelines along with the timelines may need to be prescribed. The enterprises existing at more than one location, may prefer to apply for spectrum for local use for multiple locations through a single application. Similarly, a group of companies may also prefer to apply

57 https://www.bundesnetzagentur.de/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OeffentlicheNetze/LokaleNetze/lokalenetze-node.html

58 https://digitalregulation.org/spectrum-licensing-local-and-private-networks-in-germany/

59 https://gsacom.com/paper/5g-private-networks-qualcomm-presentation-october-2020/

for their subsidiary companies. The issues need to be deliberated that how these scenarios can be taken care of in the framework.

4.46 In such a case, if an enterprise wishes to apply for spectrum frequencies at more than one location, single application may be sufficient.

4.47 In view of the forgoing discussion, the issues need to be consulted are as follows:

Issues for Consultation

Q.71 Whether some spectrum should be earmarked for localized private captive networks in India? Kindly justify your response

Q.72 In case it is decided to earmark some spectrum for localized private captive networks, whether some quantum of spectrum be earmarked (dedicatedly) from the spectrum frequencies earmarked for IMT services and/or spectrum frequencies earmarked for non-IMT services on location-specific basis (which can coexist with cellular-based private captive networks on shared basis)? Kindly justify your response with reasons.

Q.73 In case it is decided to earmark some quantum of spectrum for private captive networks, either on exclusive or shared basis, then

a) Spectrum under which band(s) (or frequency range) and quantum of spectrum be earmarked for Private Network in each band? Inputs may be provided considering both dedicated and shared spectrum (between geographically distinct users) scenarios.

b) What should be the eligibility conditions for assignment of such spectrum to private entities?

c) What should be the assignment methodology, tenure of assignment and its renewal, roll-out obligations?

d) What should be the pricing mechanism for assignment of spectrum in the band(s) suggested for private entities for localized captive use and what factors should be considered for arriving at valuation of such spectrum?

e) What should be the block size and spectrum cap for different spectrum band(s) suggested in response to point (a) above.

f) What should be the broad framework for the process of

(i) filing application(s) by enterprise at single location, enterprise at multiple locations, Group of companies.

(ii) payment of spectrum charges,

(iii) assignment of frequencies,

(iv) monitoring of spectrum utilization,

(v) timeline for approvals,

(vi) Any other

g) Any other suggestion on the related issues may also be made with details.

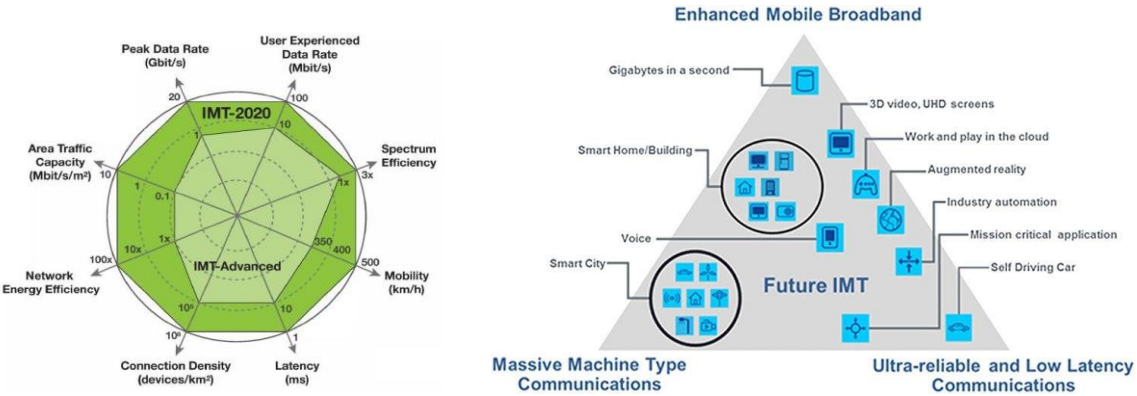
(Kindly justify your response with reasons)

G. Identification, Development and Proliferation of 5G use cases

4.48 5G is likely to create economic benefits for almost all the industry verticals, accelerating them on an unprecedented growth trajectory. The Government has been taking proactive steps to create incentives by way of fostering an environment where the major hurdles in the way of 5G.

4.49 The ITU has defined three standard 5G service profiles - Massive Machine to Machine-Type Communications (mMTC), Ultra-Reliable Low-Latency Communications (uRLLC) and Enhanced Mobile Broadband (eMBB). These profiles are expected to meet the

requirements of most industrial applications and are driving the adoption of 5G for industrial use cases.



Source: ITU

- **Massive Machine to Machine-Type Communications (mMTC)**: Providing connectivity to IoT devices and machines on a large scale with connection density of 1 million devices per square km. mMTC supports extremely high connection densities, enabling industrial-scale IoT. With it, 5G will be able to connect up to a million IoT sensors and devices per square kilometer.

- **Ultra-reliable low-latency communication (uRLLC):** For critical applications with latency of 1 milli second. With uRLLC, 5G be able to connect controllers, switches, sensors, and actuators at latency and reliability levels equivalent to those of a wired connection. 5G's URLLC service profile addresses several critical applications in different industries and scenarios, such as for manufacturing, automation, and autonomous equipment or vehicle operation.

- **Enhanced Mobile Broadband (eMBB)**: Very High Speed broadband on Cellular Network with data rates of the order of 20 Gbps.

4.50 Telecom connectivity has played its important role in digitalization and automation of processes in almost all the sectors. Telecom network in

India is now moving towards complete transformation with the deployment of 5G cellular technology. With high speed, low-latency, and high device density, the ultra-reliable 5G technology can have applications across different economic verticals and these applications are now commercially feasible and available. 5G technology coupled with IoT, Artificial Intelligence, Machine Learning and Data Analytics have given rise to numerous use cases covering almost every economic vertical such as healthcare, agriculture, transport, education, industry, mines, ports etc.

4.51 To actualize the likely benefits from implementation of 5G use cases across industry verticals, initiatives need to be taken for identification and development of India specific use cases and impetus is required to be given by the different Ministries of the Government, Industries across verticals and technology solution providers.

Issue for Consultation

Q.74 What steps need to be taken to facilitate identification, development and proliferation of India specific 5G use cases for different verticals for the benefit of the economy and citizens of the Country? Kindly provide detailed response with rationale.

CHAPTER–V: ISSUES FOR CONSULTATION

Issues related to Quantum of Spectrum and Band Plan

Q.1 Whether spectrum bands in the frequency range 526-617 MHz, should be put to auction in the forthcoming auction? Kindly justify your response.

Q.2 If your answer to Q1 above is in affirmative, which band plans and duplexing configuration should be adopted in India? Kindly justify your response.

Q.3 In case your answer to Q1 is in negative, what should be the timelines for adoption of these bands for IMT? Suggestions to make these bands ready for adoption for IMT may also be made along with proper justification.

Q.4 Do you agree that 600 MHz spectrum band should be put to auction in the forthcoming auction? If yes, which band plan and duplexing configuration should be adopted in India? Kindly justify your response.

Q.5 For 3300-3670 MHz frequency range, which band plan should be adopted in India? Kindly justify your response.

Q.6 Do you agree that TDD based configuration should be adopted for 24.25 to 28.5 GHz frequency range? Kindly justify your response

Q.7 In case your response to Q6 is in affirmative, considering that there is an overlap of frequencies in the band plans n257 and n258, how should the band plan(s) along with its frequency range be adopted? Kindly justify your response.

Q.8 Whether entire available spectrum referred by DoT in each band should be put to auction in the forthcoming auction? Kindly justify your response.

Issues related to Block Size

Q.9 Since upon closure of commercial CDMA services in the country, 800 MHz band is being used for provision of LTE services,

a. Whether provision for guard band in 800 MHz band needs to be revisited?

b. Whether there is a need to change the block size for 800 MHz band? If yes, what should be the block size for 800 MHz band and the minimum number of blocks for bidding for existing and new entrants?

(Kindly justify your response)

Q.10 Do you agree that in the upcoming auction, block sizes and minimum quantity for bidding in 700 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands, be kept same as in the last auction? If not, what should be the band-wise block sizes and minimum quantity for bidding? Kindly justify your response.

Q.11 In case it is decided to put to auction spectrum in 526-698 MHz bands, what should be the optimal block size and minimum quantity for bidding? Kindly justify your response.

Q.12 What should be optimal block size and minimum quantity for bidding in 3300-3670 MHz band? Kindly justify your response.

Q.13 What should be optimal block size and minimum quantity for bidding in 24.25-28.5 GHz? Kindly justify your response.

Issues related to Eligibility Conditions for Participation in Auction

Q.14 Whether any change is required to be made in the existing eligibility conditions for participation in Auction as specified in the NIA for the spectrum Auction held in March 2021, for the

forthcoming auction? If yes, suggestions may be made in detail with justification.

Q.15 In your opinion, should the suggested/existing eligibility conditions for participation in Auction, be made applicable for the new spectrum bands proposed to be auctioned? If not, what should be the eligibility conditions for participating in Auction? Kindly justify your response.

Issues related to Interference mitigation in TDD bands

Q.16 Is there a need to prescribe any measure to mitigate possible interference issues in 3300-3670 MHz and 24.25-28.5 GHz TDD bands or it should be left to the TSPs to manage the interference by mutual coordination and provisioning of guard bands? Kindly provide justification to your response.

Q.17 In case your response to the above question is in affirmative,

a. whether there is a need to prescribe provisions such as clock synchronization and frame structure to mitigate interference issues, as prescribed for existing TDD bands, for entire frequency holding or adjacent frequencies of different TSPs? If yes, what should be the frame structure? Kindly justify your response.

b. Any other measures to mitigate interference related issues may be made along with detailed justification.

Issues related to Roll-out Obligations

Q.18 Whether the roll-out obligations for 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz as stipulated in the NIA for last auctions held in March 2021 are appropriate? If no, what changes should be made in the roll out obligations for these bands?

Q.19 What should be associated roll-out obligations for the allocation of spectrum in 526-698 MHz frequency bands? Should it be focused to enhance rural coverage? Kindly justify your response.

Q.20 What should be associated roll-out obligations for the allocation of spectrum in 3300-3670 MHz frequency band? Kindly justify your response.

Q.21 What should be associated roll-out conditions for the allocation of spectrum in 24.25 to 28.5 GHz frequency range? Kindly justify your response.

Q.22 While assessing fulfilment of roll out obligations of a network operator, should the network elements (such BTS, BSC etc.), created by the attached VNO, be included? If yes, kindly suggest the detailed mechanism for the same. Kindly justify your response.

Issues related to Spectrum Cap

Q.23 Whether there is a need to review the spectrum cap for sub-1 GHz bands? If yes, what should be the spectrum cap for sub-1 GHz bands. Kindly justify your response.

Q.24 Keeping in mind the importance of 3300-3670 MHz and 24.25-28.5 GHz bands for 5G, whether spectrum cap per operator specific to each of these bands should be prescribed? If yes, what should be the cap? Kindly justify your response.

Q.25 Whether there should be separate spectrum cap for group of bands comprising of 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands together? If yes, kindly suggest the cap along with detailed justification.

Q.26 Whether overall spectrum cap of 35% requires any change to be made? If yes, kindly suggest the changes along with detailed justification.

Q.27 For computation of overall spectrum cap of 35%, should the spectrum in 3300-3670 MHz and 24.25-28.5 GHz bands be included? Kindly justify your response.

Q.28 Any other suggestion regarding spectrum cap may also be made with detailed justification.

Issues related to Surrender of Spectrum

Q.29 What should be the process and associated terms and conditions for permitting surrender of spectrum for future auctions? Kindly justify your response.

Q.30 What provisions may be created in the spectrum surrender framework so that any possible misuse by the licensees, could be avoided? Kindly justify your response.

Q.31 In case a TSP acquires spectrum through trading, should the period of 10 years to become eligible for surrender of spectrum, be counted from the date of original assignment of spectrum or from the date of acquisition through spectrum trading? Kindly justify your response.

Q.32 Whether provision for surrender of spectrum should also be made available for the existing spectrum holding of the TSPs? If yes, what should be the process and associated terms and conditions? Kindly justify your response.

Q.33 Whether spectrum surrender fee be charged from TSPs? If yes, what amount be levied as surrender fee? Kindly justify your response.

Issues related to Valuation and Reserve price of Spectrum

Q.34 Which factors are relevant in the spectrum valuation exercise and in what manner should these factors be reflected in the valuation of spectrum? Please give your inputs with detailed reasoning.

Q.35 In what manner, should the extended tenure of spectrum allotment from the existing 20 years to 30 years be accounted for in the spectrum valuation exercise? Please support your response with detailed rationale/ inputs.

Q.36 What could be the likely impact of the following auction related telecom reforms announced by the Government in September 2021 on the valuation of various spectrum bands?

(a) Rationalization of Bank Guarantees to securitize deferred annual spectrum payment instalments in future auctions

(b) No spectrum usage charges (SUC) for spectrum acquired in future auctions

(c) Removal of additional SUC of 0.5% for spectrum sharing

(d) Provision for surrender of spectrum

In what manner, should the above provisions be accounted for in the valuation of spectrum? Please support your response with detailed justification.

Q.37 Whether the auction determined prices of March 2021 auction be taken as the value of spectrum in the respective band for the forthcoming auction in the individual LSA? Should the prices be indexed for the time gap (even if less than one year or just short of one year)? If yes, please indicate the basis/ rate at which the indexation should be done, with reasons.

Q.38 If the answer to the above question is in negative, whether the valuation for respective spectrum bands be estimated on the basis of the various valuation approaches/methodologies being followed by the Authority in the previous recommendations, including for those bands (in an LSA) for which either no bids were received, or spectrum was not offered for auction?

Q.39 Whether the method followed by the Authority in the Recommendations dated 01.08.2018 of considering auction determined prices of the auctions held in the previous two years be continued, or the prices revealed in spectrum auctions conducted earlier than two years may also be taken into account? Kindly justify your response.

Q.40 Whether the valuation exercise be done every year in view of the Government's intention to have an annual calendar for auction of spectrum? Please support your response with detailed justification.

Q.41 Whether there is a need to bring any change in the valuation approaches/ methodologies followed by the Authority for spectrum valuation exercises in view of the changing dynamics in the telecom sector largely due to the usage of various spectrum bands by the TSPs in a technologically neutral manner? If yes, please provide suggestions along with a detailed justification about the methodology.

Q.42 In your opinion, what could be the possible reasons for the relative lack of interest for the spectrum in the 2500 MHz band? Could this be attributed to technological reason(s) such as development of network/device ecosystem or availability of substitute spectrum bands or any other reasons(s)? Please support your response with detailed justification.

Q.43 Whether the March 2021 auction determined prices be used as one possible valuation for the spectrum in 2300 MHz band for the current valuation exercise? If yes, should these prices be indexed for the time gap and at what rate? Please justify your response.

Q.44 Whether auction determined prices of October 2016 (i.e. for the auction held earlier than two years) be used as one possible valuation for the spectrum in 2500 MHz band for the current valuation exercise? If yes, should these prices be indexed for the time gap and at what rate? Please justify.

Q.45 Whether the value of the spectrum in 2300 MHz/ 2500 MHz bands should be derived by relating it to the value of spectrum in any other band by using technical efficiency factor? If yes, which band and what rate of efficiency factor should be used? If no, then which alternative method should be used for its valuation? Please justify your response with rationale and supporting studies, if any.

Q.46 In your opinion, what could be the possible reasons for the relative lack of interest for the spectrum in the 700 MHz band? Could this be attributed to technological reason(s) such as development of network/device ecosystem or availability of substitute spectrum bands or any other reasons(s)?

Q.47 Whether the value of spectrum in 700 MHz band be derived by relating it to the value of other spectrum bands by using a technical efficiency factor? If yes, with which spectrum band, should this band be related and what efficiency factor or formula should be used? Please justify your views with rationale and supporting studies, if any.

Q.48 If your response to the above question is in negative, what other valuation approach(es) be adopted for the valuation of 700 MHz

spectrum band? Please support your response with detailed methodology.

Q.49 Whether the valuation of the 3300-3670 MHz spectrum band should be derived from value of any other spectrum band by using technical efficiency factor? If yes, what rate of efficiency factor should be used? If no, which other method(s) should be used for its valuation? Please justify your response with rationale and supporting documents, if any.

Q.50 In case you are of the opinion that frequencies in the range 526-698 MHz should be put to auction in the forthcoming spectrum auction, whether the value of 526-698 MHz be derived by using technical efficiency factor? If yes, with which spectrum band, should this band be related and what efficiency factor or formula should be used? Please justify your suggestions.

Q.51 If your response to the above question is in negative, which other valuation approach(es) should be adopted for the valuation of these spectrum bands? Please support your suggestions with detailed methodology, related assumptions and any other relevant factors.

Q.52 Whether the value of spectrum in 24.25 - 28.5 GHz band be derived by relating it to the value of other bands by using technical efficiency factor? If yes, with which spectrum band, should this band be related and what efficiency factor or formula should be used? Please justify your suggestions.

Q.53 If your response to the above question is in negative, which other valuation approaches should be adopted for the valuation of these spectrum bands? Please support your suggestions with detailed methodology, related assumptions and other relevant factors.

Q.54 Whether international benchmarking by comparing the auction determined price in countries where auctions have been concluded be used for arriving at the value of these new bands? If yes, then what methodology can be followed in this regard? Please explain.

Q.55 For international benchmarking, whether normalization techniques be used for arriving at the valuation of these new bands in the Indian context? If yes, please justify your response with rationale /literature, if any.

Q.56 Whether a common methodology/ approach should be used for valuation of all sub-1 GHz bands, which are currently planned for IMT? If yes, suggest which methodology/ approach should be used. Please give your views along with supporting reasoning and documents/ literature, if any.

Q.57 Whether the extrapolated ADP based on a time-series analysis, may be considered as the valuation itself or some normalization may be performed taking into account the financial, economic and other parameters pertaining to a particular auction? If yes, which factors should be considered and what methodology should be followed?

Q.58 Whether the value arrived at by using any single valuation approach for a particular spectrum band should be taken as the appropriate value of that band? If yes, please suggest which single approach/ method should be used. Please justify your response.

Q.59 In case your response to the above question is negative, will it be appropriate to take the average valuation (simple mean) of the valuations obtained through the different approaches attempted for valuation of a particular spectrum band, or some other approach like taking weighted mean, median etc. should be followed? Please justify your response

Q.60 Is there any valuation approach other than those discussed above or any international auction experience/ approach that could be used for arriving at the valuation of spectrum for 700 MHz/ 800 MHz/ 900 MHz/ 1800 MHz/ 2100 MHz/ 2300 MHz/ 2500 MHz/ 3300-3670 MHz/ 24.25 - 28.5 GHz/ 526 - 698 MHz bands? Please support your suggestions with a detailed methodology and related assumptions.

Q.61 Should the reserve price be taken as 80% of the valuation of spectrum? If not, then what ratio should be adopted between the reserve price for the auction and the valuation of the spectrum in different spectrum bands and why?

Q.62 Whether the realized/ auction determined prices achieved in the March 2021 auction for various spectrum bands can be directly adopted as the reserve price in respective spectrum bands for the forthcoming auction? If yes, should these prices be indexed for the time gap since the auction held in March 2021 and at which rate the indexation should be done?

Q.63 Should the method followed by DoT in the previous auction in respect of collecting bid amount from the successful bidder in case spectrum is not available in a part of the LSA be followed in the forthcoming auction? Please justify your response in detail.

Q.64 What percentage rate of upfront payment should be fixed in case of each spectrum band?

Q.65 What should be the applicable period of moratorium for deferred payment option?

Q.66 How many instalments should be fixed to recover the deferred payment?

Q.67 What rate of discount should be used while exercising pre-payment/deferred payment option, in order to ensure that the net present value of payment/ bid amount is protected?

(Please support your suggestions for Q64 to Q67 with proper justifications.)

Issues related to Spectrum for Private Cellular Networks

Q.68 To facilitate the TSPs to meet the demand for Private Cellular Networks, whether any change(s) in the licensing/policy framework, are required to be made. If yes, what changes are required to be made? Kindly justify your response.

Q.69 To meet the demand for spectrum in globally harmonized IMT bands for private captive networks, whether the TSPs should be permitted to give access spectrum on lease to an enterprise (for localized captive use), for a specific duration and geographic location? Kindly justify your response.

Q.70 In case spectrum leasing is permitted,

i. **Whether the enterprise be permitted to take spectrum on lease from more than one TSPs?**
ii. **What mechanism may be prescribed to keep the Government informed about such spectrum leasing i.e., prior approval or prior intimation?**
iii. **What timeline should be prescribed (in number of days) before the tentative date of leasing for submitting a joint request by the TSPs along with the enterprise, for approval/intimation from/to the Government?**
iv. **Whether the spectrum leasing guidelines should prescribe duration of lease, charges for leasing, adherence of spectrum cap provisions, roll out obligations, compliance**

obligations. If yes, what terms and conditions should be prescribed?

v. **What other associated terms and conditions may be prescribed?**

vi. **Any other suggestion relevant to leasing of spectrum may also be made in detail.**

(Kindly justify your response)

Q.71 Whether some spectrum should be earmarked for localized private captive networks in India? Kindly justify your response

Q.72 In case it is decided to earmark some spectrum for localized private captive networks, whether some quantum of spectrum be earmarked (dedicatedly) from the spectrum frequencies earmarked for IMT services and/or spectrum frequencies earmarked for non-IMT services on location-specific basis (which can coexist with cellular-based private captive networks on shared basis)? Kindly justify your response with reasons.

Q.73 In case it is decided to earmark some quantum of spectrum for private captive networks, either on exclusive or shared basis, then

a) **Spectrum under which band(s) (or frequency range) and quantum of spectrum be earmarked for Private Network in each band? Inputs may be provided considering both dedicated and shared spectrum (between geographically distinct users) scenarios.**
b) **What should be the eligibility conditions for assignment of such spectrum to private entities?**
c) **What should be the assignment methodology, tenure of assignment and its renewal, roll-out obligations?**
d) **What should be the pricing mechanism for assignment of spectrum in the band(s) suggested for private entities for**

localized captive use and what factors should be considered for arriving at valuation of such spectrum?

e) What should be the block size and spectrum cap for different spectrum band(s) suggested in response to point (a) above.

f) What should be the broad framework for the process of

(i) filing application(s) by enterprise at single location, enterprise at multiple locations, Group of companies.

(ii) payment of spectrum charges,

(iii) assignment of frequencies,

(iv) monitoring of spectrum utilization,

(v) timeline for approvals,

(vi) Any other

g) Any other suggestion on the related issues may also be made with details.

(Kindly justify your response with reasons)

Q.74 What steps need to be taken to facilitate identification, development and proliferation of India specific 5G use cases for different verticals for the benefit of the economy and citizens of the Country? Kindly provide detailed response with rationale.

ANNEXURES

Annexure – 1.1

(DoT Reference Letter dated 13th September 2021, without its Annexure-II)

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning & Coordination (WPC) Wing
6th floor, Sanchar Bhawan,
20, Ashoka Road, New Delhi – 110001.

No.: L-14006/01/2021-NTG Date: 13.09.2021

To,

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

Subject: Seeking TRAI recommendations for the auction of spectrum in the frequency bands identified for International Mobile Telecommunications (IMT)/ 5G.

Sir,

In response to DoT's reference dated 17.04.2017, TRAI provided its recommendations dated 01.08.2018 on various issues involved in the auction of spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz and 3300-3600 MHz bands. Based on the TRAI recommendations dated 01.08.2018 and response dated 08.07.2019 on DoT's back-reference, Government conducted auction of spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands in March 2021. A total of 2308.80 MHz spectrum worth Rs. 400396.20 Crore at Reserve Price in different band-LSA combinations was put to auction, out of which 855.60 MHz quantum was sold in the auction resulting in total winning bids worth Rs. 77820.81 Crore. No bids were received in 700 MHz and 2500 MHz bands. Spectrum unsold in the auction held in March 2021 may be put to auction in the forthcoming auction. LSA-wise quantum available with the Government in these bands after the auction is given in ***Annexure-I***.

2. In the recommendations dated 01.08.2018, spectrum in 3300-3600 MHz band was also included. However, due to certain issues, the Government decided to initiate action to auction spectrum in this band separately after resolution of these issues and, therefore, it was not a part of the auction held in March 2021. Now, as the issues have been resolved as well as the range of available frequencies in this range has slightly gone up, it has been decided by the Government that spectrum in the frequency range 3300-3670 MHz should be made available to the Telecom Service Providers for IMT/ 5G through auction, except in few areas/locations (details of excluded areas/locations in ***Annexure-II***).

3. In addition to the above, new frequency bands (mentioned below) have also been decided to be used for IMT/5G:

(i) 526-582 MHz in all the LSAs in coordination with Ministry of Information & Broadcasting. The use will be coordinated with minimum keep out distance from MIB transmitters.

(ii) 582-617 MHz in all the LSAs. This band will be available for IMT/5G and rural point to point links.

(iii) 617-698 MHz in all the LSAs; except few areas/locations (details of excluded areas/locations in ***Annexure-II***).

(iv) 24.25 to 28.5 GHz in all the LSAs except at 5 locations (details of locations in ***Annexure-II***) with protection distance of 2.7 km.

4. DoT has also received few requests regarding spectrum requirements for captive usage of 5G applications by some industries e.g. Industry 4.0. COAI has also submitted a letter regarding Private Captive Networks, wherein they have *inter alia* requested not to reserve any spectrum which has been identified for IMT, for Private Captive Networks.

5. Parliamentary Standing Committee on Information Technology in its report on "India's preparedness for 5G" has made certain observations on pricing of spectrum. Also, DoT has received request from COAI regarding effective spectrum pricing. Copy of the relevant pages of the Standing Committee report is enclosed as ***Annexure-III***.

6. Department of Space (DoS) had invited comments on Draft Spacecom Policy liberalizing space segment for private sector participation to provide commercial communication services in India. This includes the Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellite constellations operational over India. In case of satellite communication, the subscriber is accessed from the satellite through "Access spectrum"

similar to "Access spectrum" in terrestrial network and the demand for such spectrum will potentially increase in the future.

7. In view of the above, under the terms of clause 11 (1)(a) of TRAI Act, 1997 as amended by TRAI Amendment Act 2000, TRAI is requested to:

(a) provide recommendations on applicable reserve price, band plan, block size, quantum of spectrum to be auctioned and associated conditions for auction of spectrum in 526-698 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3670 MHz and 24.25-28.5 GHz bands for IMT/ 5G.

(b) provide recommendation on quantum of spectrum/bands, if any, to be earmarked for private captive/isolated 5G networks, competitive/transparent method of allocation, and pricing, for meeting the spectrum requirements if captive 5G applications of industries for machine/plant automation purposes/M2M in premises.

(c) provide recommendation on appropriate frequency bands, band plan, block size, applicable reserve price, quantum of spectrum to be auctioned and associated conditions for auction of spectrum for space-based communication services, in view of para 6 above.

(d) provide any other recommendations deemed fit for the purpose of spectrum auction in these frequency bands, including the regulatory/ technical requirements as enunciated in the relevant provisions of the latest ITU-R Radio Regulations.

This issues with the approval of the competent authority.

13/9/2021

(Sukhpal Singh)
Joint Wireless Adviser

Enclosure:

i) ***Annexure-I***: LSA-wise quantum available with the Government in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands after March' 2021 auction and after earmarking of 5 MHz (paired) to Indian Railways in 700 MHz band.

ii) ***Annexure-II***: Details of the areas/locations where certain spectrum would not be available for IMT/5G.

iii) ***Annexure-III***: Copy of the relevant pages of Parliamentary Standing Committee Report on "India's Preparedness for 5G".

Copy to:

Secretary, DoS, for kind information please.

Annexure-I of DoT Letter dated 13th September 2021 (with updated spectrum availability)

LSA-wise quantum of spectrum available with the Government for auction of spectrum in 700, 800, 900, 1800, 2100, 2300, 2500 MHz bands

(The information provided by DoT through letter dated13.09.2021 has been updated based on information as in DoT letter dated 27.11.2021)

		Quantum available for auction (in MHz)						
Sl. No.	Service Area	700 MHz band (718-748 / 773-803 (Paired)	800 MHz band (Paired)	900 MHz band (Paired)	1800 MHz band (Paired)	2100 MHz band (Paired)	2300 MHz band (Unpaired)	2500 MHz band (Unpaired)
1	Andhra Pradesh	30.00	7.50	3.60	12.20	15.00	10.00	30.00
2	Assam	30.00	2.50	5.80	2.20	5.00	-	-
3	Bihar	30.00	7.50	7.00	0.80	5.00	-	10.00
4	Delhi	30.00	3.75	2.20	10.80	15.00	10.00	20.00
5	Gujarat	30.00	1.25	-	13.80	10.00	-	10.00
6	Haryana	30.00	1.25	0.80	28.20	5.00	-	-
7	Himachal Pradesh	30.00	5.00	2.60	18.00	15.00	-	10.00
8	Jammu & Kashmir	30.00	2.50	3.00	4.00	5.00	-	10.00
9	Karnataka	30.00	3.75	3.80	4.60	10.00	10.00	40.00
10	Kerala	30.00	3.75	-	23.20	5.00	-	-
11	Kolkata	30.00	2.50	4.20	23.40	10.00	10.00	20.00
12	Madhya Pradesh	30.00	2.50	5.80	11.00	10.00	-	-
13	Maharashtra	30.00	2.50	4.20	17.20	5.00	-	10.00
14	Mumbai	30.00	2.50	2.20	22.20	10.00	10.00	20.00
15	North East	30.00	2.50	3.80	0.20	5.00	-	-
16	Orissa	30.00	6.25	1.40	15.00	10.00	-	-
17	Punjab	30.00	5.00	1.20	9.60	5.00	-	10.00
18	Rajasthan	30.00	2.50	0.60	16.80	-	-	-
19	Tamil Nadu	30.00	3.75	7.60	1.20	-	10.00	40.00
20	Uttar Pradesh (East)	30.00	7.50	1.40	10.60	-	-	-
21	Uttar Pradesh (West)	30.00	2.50	2.40	14.60	10.00	-	-
22	West Bengal	30.00	2.50	1.60	3.20	5.00	-	-
	Total	660.00	81.25	65.20	262.80	160.00	60.00	230.00

Annexure-III

21

STANDING COMMITTEE ON
INFORMATION TECHNOLOGY
(2020-21)

SEVENTEENTH LOK SABHA

MINISTRY OF COMMUNICATIONS
(DEPARTMENT OF TELECOMMUNICATIONS)

INDIA'S PREPAREDNESS FOR 5G

TWENTY- FIRST REPORT

LOK SABHA SECRETARIAT
NEW DELHI

February, 2021/Magha, 1942 (Saka)

TWENTY- FIRST REPORT

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INDIA'S PREPAREDNESS FOR 5G

Presented to Lok Sabha on 08.02.2021

Laid in Rajya Sabha on 08.02.2021

LOK SABHA SECRETARIAT
NEW DELHI

February, 2021/Magha, 1942 (Saka)

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3. Shri Karti P. Chidambaram
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26. Shri Suresh Gopi
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29. Shri Syed Zafar Islam
30. Dr. Narendra Jadhav
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Secretariat

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2.	Dr. Sagarika Dash	-	Additional Director
3.	Shri Shangreiso Zimik	-	Deputy Secretary

*Nominated to this Committee w.e.f. 15.10.2020 vide Bulletin Part-II dated 15.10.2020.

#Nominated to this Committee w.e.f. 28.12.2020 vide Bulletin Part-II dated 28.12.2020.

ABBREVIATIONS

3GPP	3rd Generation Partnership Project
5G	Fifth Generation
AR	Augmented Reality
BBNL Bharat	Broadband Network Limited
BIS	Bureau of Indian Standards
BRI	Broadband Readiness Index
CEWiT	Centre of Excellence in Wireless Technology
CMRTS	Captive Mobile Radio Trunking
CMSP	Cellular Mobile Service Provider
COAI	Cellular Operators Association of India
DoS	Department of Space
DoT	Department of Telecommunications
EMBB	Enhanced Mobile Broadband
EMS	Electronics Manufacturing Services
ER	Essential Requirements
EU	European Union
GHz	Gigahertz
HLF	High Level Forum
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ICRIER)	Indian Council for Research on International Economic Relations
IDRBT	Institute for Development and Research in Banking Technology
IMC	Inter-Ministerial Committee
IMG	Inter-Ministerial Group
IoT	Internet of Things
ITU	International Telecommunications Union
LMLC	Low Mobility Large Cell
LSA	Licensed Service Area
MHz	Megahertz
MMTC	Massive Machine Type Communications
MoD	Ministry of Defence
M-SIPS	Modified Special Incentive Package Scheme
MTCTE	Mandatory Testing and Certification of Telecommunication Equipment
NCCS	National Centre for Communication Security
NDCP	National Digital Communication Policy
NPV	Net Present Value
OFC.	Optical Fiber Cable
PLI	Production Linked Incentive
PMP	Phased Manufacturing Programme
RAN	Radio Access Network
SMEs	Small and medium Enterprises
SPECS	Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors

TAIPA	Tower and Infrastructure Providers Association
TEC	Telecom Engineering Centre
TEMA	Telecom Equipment Manufacturers Association of India
TRAI	Telecom Regulatory Authority of India
TRDF	Telecom Research and Development Fund
TSDSI	Telecom Standards Development Society, India
TSP	Telecom Service Provider
UASL	Unified Access Service License
URLLC	Ultra-reliable and Low-Latency Communications
VR	Virtual Reality
WHO	World Health Organization

20. During the course of examination of the subject, the Committee came across numerous issues and challenges as submitted by various stakeholders and experts. These need to be addressed in war footing if the vision of 5G is to be achieved. The Committee will now deal these issues in detail.

IV. Spectrum Related Issues

(i) Availability of Spectrum for 5G

21. The Department have informed that they intend to make available 5G spectrum in various bands in line with global ecosystem. The Telecom Regulatory Authority of India (TRAI) had given their recommendation for the auction of spectrum in the 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands on 01.08.2018 for providing mobile services. Digital Communications Commission has decided to hold auction of 3300-3600 MHz band separately. The opening up of the mmWave bands viz. 26 GHz etc. for IMT Services/5G is under deliberations.

22. Secretary, DoT, stated during evidence as under:

> —The bandwidth of 3,300 MHz. to 3,600 MHz. is not yet used in the 2G, 3G and 4G. It is envisaged to be used for 5G, but that does not mean that 5G will not use other spectrum bands. So, 5G would also come in 700 MHz., 800 MHz., 900 MHz. bands in the time to come. 5G would also be coming in what are called the millimeter wave bands, which are 24.25 GHz. to 27.5 GHz. Sir, that is also where the international ecosystem is coming up. Currently, the Digital Communications Commission has decided that the auction of 3,300 MHz. to 3,600 MHz. bands will be delinked from the other auctions. So, we are now preparing a Cabinet Note for auctions in other bands like 700 MHz., 800 MHz., 900 MHz., 1,800 MHz., and 3,300 MHz. to 3,600 MHz. bands will be considered separately. There is also an issue in this matter as part of the spectrum is being used by ISRO. So, that 25 MHz. has been taken away. There is also a band of about 100 MHz. between 3,300 MHz. to 3,400 MHz., which is to be used along with Defence. So, Defence has written now to us to allocate this entire band to them. We are in discussion with them because if we give this band to Defence, then what is available for 5G would just be about 175 MHz., which may not be sufficient for different vendors to actually give their services. We are holding discussions with them, and hopefully we will come with some solution on this issue."

23. As per COAI countries are identifying spectrum in sub-GHz, Mid band (3.5GHz) & mmWave bands for 5G deployment. India at present does not have sufficient spectrum earmarked for 5G in any of these bands as many other stakeholders are seeking spectrum in the 5G bands recommended by the 5GHLF as well as also being commercially deployed in other countries. To make India 5G ready at the earliest, Government needs to allocate at least the following spectrum per operator:

a. 3.5GHz : at least 100MHz per operator.
b. Mm Wave (26, 28, 37 GHz): at least 400MHz per operator.
c. Sub-GHz (600MHz & 700MHz): at least 2x10MHz per operator in each of these bands.
d. E-Band: at least 2x1GHz per operator.
e. V-Band: at least 1GHz per operator.

24. Bharti Airtel in a written submission to Committee have submitted as under:

> —In India, only the 3.5 GHz band (3.4-3.6 GHz) has been earmarked for 5G services, with just 175 MHz of spectrum being available for5G. In contrast, the sector needs a minimum of 300-500 MHz spectrum availability in this band. Apart from 3.5 GHz, other bands e.g. mmWave (26GHz) band and 600 MHz band, can be used for 5G services. However, the same is yet to be earmarked in India. India must consider the allocation of mmWave band (i.e. 26 GHz) for 5G and make it a part of the auction along with the 3.4-3.6 GHz band. For rural penetration, the spectrum in the 600 MHz band should be identified and earmarked for 5G."

25. A representative of a Telecom Service Provider (TSP) further submitted during evidence as under:

> —In India we are talking about only 175 MHz of spectrum that is right now having visibility for the 3.5 GHz spectrum, which means that every operator gets close to or less than 50 MHz spectrum, which is not sufficient. The second point is, the millimeter wave spectrum, which is the capacity spectrum, has yet to be identified. So, certainly there is need for getting the spectrum identified."

26. Explaining the impact of allocating less amount of spectrum, representative of a TSP during the sitting of the Committee stated as under:

> —On spectrum, our humble submission to the Committee is that there should be the right amount of spectrum at the right prices as per the global practices. For example, the famous 3.5GHz of spectrum which we call as sub-6 band in 5G, almost every operator across the globe has 100MHz of it. There are some exceptions with 80MHz of it but if we go lower than

80MHz, there are equipment on which we will spend billions of Dollars, I think, it would be a severe underutilisation of that. It is like buying a car and working it with one particular seat because the other three seats are not available. The equipment itself will be severely underutilised."

27. He had further commented as under:

"On an average, our 4G spectrum per operator is not more than one fourth of what any other operators across the globe has. That is not the only problem. The other problem is our footfall not only that we have 25 per cent of the spectrum, we have three and a half to four times people per sq. kms. So, you have four times more people and you have four times less spectrum which means the spectrum available to one person is 1/16. The number of customer is four to five times and that is again making the point that if we go the same way in 5G where everybody else is getting 100 MHz and we are getting 50 MHz and we have three or four times more customers, we will again be pegged at a much lower level saying that Indian customer will get four times less than what he is getting in US."

28. When the Secretary, DoT, was asked to clarify on the issue, he stated as under:

"Insofar as the spectrum availability is concerned, typically, we are talking of 5G spectrum as the band which is between 3.3 and 3.6 gigahertz. I had also flagged this issue last time. Of these 300 megahertz, which are available, 25 megahertz are required for certain satellite uses, which TRAI also said that we should give them with a suggestion that beyond the footprint of the use, the available spectrum -- even out of this 25-megahertz -- should be used wherever we can for our various experimental and trial purposes. Now, out of the balance 275 megahertz, about 100 megahertz -- between 3.3 and 3.4 gigahertz -- Defence is also wanting a part of it. So, we are having discussions with them. Two meetings have been held. A very positive response has come. I am sure this issue will be resolved. If this is deducted, then 175 megahertz are available to us. If this is added, then 275 megahertz are available. There are four players. Ideally, we should have about 300 megahertz. We are also trying to see if we can get a little more, that is, beyond 3.6. There we have a problem, because that is already committed for satellite usage. There is also millimetre wave, which has not yet gone to TRAI for recommendations. The auction, right now, is not thought of. No recommendation has come. There will be a consultation process. So, I would like to assure the hon. Committee that we will take a balanced view and a holistic view and see how best the interest of the industry, consumer and the public which is prime and supreme is balanced and then we will act accordingly."

29. Asked how the Department are addressing the issue of lack of spectrum, the Department have stated that they are deliberating with Department of Space (DoS) and the Ministry of Defence (MoD) for making sufficient spectrum available for 5G IMT services. Further DoT is working on sharing/ coexistence of spectrum uses in different spectrum bands including 3300-3600 MHz band and 24.25-27.5 GHz band.

(ii) Spectrum Audit

30. Licensed Service Area (LSA) is a concept to dynamically share a spectrum band, whenever and wherever it is unused by the incumbent users. Shared use of the spectrum is only allowed based on an individual authorization (i.e. licensed). All the Government agencies in India are assigned spectrum administratively. Spectrum audit will help in identification of unutilized or inefficiently utilized spectrum. After the identification, LSA can be used for optimal utilization of spectrum.

31. Asked as to whether any spectrum audit had been conducted in the county to suggest measures for efficient and best utilization of spectrum in India, TRAI stated that Spectrum is a scarce resource. Any amount of spectrum, if not put to use optimally and efficiently, results not only into financial loss to the Government, but also hinders economic and social development of the country. Spectrum allocation and spectrum management is done by DoT. Spectrum is also used by various Government agencies where its effective and efficient utilization needs to be measured. Therefore, spectrum audit is required to be done to detect under-utilization and to make effective and efficient utilization of this natural resource. Since 2015, TRAI in its various recommendations, has raised its concerns and has recommended to DoT that there is an urgent need for audit of all allocated spectrum both commercial as well as spectrum allocated to various PSUs / Government organizations. Government decision in the matter is awaited. Considering the importance of the spectrum audit, it should be done on priority basis by an independent agency regularly.

(iii) **High Spectrum Price in the Country**

32. COAI has submitted that TRAI earmarked spectrum in 3.3-3.6 GHz band for 5G. TRAI recommended the reserve price at INR 492 crore per MHz which is far higher than the auctioned spectrum price in other country. Minimum block of 20 MHz (Price for a block of 20 MHz will be Rs.9,840 crore). Minimum 80 MHz per TSP (Price will be INR 39,360 crores per operator).

33. Commenting on the present spectrum pricing policy, representative of TEMA during the sitting stated as under:

> —I believe that the policy of spectrum which we are holding in our country is of inverted structure. We expect raw material to be purchased at the highest price and the product should be rolled out at the minimum price which is absolutely inverted structure. I would like to say that when Government thinks about it, the ultimate idea should be to take it from the taxes, take it from the growth, not from the raw material."

34. Bharti Airtel submitted a comparative statement of the TRAI recommended Reserve Price in India vis-à-vis the auctioned discovered spectrum price in other countries in the 3.5 GHz band, both in absolute and relative terms as under:

Country	Auction determined price (in Cr/MHz)	Spectrum Price in India is x times the price in other countries		
		In Absolute Terms	Basic Spectrum Price/Population/ GDP per capita	Basic Spectrum Price/Population/ ARPU
Italy	182	3	2	1
UK	70	7	6	3
Australia	35	14	6	3
Spain	14	35	16	12
Austria	7	70	10	3
India	492	1	1	1

35. They have submitted that the recommended price of TRAI for India is exorbitantly higher and ranges from 3-70 times of the market-determined price of the spectrum in other countries in absolute terms and is 16 times of the price in the case of comparison in relative terms. Therefore, even if the price is compared after considering the Population and GDP per Capita / ARPU, the TRAI recommended reserve price in India is substantially higher than the auction determined price in other countries. Moreover, to roll out 5G, any TSP will require a minimum of 100 MHz spectrum in the 3.5 GHz band, which will cost around Rs. 50,000 Crores, even at TRAI recommended reserve price, thus making it too costly a proposition for the TSPs. Thus, to ensure the off-take of 5G services in India, the spectrum's pricing should be kept moderate. There is a need to strike a balance between the Government's expectation to generate revenue from the auction and growth of the sector and the overarching impact of 5G across the sectors. This is also critical since the monthly ARPU in India is under two dollars. India has one of the lowest ARPU in the world. While this can be seen as the telecom services are most affordable in India, below- cost pricing of services will only stifle the telecom sector and deprive the customers of good quality service and new technologies e.g., 5G. Hence, the necessary steps need to be taken to ensure adequate ARPU for the TSPs.

36. On the issue, representative of a TSP submitted as under:

> For one-fourth of the spectrum, there are four times more footfalls but then one-eighth the ARPU. That is another point. I think we should add to the equation. One-fourth, one-fourth and one-eighth is where the Indian telecom is right now."

37. Asked as to whether any consultations have been held with the various Stakeholders before giving the recommendations on 5G spectrum pricing, the Department have stated that before giving its recommendations on "Auction of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands", which included 3300-3600 MHz band (globally adopted for 5G), TRAI has consulted with stakeholders and in this regard a consultation Paper was issued by TRAI on 28th August 2017 for the

comments of the stakeholders. The pricing methodology adopted by TRAI is given in the TRAI recommendation dated 1st August, 2018.

38. On pricing of spectrum, Secretary, DoT during the sitting stated as under:-

> "TRAI has given recommendations even for 3,300 MHz. to 3,600 MHz. This was considered and taken up in the Digital Communications Commission. It was referred back to TRAI, but they have reiterated the same prices and they have done very detailed analysis of it. All the telecom players do get an opportunity to give their viewpoints as TRAI has public consultation, etc. So, TRAI has given a very detailed report on this issue. The Digital Communications Commission has accepted what TRAI has said, but we have not yet finalised the prices because the prices are finalised by a Cabinet decision. We have not yet gone to the Cabinet, and prices have not been finalised."

39. Representative of TRAI has further stated as under:

> "We compare a country which is equivalent to the size of a State in India and compare price of whole of India, I think, it is not an apple to apple comparison. But nevertheless, there are 7-8 well-defined international parameters. One has to judge the price based on those parameters.....I think a statement that the price of TRAI is very high requires some more in-depth deep dive so that we can reach to a conclusion."

40. On the reasons for high spectrum cost in the country, the Department submitted that the sector regulator, TRAI, have recommended the reserve price of spectrum in different bands including 3300-3600 MHz band (mid-band for 5G in industry parlance) after due considerations of all the aspects of it and due consultation with the stakeholders. Department's proposals for auction of spectrum in various bands including reserve price, after due consideration of TRAI recommendation, will be placed before the Cabinet, for a decision.

41. The Committee also enquired about the measures taken by the Department to help the telcos to ease the burden of high spectrum cost. The Department replied that pursuant to the recommendations of Inter-Ministerial Group (IMG) on "Stressed assets in Telecom Sector", Telecom Service Providers (TSPs) had been given a one-time opportunity to opt for higher number of installments (16) instead of the previously permitted 10 installments in respect of spectrum auction deferred payment, subject to the Net Present Value (NPV) being protected. Considering the

stress in the sector, the Government has given an option to the Telecom Service Providers (TSPs) to defer payment of the spectrum auction installments due for 2020-21 and 2021-22, either for one or both years. All the operational TSPs have generally opted for moratorium of 2 years. Deferment of spectrum auction installments will ease the cash outflow of the stressed TSPs and facilitate payment of statutory liabilities and interest on bank loans.

42. When asked whether the AGR issues will have any impact on the TSPs to bid for 5G, COAI have stated that apart from the AGR issue, there is a need to rationalize other levies and duties on the telecom sector so as to ease their financial burden. Key asks including providing soft loans against GST input line credit due to Operators, to address the immediate liquidity crunch as also reducing the SUC by 3% for all TSPs and reducing Licence Fee (USOF Contribution) from 8% to 3%. Exempt the levy of GST on payments to the government such as License Fees, SUC and Payment of Spectrum debt acquired in auctions. They also seek exemption of service tax on the amount of LF/SUC payable by telecom operators before implementation of GST, in compliance with the Hon'ble Supreme Court AGR Order. We believe that sector can be compensated from the USO Fund, which is estimated to be more than Rs. 51,500 crore, lying unutilised as on March 31, 2020. The industry can be provided the refund of the unutilized input tax credit immediately or be provided soft loans at MCLR rate, using the GST input credit as collateral.

(iv) Spectrum for Industrial Use

43. TEMA had submitted before the Committee that industry 4.0 is the main driver for 5G. Many countries around the world, be it the US, Germany, UK and Australia, all have allocated spectrum for the industrial development of 5G which is lacking in India. For example, in Germany, Mercedes is setting up a factory entirely based on 5G, famously known as 'Factory 56' around the world, but the German Government has separately allocated the spectrum for that. In the same way, the US has done it and the UK has done it. Every country is setting apart spectrum and laying out policies for industrial growth of that country using 5G. In India,

unfortunately, we have a very double licensing system that for a factory to set up any system of its own, they have a two-year long process, first to get a license and then to get a spectrum which is really not very conducive to supplying the 5G equipment to the industries.

44. Asked to explain the term Industry 4.0, the Department have stated that Industry 4.0 is rooted in the concept of advanced manufacturing, also called Smart Manufacturing. Industry 4.0 based solutions enable better interoperability, more flexible industrial processes, and autonomous and intelligent manufacturing. Physical components of industrial production are being transformed into cyber physical systems by smart, digital networking, allowing for real-time management of production processes across great distances and products. DoT has not received any specific request/ demand for allocating spectrum for industry 4.0 uses.

45. On the present policy governing spectrum allocation for industrial uses in the country, the Department replied that currently, based on requests in this regard, industries are assigned spectrum, administratively, for their captive use in India.

46. TEMA has submitted that spectrum for industrial 4.0 uses be released immediately. TEMA has further stated regulators around the world have realised the importance of captive communications by their industries and enterprises and have been proactively working towards making the necessary spectrum resources available for their captive needs, keeping in view the importance of these users in nation building and economic growth. TEMA would request that DOT may take the lead and ask TRAI to conduct for a public consultation on spectrum needs and issues for captive users. TEMA also requests that a group be formed to work out policy for spectrum allocation and operation of 5G for 4.0 industrial uses.

47. Further elaborating on the issue, TEMA in a written note have submitted that Captive users of mobile wireless communications are industries, police, paramilitary, fire, forestry and mining, municipal corporations and public utilities as well as critical

infrastructure services projects such as railways, metros, airports, sea ports, refineries, highways, etc. They apply to WPC/DOT for three licenses- CMRTS (Captive Mobile Radio Trunking Services) License, spectrum license and import licenses. These projects are lifeline of the Country's economic development, Public safety, Industrial development and logistics and are critical to support Atam Nirbhar Bharat. The process of obtaining the necessary DOT/WPC approvals for such users typically takes between six months to two years. The main delay is in issue of a CMRTS license and also because of the sequential nature of the process where three separate licenses have to be taken from DOT one after the other rather than as single approval or as a parallel process.

48. Currently captive users like police, paramilitary, metros, airports, refineries, factories etc. have to take a CMRTS license before they can apply for a DOT spectrum license. These captive users only need wireless spectrum for their —captive" use only and no telecom service is being provided by them to the public or to anyone else. Thus, in principle, it appears there should be no need for a separate CMRTS license under Section 4 of the Indian telegraph act as these users do not provide any service to any customers and the wireless network is 100% used for internal communications and coordination purposes such as security, safety and logistics. In June 2018, the TRAI had recommended that DoT should do away with CMRTS license. TEMA requests that the CMRTS (Captive Mobile Radio Trunking) License may merged with the WPC spectrum license and that there needs to be a simplified process where the users directly apply for spectrum to WPC, instead of first going through an elaborate CMRTS licensing process with DoT and then applying for spectrum to WPC. This will cut down the process time substantially.

49. TEMA have further stated that it is critically important that radio spectrum for all captive users that share the primary mission to protect lives and property and help the Country to prosper is made available under a permanent administrative allocation process. Spectrum authorizations need to be based on relatively simple application policies that require only nominal administrative fees from the agencies and organization that require use of the spectrum for —private", non-commercial

communications networks. Consistent with the administrative policies of Countries around the world, the authorization process for private networks need be distinguished from the competitive bidding -spectrum auctions" that are commonly used to authorize commercial wireless networks that provide telecommunications services to the public at large on a for-profit basis.

V. 5G Test Bed, Use Case and 5G Field Trials

(i) Setting up of Indigenous 5G Test Bed

50. Keeping in view India's specific requirements and to take lead in 5G deployment, Department of Telecommunications (DoT) approved financial grant for the multi-institute collaborative project to set up 'Indigenous 5G Test Bed' (Building an end to end 5G Test Bed) in India in March 2018 with total cost of Rs. 224.01 Crore. The test bed is expected to be ready by October, 2021. The eight collaborating institutes in the project are IIT (Indian Institute of Technology) Madras, IIT Delhi, IIT Hyderabad, IIT Bombay, IIT Kanpur, IISc Bangalore, Society for Applied Microwave Electronics Engineering & Research (SAMEER) and Centre of Excellence in Wireless Technology (CEWiT). The test bed is likely to enhance national capability in telecom technology, develop indigenous Intellectual Property (IP) and give fillip to Indian telecom manufacturers.

51. The main goals of 'Indigenous 5G Test Bed' are to provide an open 5G test bed that can enable Indian academia and industry to validate their products, prototypes and algorithms and demonstrate various services, provide a test bed with complete access for research teams to work on new novel concepts/ideas holding potential for standardization in India and on global scale., make a test bed available for Indian operators to understand the working of 5G technologies along with security aspects and plan their future networks, provide the facilities of 5G networks for experimenting and demonstrating applications / use cases of importance to Indian society, and implement and demonstrate IoT based systems and services.

Annexure – 1.2

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning & Coordination (WPC) Wing
6th floor, Sanchar Bhawan,
20, Ashoka Road, New Delhi – 110001.

No.: L-14006/01/2021-NTG Date: 23.09.2021

To,

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

Subject: Seeking TRAI recommendations for the auction of spectrum in the frequency bands identified for International Mobile Telecommunications (IMT)/ 5G.

Reference: DoT letter of even no. dated 13.09.2021 on the above subject.

Sir,

In continuation of our above-referred letter dated 13.09.2021 on the above-mentioned subject matter, this is to further inform you that the Government has recently taken the following decisions with regard to future spectrum auctions:

(i) **Rationalizing Bank Guarantees to securitize Deferred Annual Spectrum payment instalments in future spectrum auctions:** For spectrum auctions held in the future, the requirement for the successful bidder to submit a Financial Bank Guarantee (FBG) of an amount equal to one annual instalment to securitize the instalment, and to submit Performance Bank Guarantee (PBG) for roll out obligations etc., will be dispensed with. DOT will also appropriately address the eligibility conditions for participation in the auction, so that the participants have sufficient financial capacity.

(ii) **Increase in duration of Spectrum Allocation:** In future auctions, access spectrum will be assigned for a period of 30 years. However, since in past auctions the reserve prices and bids were corresponding to validity of 20 years, there will be no change in the tenure for spectrum acquired in past auctions.

While undertaking auction for spectrum with validity for 30 years, TRAI recommendations will be sought for associated conditions like upfront payment requirements, applicable moratorium period after upfront payments, number of deferred payment instalments and other related modalities.

(iii) **Regular conduct of Spectrum Auction on annual basis:** Spectrum auctions will be held normally in the last quarter of every financial year. Whenever necessary, auctions can be held at shorter intervals also.

(iv) **Provisions for Surrender of Spectrum**: In order to encourage better utilization of spectrum and to encourage business, for the auctions conducted henceforth, TSPs may be permitted to surrender spectrum after a minimum period of 10 (ten) years. TSPs will have to inform one year prior to surrendering their spectrum. An appropriate surrender fee will, however, be charged. TRAI's recommendations will be sought on the conditions and fee for such surrender. However, the spectrum purchase dues for the remaining (post surrender) period will not be levied.

(v) **No Spectrum Usage Charges (SUC) for Spectrum acquired in future auctions**: For spectrum acquired in future auctions no SUC will be charged. The condition of minimum 3% weighted average SUC rate and SUC floor amount will also be removed. Guidelines will be issued by DOT to operationalize the decision.

(vi) **Sharing of Spectrum**: In order to encourage spectrum sharing for better utilization and efficiency, henceforth spectrum sharing will not attract an increase in the SUC rate by 0.5%. Guidelines for the same will be issued by DOT.

2. In view of the above, TRAI is requested to consider/factor in the above-mentioned decisions of the Government while providing recommendations in response to our earlier letter dated 13.09.2021.

This issues with the approval of the competent authority.

23/9/2021

(Sukhpal Singh)
Joint Wireless Adviser

Annexure 2.1

International Scenario on mid-band and mmWave bands

United Kingdom

1. In April 2021, OFCOM, UK conducted auction for 3.6-3.8 GHz spectrum band. It made available 120 MHz in 24 lots of 5 MHz of time division duplex (TDD) 3.6-3.8 GHz spectrum, with a reserve price of £20m per lot[60]. OFCOM while deciding[61] to auction the spectrum in this band based on a block size of 5 MHz in the 3400 MHz band on a Time Division Duplex (TDD) basis, noted "*Having reviewed stakeholder responses, we consider it is still important to maintain flexibility and avoid precluding options for bidders in 3.6-3.8 GHz. We maintain that bidders will be able to make use of this spectrum in multiples of 5 MHz for 5G, given there are equipment options for 15 MHz.*". The licences were issued for an initial period of 20 years starting from the date of issue, but for an indefinite duration[62]. OFCOM also decided to adopt a minimum bid of 10 MHz (two lots) in 3.6-3.8 GHz. However, it is also noted that in 2017[63], for Award of the 3.4 GHz spectrum band, OFCOM had specified a minimum requirement of up to 20 MHz (i.e., four 5 MHz lots) in the Simultaneous Multiple Round Auction (SMRA) auction format, which was also the format for the 2021 auction.[64]

[60] https://www.ofcom.org.uk/__data/assets/pdf_file/0020/192413/statement-award-700mhz-3.6-3.8ghz-spectrum.pdf
[61] https://www.ofcom.org.uk/__data/assets/pdf_file/0020/192413/statement-award-700mhz-3.6-3.8ghz-spectrum.pdf
[62] https://www.ofcom.org.uk/__data/assets/pdf_file/0020/192413/statement-award-700mhz-3.6-3.8ghz-spectrum.pdf
[63] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/103819/Statement-Award-of-the-2.3-and-3.4-GHz-spectrum-bands-Competition-issues-and-auction-regulations.pdf
[64] https://www.ofcom.org.uk/__data/assets/pdf_file/0020/192413/statement-award-700mhz-3.6-3.8ghz-spectrum.pdf

2. In the 3.6-3.8 GHz auction, Vodafone Limited paid £176,400,000, Telefónica UK Limited paid £448,000,000, and EE Limited paid £475,000,000, for 40 MHz each.[65]

3. A cap of 416 MHz (37%) on the total amount of spectrum designated for mobile services that any single MNO may hold, to ensure that consumers and businesses continue to benefit from strong competition in the provision of mobile services.

4. No coverage obligations in the licences to be awarded. This is because the MNOs have committed to achieve more comprehensive mobile coverage in the Shared Rural Network programme than OFCOM would be able to require through coverage obligations in this award. Their commitments, now agreed with the Government, are included in their current spectrum licences and are legally binding.

South Korea[66]

5. In June 2018, South Korea completed spectrum auction for 3.5 GHz (3.4 – 3.7 GHz) and 28 GHz bands for the provision of 5G services. The government had made available a total of 280 megahertz in the 3.5 GHz spectrum band and 2,400 megahertz in the 28 GHz (24.65–27.5GHz) band. The spectrum was divided into 28 blocks and 24 blocks respectively.

6. The 280 MHz of spectrum from 3.4 GHz to 3.7 GHz was divided into 28 blocks of 10 MHz with a cap of 10 blocks per bidder. The 2400 MHz of spectrum in 28 GHz band was auctioned with a block size of 100 MHz with a cap of 10 blocks per bidder.

7. The telcos paid a total of 3.6183 trillion won ($3.3 billion) for the spectrum, 340 billion higher than the starting price of 3.3 trillion. In the 3.5 GHz range, SK Telecom paid nearly 1.22 trillion won ($1.1

[65] https://www.ofcom.org.uk/__data/assets/pdf_file/0028/217954/notice-reg-121.pdf
[66] https://www.rcrwireless.com/20180620/5g/south-korea-completes-5g-pectrum-auction-tag23

billion) for 100 megahertz of spectrum, with KT paying 968 billion won ($870 million) for the same amount. LG U+ acquired an 80 MHz license in this range for about 810 billion won ($728 million). In the 28 GHz segment, each operator secured 800 megahertz, paying between 207 billion won ($186 million) and 208 billion won ($187 million) for its license.

8. Validity of spectrum license: 3.5 GHz band license has been issued for a ten-year period and the 28 GHz band for a five-year term.

9. Network Deployment Obligations: In the 3.5 GHz band, deployment of 150,000 base stations were obligated: 22,500 (15%) by in three years, and 45,000 (30%) in five years. [67] In the 28 GHz band, 100,000 base stations are to be deployed, of which 15 percent or more were obligated to be completed in the nationwide network within three years.[68]

USA

10. The U.S. Federal Communication Commission's concluded 280 MHz in 3.7-3.98 GHz in February 2021. Regarding licence period, the FCC decided that initial authorizations will have a term not to exceed 15 years from the date of initial issuance or renewal. [69]The spectrum was put to auction in the block size of 20 MHz. Auction of 3.7 GHz Service Licenses yielded over $81 Billion in Gross Bids and provided mid-Band Spectrum for 5G Services. The obligations imposed on the licensees were two-fold. Licensees in the 3.7 GHz Service relying on mobile or point-to-multipoint service shall provide reliable signal coverage and offer service within eight (8) years from the date of the initial license to at least forty-five (45) percent of the population in each of its license areas ("First Buildout Requirement"). Licensee shall provide reliable signal coverage and offer service within twelve (12) years from the date

[67] https://openknowledge.worldbank.org/bitstream/handle/10986/35780/Entering-the-5G-Era-Lessons-from-Korea.pdf?sequence=1&isAllowed=y
[68] https://openknowledge.worldbank.org/bitstream/handle/10986/35780/Entering-the-5G-Era-Lessons-from-Korea.pdf?sequence=1&isAllowed=y
[69] https://www.fcc.gov/auction/107/factsheet

of the initial license to at least eighty (80) percent of the population in each of its license areas ("Second Buildout Requirement").[70]

11. FCC announced auction of 3.45 to 3.55 GHz band auction[71] in June 2021, wherein 3.45 to 3.55 GHz band has been divided into ten 10 MHz blocks to be licensed by geographic areas known as Partial Economic Areas (PEAs). All 3.45 GHz Service licenses will be issued for 15-year, renewable license terms.[72] The Commission adopted a spectrum aggregation limit for flexible-use licenses in the 3.45 GHz Service that allows any entity to hold a maximum of 40 megahertz (i.e., four blocks out of ten) in any PEA at any point in time for four years post-auction.[73] The FCC is setting a reserve price of $14.8 billion, in part to help cover relocation costs for incumbents in the band.[74] The build-out requirements were determined as followed Licensees relying on mobile or point-to-multipoint service shall provide reliable signal coverage and offer service within four (4) years from the date of the initial license to at least forty-five (45) percent of the population in each of its license areas ("First Performance Benchmark"). Licensees shall provide reliable signal coverage and offer service within eight (8) years from the date of the initial license to at least eighty (80) percent of the population in each of its license areas ("Second Performance Benchmark").[75]

12. On May 28, 2019, the Federal Communications Commission (Commission) completed the auction of 24 GHz spectrum band. In auction of 24 GHz (24.25-24.45 & 24.75-25.25) band (named as Auction 102[76]), 2,912 geographic area-based licenses in the 24 GHz band were

[70] https://www.fcc.gov/auction/107/factsheet
[71] https://www.fcc.gov/document/fcc-announces-345-ghz-band-auction-procedures
[72] AUCTION OF FLEXIBLE-USE SERVICE LICENSES IN THE 3.45–3.55 GHz BAND FOR NEXT-GENERATION WIRELESS SERVICES NOTICE AND FILING REQUIREMENTS, MINIMUM OPENING BIDS, UPFRONT PAYMENTS, AND OTHER PROCEDURES FOR AUCTION 110, PUBLIC NOTICE FCC
[73] AUCTION OF FLEXIBLE-USE SERVICE LICENSES IN THE 3.45–3.55 GHz BAND FOR NEXT-GENERATION WIRELESS SERVICES NOTICE AND FILING REQUIREMENTS, MINIMUM OPENING BIDS, UPFRONT PAYMENTS, AND OTHER PROCEDURES FOR AUCTION 110, PUBLIC NOTICE FCC
[74] https://www.fiercewireless.com/regulatory/fcc-tees-up-3-45-ghz-for-mid-band-5g-spectrum-auction-later-year
[75] https://www.fcc.gov/auction/110/factsheet
[76] https://www.fcc.gov/document/fcc-establishes-procedures-first-5g-spectrum-auctions-0

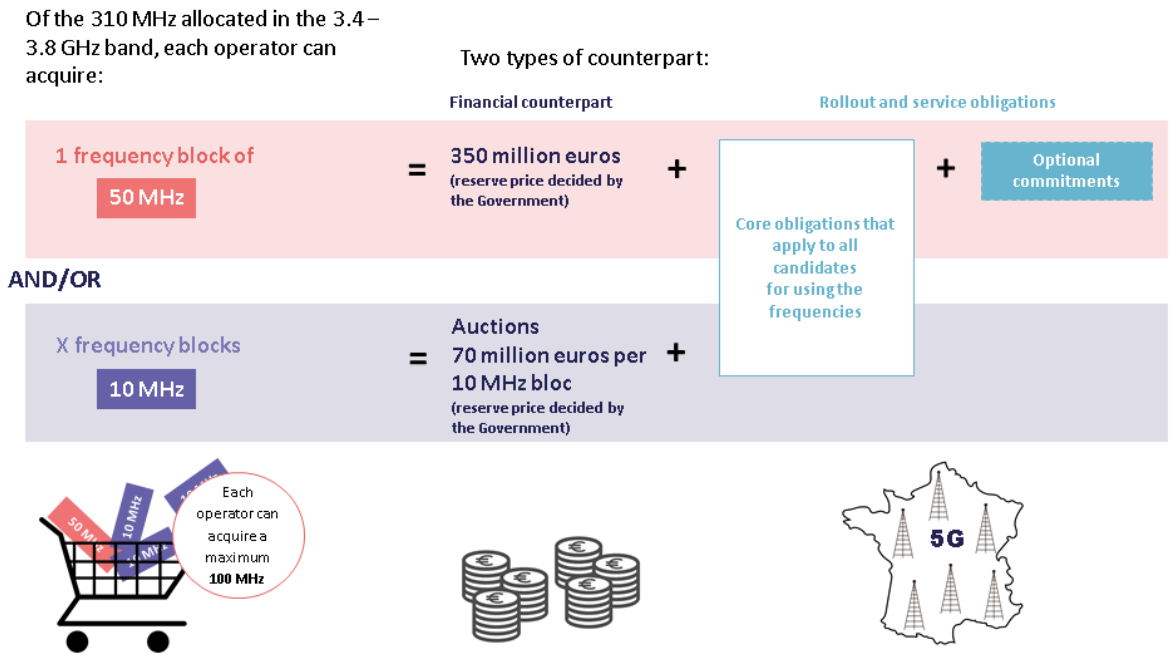
offered. Entire spectrum was divided into 7 blocks of 100 MHz each. Regarding the license period, it was decided that initial authorizations will have a term not to exceed ten years from the date of initial issuance or renewal.[77] As for the construction requirements, licensees relying on mobile or point-to-multipoint service must show that they are providing reliable signal coverage and service to at least 40 percent of the population within the service area of the licensee, and that they are using facilities to provide service in that area either to customers or for internal use. [78] This auction raised a total of $2,022,676,752 in net bids ($2,024,268,941 in gross bids), with 29 bidders winning a total of 2,904 licenses.

13. The FCC held an mm-Wave auction of 28 GHz spectrum band which offered licenses in select areas around the country. A total of 850 MHz was auctioned, divided into two blocks of size 425 MHz each. Regarding the license period, it was decided that Initial authorizations will have a term not to exceed ten years from the date of initial issuance or renewal. As for the construction requirements, FCC mandated that licensees relying on mobile or point-to-multipoint service must show that they are providing reliable signal coverage and service to at least 40 percent of the population within the service area of the licensee, and that they are using facilities to provide service in that area either to customers or for internal use.[79] The amount raised from the auction was $700 million.[80]

France

[77] https://www.fcc.gov/auction/102/factsheet
[78] https://www.fcc.gov/auction/102/factsheet
[79] Auction 101: Spectrum Frontiers – 28 GHz | Federal Communications Commission (fcc.gov)
[80] https://venturebeat.com/2019/01/25/fccs-28ghz-mmwave-5g-auction-ends-raising-millions-but-leaving-questions/

14. ARCEP concluded Auction[81] for the award of 3.4 – 3.8 GHz band spectrum in October 2020. 110 MHz, consisting of 11 blocks of size 10 MHz each, were put to auction. 4 operators won spectrum, 2 operators won 2 blocks, 1 operator won 3 blocks and 1 operator won 4 blocks. In addition to the frequencies obtained during the main auction, the four candidates that made the additional commitments set out in the specifications were awarded a block of 50 MHz for the sum of 350 M€.



2-stage auction for 3.4-3.8 GHz band[82]

Orange bid €854 million for a total of 90 megahertz; SFR €728 million for 80 megahertz, while Bouygues Telecom and Free Mobile (Iliad) each offered €602 million for 70 megahertz.[83]

[81] https://en.arcep.fr/news/press-releases/view/n/5g-011020.html

[82] https://en.arcep.fr/news/press-releases/view/n/5g-23.html

[83] https://www.rcrwireless.com/20201002/business/france-completes-5g-spectrum-auction

Bidder	Bouygues Telecom	Free Mobile	Orange	SFR	Total
Frequencies	3570 – 3640 MHz	3640 – 3710 MHz	3710 – 3800 MHz	3490 – 3570 MHz	-
Amount of spectrum	70 MHz	70 MHz	90 MHz	80 MHz	310 MHz
Amount due	€602,000,000	€605,096,245	€854,000,000	€728,000,000	€2,789,096,245

3.4-3.8 GHz winning bidders[84]

This auction raised a total of 2.8 B€. [85] The licenses will be valid for a period of 15 years, with a possible extension by 5 years if the licence-holder agrees to the conditions attached. (https://www.arcep.fr/uploads/tx_gsavis/19-1386.pdf)[86]

15. Spectrum Cap: Each operator could acquire a maximum of 100 MHz overall.[87]

16. Network Deployment Obligations: ARCEP's specifications stipulated that each operator must launch 5G services in at least two cities before the end of 2020. Each carrier should deploy 3,000 sites by 2022, 8,000 sites in 2024 and 10,500 sites by 2025.[88] By 2022, at least 75% of cell sites must be capable of providing speeds of at least 240 Mbps at each site, according to ARCEP's initial specifications.[89] ARCEP also highlighted that 25% of 3.4-3.8 GHz band sites in the last two stages must be in sparsely populated areas, targeting economic activity, notably manufacturing, excluding major metropolitan areas.[90] Moreover, obligations that apply specifically to transport corridors have two main milestones: coverage of the country's motorways (16,642 km) by 2025 and by 2027, coverage of the main roadways (54,913 km).

[84] https://en.arcep.fr/news/press-releases/view/n/5g-041120.html
[85] https://5gobservatory.eu/3-4-3-8-ghz-auction-completed-in-france/
[86] https://en.arcep.fr/news/press-releases/view/n/5g-23.html
[87] https://en.arcep.fr/news/press-releases/view/n/5g-23.html
[88] https://www.rcrwireless.com/20201002/5g/france-completes-5g-spectrum-auction

[89] https://www.rcrwireless.com/20201002/5g/france-completes-5g-spectrum-auction

[90] https://www.rcrwireless.com/20201002/5g/france-completes-5g-spectrum-auction

These obligations stipulate connection speeds of a minimum 100 Mbit/s at each cell site.[91]

Italy[92]

17. **3.6-3.8 GHz**[93]: The mid-band auction ended on October 2nd, 2018, 14 days after start and 171 rounds. It made available 200 MHz of spectrum in the form of two 80 MHz blocks and two 20 MHz blocks on a nationwide basis. The spectrum cap was set at 100 MHz per operator.[94] The auction format was Simultaneous Multiple Round Auction (SMRA), and licences will be valid for 18 years. *Telecom Italia and Vodafone won the largest blocks of spectrum (80 MHz each) for approx.1.7 billion EUR each. Respectively they paid 1.694 billion EUR and 1.685 billion EUR. Wind and Iliad paid 483.9 million EUR each for 20 MHz of spectrum each (483.92 million EUR for Wind and 483.9 million EUR for Illiad).*

Band	Lot	Spectrum [MHz]	Reserve price [€]	Winner	Price paid [€]
3.7 GHz	3700_C1	80	158.374.470	TIM	1.694.000.000
	3700_C2	80	158.696.043	Vodafone	1.685.000.000
	3700_C3	20	39.674.011	Wind Tre	483.920.000
	3700_C4	20	39.674.011	Iliad	483.900.000
		200	***396.418.535***		***4.346.820.000***

3.6-3.8 GHz auction results[95]

Overall, the 3.7 GHz auction hit over 4 billion EUR reaching 4.3 billion EUR. The average price of spectrum closed at 18 cEUR/MHz/PoP/10 years significantly higher than in the UK or in Spain.

Network Deployment Obligations: In the 3.6-3.8 GHz band, licensees must use the awarded frequencies in all the Italian provinces within 2

[91] https://en.arcep.fr/news/press-releases/view/n/5g-23.html
[92] https://5gobservatory.eu/5g-spectrum/national-5g-spectrum-assignment/#1533310457982-93376798-7871
[93] https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Events2019/SantoDomingo/5G-Workshop/TallerS4Expositor4.pdf
[94] https://blog.telegeography.com/italian-5g-auction-causes-concern
[95] http://www.emergonline.org/wp-content/uploads/2018/12/EMERG-BEREC-workshop-on-5G_Marco-Petracca.pdf

years. In the 80 MHz lots, coverage must be provided to 10% of the communes in each region with fewer than 5,000 people, and those that are not covered by ultrabroadband. In the 20 MHz lots, coverage must be provided to 5% of the population in each region within 4 years from the availability of the spectrum. Moreover, other operators without frequencies in bands up to 3.6-3.8 GHz can use the frequencies in the same band not used by the licensees in any communes of the "free list" (set of communes with less than 5,000 inhabitants not included in the obligation lists of all licensees) by leasing them. [96] Each licensee with at least 80 MHz at national level (in this band or in general in the 3.4-3.8 GHz band) must be "ready to deliver" 5G services to any (residential or business) applicant customer in the obligation area, within 6 months from the demand, whereby offer conditions (including price) must be non-discriminatory and equivalent compared to the rest of the users and without charging any burden arising from the location of the applicant. Also, in case of eMBB services, download speed of at least 30 Mbit/s must be ensured[97].

18. **26 GHz**[98]: 1,000 MHz of the 26.5 GHz-27.5 GHz spectrum (split into five lots of 200 MHz) was auctioned in September 2018, in a multi-band auction along with 700 MHz and 3.5 GHz bands. The spectrum cap was 400 MHz per bidder. The process ended on October 2nd, 2018, 14 days after start. The auction for 26 GHz frequencies have not shown a huge interest by players, and the lack of competition led to a lot being allocated to each participant.[99] The five lots were allocated, raising a total of 167.3 million EUR. Telecom Italia paid its slot 33 million EUR, Illiad received another lot for a little less at 32.9 million EUR, while Fastweb, Wind and Vodafone paid 32.6 million EUR each. Licenses will

[96] https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Events2019/SantoDomingo/5G-Workshop/TallerS4Expositor4.pdf
[97] http://www.emergonline.org/wp-content/uploads/2018/12/EMERG-BEREC-workshop-on-5G_Marco-Petracca.pdf
[98] https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Events2019/SantoDomingo/5G-Workshop/TallerS4Expositor4.pdf
[99] https://www.oxera.com/insights/agenda/articles/5g-spectrum-the-varying-price-of-a-key-element-of-the-5g-revolution/

be valid until 2037 with the right of use to start as of December 1st, 2018.

19. Network Deployment Obligations: In the 26 GHz band, licensees must use the awarded frequencies in all the Italian provinces within 4 years. There are no coverage obligations in this band. Regarding access, there is a club use model via which each licensee can use all the awarded spectrum (up to 1 GHz) in areas where frequencies are not used by other licensees. However, each license holder has pre-emptive rights on its assigned lot. Also, each licensee must provide wholesale access to other players (non-telcos and verticals) for the development of 5G services.[100]

Spain[101]

20. 3.4-3.6 GHz spectrum has already been awarded for 5G services (2016, licenses are valid until 2030). Four licenses have 2×20 MHz of spectrum. The remaining 2×20 MHz are used for radiolocation and guard bands.

21. The 3.6-3.8 GHz spectrum auction was held in July 2018. The spectrum was divided into forty blocks, each of size 5 MHz (total of 200 MHz). The auction raised 438 MEUR. An overall spectrum cap of 120 MHz was set for frequencies in the 3.4 GHz-3.6 GHz/3.6 GHz-3.8 GHz bands. To comply with it, Orange Espana, which acquired a 2×20 MHz block of 3.5 GHz spectrum in 2016, was subject to a spectrum cap of 80 MHz for the auction[102]. Eventually, 90 MHz were awarded to Vodafone Spain, 60 MHz to Orange, and 50 MHz to Telefonica.[103] The licences are valid for a period of 20 years[104].

[100] https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/Events2019/SantoDomingo/5G-Workshop/TallerS4Expositor4.pdf
[101] https://5gobservatory.eu/5g-spectrum/national-5g-spectrum-assignment/#1533313602953-9ee79f1d-27c2

[102] https://www.commsupdate.com/articles/2018/05/29/spain-launches-3-6ghz-3-8ghz-5g-auction-process/
[103] https://5gobservatory.eu/status-of-the-lte-ecosystem/
[104] https://5gobservatory.eu/status-of-the-lte-ecosystem/

Australia[105]

22. The Australian Communications and Media Authority (ACMA) conducted the 3.6 GHz (3575-3700 MHz) band spectrum auction in November/December 2018. The 350 lots of 5 MHz each were offered for sale by enhanced simultaneous multi-round ascending (ESMRA) auction. All lots were sold to Dense Air Australia, Mobile JV, Optus Mobile and Telstra raising total revenue of approximately $852.8 million. The Auction was concluded in December 2018 and the spectrum allocated will remain valid till 13 December 2030 i.e., 12 years. As regards spectrum cap, it was specified that no bidder could acquire more than 60 MHz/80 MHz of the relevant band in each metropolitan area/ regional area, respectively. Results of the mid-band auction are shown below:

Winning bidder	Spectrum sold	Winning price
Dense Air Australia Pty Ltd	29 x 5 MHz	$18,492,000
Mobile JV Pty Limited	131 x 5 MHz	$263,283,800
Optus Mobile Pty Ltd	47 x 5 MHz	$185,069,100
Telstra Corporation Limited	143 x 5 MHz	$386,008,400
Total	350 lots	$852,853,300

[105] https://www.acma.gov.au/auction-summary-36-ghz-band-2018

23. The ACMA conducted the 26 GHz[106] (25.1–27.5 GHz) band spectrum auction in April 2021, starting on 12 April 2021 and ending on 21 April 2021. The available frequency range of 2400 MHz was auctioned in the block size of 200 MHz. Geography wise 360 lots were made available in the auction, 358 were sold, raising a total revenue of $647,642,100. License period is up to 15 years, with a common expiry date in 2036. Spectrum cap of 1000 MHz per bidder in each designated area was specified.

Winning bidder	Number of lots won	Winning price
Dense Air Australia Pty Ltd	2	$28,689,900
Mobile JV Pty Limited	86	$108,186,700
Optus Mobile Pty Ltd	116	$226,203,100
Pentanet Limited	4	$7,986,200
Telstra Corporation Limited	150	$276,576,200

26 GHz Auction Results[107]

Finland

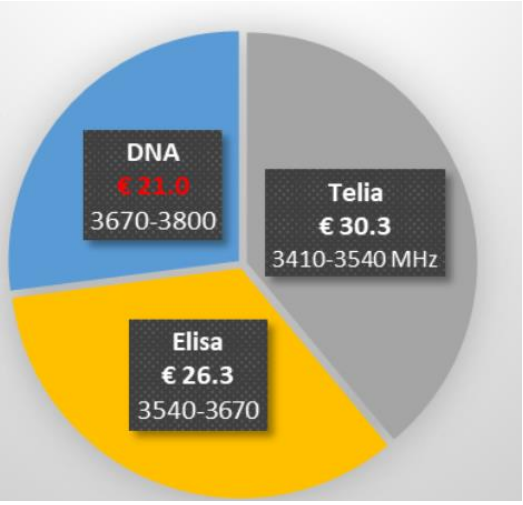
24. **3.4-3.8 GHz:** The 3410-3800 MHz was awarded through auction via a Simultaneous Multi Round Auction (SMRA) model in October 2018, consisting of a total of 390 MHz divided into three blocks, each of size 130 MHz. The spectrum cap was of 130 MHz.[108] The licence duration was set from 2019 to 2033. The licences are country-wide without coverage obligations. However, licensees are obliged to lease their

[106] https://www.acma.gov.au/auction-summary-26-ghz-band-2021#spectrum-details

[107] https://www.acma.gov.au/26-ghz-band-auction-results

[108] https://auctiometrix.com/finnish-5g-auction-concluded/

spectrum if they do not offer a local vertical specific network in a given location if requested. Three license holders (existing MNOs) won spectrum, and the total price paid was 77.6 M€.[109]



3.4-3.8 GHz Auction Results[110]

Overall, the auction raised 77.6 million EUR, a reasonable amount, in line with government base prices. The price of a MHz per PoP for 10 years was 2.4 cEUR.[111]

25. **26 GHz:** The auction on 26 GHz (25.1–27.5 GHz) spectrum arranged by Finland's Transport and Communications Agency Traficom concluded in June 2020.[112] A total of 2400 MHz was assigned for national use with three 800 MHz frequency blocks.[113] Eventually, 3 operators, viz. Elisa Corporation, Telia Finland and DNA acquired 800 MHz each, at the starting price of €7 million.

Frequency bands	Winner	Winning bid
25.1 - 25.9 GHz (A)	Elisa Corporation	7 000 000 €

[109] Analysis of Spectrum Valuation Elements for Local 5G Networks: Case Study of 3.5 GHz Band, IEEE
[110] https://www.linkedin.com/pulse/finnish-5g-spectrum-auction-lessons-roberto-ercole/
[111] https://5gobservatory.eu/3-4-3-8-ghz-auctions-in-finland/
[112] Finland concludes 26 GHz 5G spectrum auction | (advanced-television.com)
[113] Finland's Ministry of Transport and Communications launched a consultation on the 26 GHz frequency band – 5G Observatory

25.9 - 26.7 GHz (B)	Telia Finland Oyj	7 000 000 €
26.7 - 27.5 GHz (C)	DNA Plc	7 000 000 €

26 GHz Auction Results[114]

GERMANY

26. **3.4-3.8 GHz:** Auctions were conducted for the frequencies in 3400-3700 MHz in Spring 2019 together with 2.1 GHz band, with a validity period until 2040. It consisted of 300 MHz to be divided into one 20 MHz lot and twenty-eight 10 MHz lots[115]. No spectrum cap was defined.[116] The coverage obligations for the licence winners include a requirement to supply speeds of a minimum of 100 Mbps to at least 98% of households in each state by the end of 2022, as well as all federal highways, and the major roads and railways. By the end of 2024, 5G spectrum holders will be obliged to provide speeds of 100Mbps to all other main roads, while covering the smaller roads, railways, seaports and the main waterways with data rates of at least 50Mbps. Furthermore, each operator will have to set up 1,000 5G base stations by the end of 2022, in addition to 500 base stations in 'white spot' unserved rural areas. For newcomers, less stringent coverage requirements apply.[117]

[114] https://www.traficom.fi/en/communications/communications-networks/spectrum-auction-26-ghz-frequency-band

[115] Analysis of Spectrum Valuation Elements for Local 5G Networks: Case Study of 3.5 GHz Band, IEEE

[116] https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/Areas/Telecommunications/Companies/TelecomRegulation/FrequencyManagement/ElectronicCommunicationsServices/FrequencyAward2018/20181214_Decision_III_IV.pdf?__blob=publicationFile&v=2

[117] German 5G spectrum auction ends, raising EUR6.5bn (commsupdate.com)

Operator	Amount (MHz)	Fee (€ '000)	Fee per MHz pop ($)
1&1 Drillisch	50	735,190	0.20
Telefónica	70	1,043,728	0.20
Deutsche Telekom	90	1,323,423	0.20
Vodafone	90	1,073,188	0.16
Total	300	4,175,529	0.19
Source: Bundesnetzagentur, operators.			

3.6 GHz Band Auction Results[118]

The multi-band 5G spectrum auction raised a total of EUR6.5 billion (USD7.3 billion).[119]

HONG KONG

27. **3.5 GHz:** The OFCA assigned 200 MHz of spectrum in the 3.4 – 3.6 GHz band (the "3.5 GHz band") in October 2019, divided into 20 frequency blocks, each with a bandwidth of 10 MHz. The validity period of the licenses would be 15 years. A spectrum cap of 70 MHz was imposed. Regarding the network and service roll-out obligations, it was decided that each successful bidder will be required to provide a minimum coverage of 45% of the population with regard to mobile services within five years from the grant of the licence. The auction was conducted in two stages, namely the Quantity Stage to first decide the number of frequency blocks to be assigned to each bidder using a clock auction format; followed by the Assignment Stage to determine the specific and contiguous frequency blocks to be assigned to each bidder which has successfully bid for frequency blocks at the Quantity Stage [120]. The band was successfully auctioned off to four mobile network operators at a total of spectrum utilization fees (SUFs) of HK$1.006 billion.[121] CMHK acquired 60 MHz for HK$300 million, HKT and SmarTone each acquired

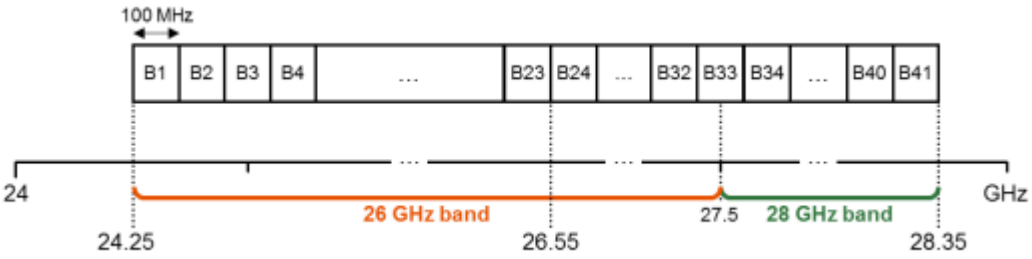
[118] https://www.lightreading.com/mobile/spectrum/germany-raids-telcos-for--euro-65b-in-epic-5g-auction/d/d-id/752144
[119] German 5G spectrum auction ends, raising EUR6.5bn (commsupdate.com)
[120] https://www.coms-auth.hk/filemanager/statement/en/upload/481/joint_statement_st_062018.pdf
[121] https://www.ofca.gov.hk/en/news_info/press_releases/index_id_2005.html

50 MHz for HK$252 million, and HTCL acquired 40 MHz for HK$202 million.[122]

Frequency Block	Frequency Range	Provisional Successful Bidder	SUF Payable
A1 – A6	3400 – 3460 MHz	CMHK	HK$300 million
A7 – A11	3460 – 3510 MHz	HKT	HK$252 million
A12 – A16	3510 – 3560 MHz	SmarTone	HK$252 million
A17 – A20	3560 – 3600 MHz	HTCL	HK$202 million

3.5 GHz auction results[123]

28. **26/28 GHz:** In 2018, OFCA decided to allocate spectrum in the 26 GHz band (24.25 – 27.5 GHz) and 28 GHz band (27.5 – 28.35 GHz). It decided to adopt a channel bandwidth of 100 MHz for the 4100 MHz of spectrum in the 26/28 GHz bands, making it a total of 41 frequency slots available for assignment.



Band Plan for 26/28 MHz band[124]

29. It set aside 3700 MHz of spectrum in the 26/28 GHz bands as Non-shared Spectrum for provision of large scale public mobile services; and 400 MHz of spectrum as Shared Spectrum for provision of localised wireless services including fixed services A cap of 800 MHz was set for the amount of Non-shared Spectrum which may be held by an assignee, and as for the Shared Spectrum (for providing services in specified

[122] https://www.ofca.gov.hk/en/news_info/press_releases/index_id_2005.html
[123] https://www.ofca.gov.hk/en/news_info/press_releases/index_id_2005.html
[124] https://www.coms-auth.hk/filemanager/statement/en/upload/480/joint_statement_st_052018.pdf

locations), the cap is set at 400 MHz. The assignments were for a period of 15 years from 1 April 2019 to 31 March 2034. For an applicant assigned with 800 MHz of Non-shared Spectrum in the 26/28 GHz bands, a minimum of 5000 radio units were obligated be installed and put into use within the first five years following spectrum assignment. The network and service rollout obligations would be reduced proportionately in accordance with the amount of spectrum assigned. 20% of the radio units required to be installed shall be installed within the first one and a half years following spectrum assignment; an addition of 20% of the radio units within the next one and a half years; an addition of 30% of radio units by the end of the fourth year; and an addition of the remaining 30% of radio units by the end of the fifth year. Shared Spectrum to be assigned for the provision of small scale localised wireless services should not be subject to network and service rollout obligations [125] In April 2019, a total of 1200 MHz of spectrum in the 26/28 GHz band was assigned to three MNOs, viz. CMHK, HKT and SmarTone[126] as per their applications for the provision of large-scale public mobile services. 400 MHz of spectrum was assigned to each of the three MNOs by way of administrative assignment.

	Spectrum Offered for Assignment	
Successful Applicant	Frequency Range (GHz)	Amount (MHz)
a. SmarTone Mobile Communications Limited	26.55 - 26.95	400
b. China Mobile Hong Kong Company Limited	26.95 - 27.35	400
c. Hong Kong Telecommunications (HKT) Limited	27.35 - 27.75	400

26/28 GHz band assignments[127]

[125] https://www.coms-auth.hk/filemanager/statement/en/upload/480/joint_statement_st_052018.pdf
[126] https://www.info.gov.hk/gia/general/201903/27/P2019032700308.htm
[127] https://www.info.gov.hk/gia/general/201903/27/P2019032700308.htm

30. The assignees currently do not need to pay SUF for the use of the spectrum as less than 75% of the spectrum in the 26 GHz and 28 GHz bands has been occupied. When this percentage is exceeded, the SUF would be set at $21,600 per MHz per annum. The network and service roll-out obligations include 2500 radio installations for 400 MHz of spectrum already assigned. The CA plans to invite second round applications in 2021 for assignment of the remaining spectrum in the 26 GHz and 28 GHz bands for the provision of large-scale public mobile services. [128]

[128] itb20210419cb1-779-5-e.pdf (legco.gov.hk)

Annexure 3.1

Comparative statement of Valuation, Reserve Price and Auction Price in the spectrum auction of March 2021

Auction of 700 MHz (Rs. in crore per MHz)				
LSA	**TRAI's Valuation**	**TRAI's recommended Reserve Price**	**Reserve price fixed by DOT**	**Auction price**
Delhi		915	915	No Bid
Mumbai		1122	1122	No Bid
Kolkata		347	347	No Bid
Andhra Pradesh		557	557	No Bid
Gujarat		546	546	No Bid
Karnataka		219	219	No Bid
Maharashtra		729	729	No Bid
Tamilnadu		199	199	No Bid
Haryana		113	113	No Bid
Kerala		190	190	No Bid
Madhya Pradesh		190	190	No Bid
Punjab		177	177	No Bid
Rajasthan		211	211	No Bid
U. P. (East)		305	305	No Bid
U.P. (West)		230	230	No Bid
West Bengal		105	105	No Bid
Assam		92	92	No Bid
Bihar		175	175	No Bid
Himachal Pradesh		37	37	No Bid
J&K		30	34	No Bid
North East		25	34	No Bid
Orissa		54	54	No Bid

Auction of 800 MHz (Rs. in crore per MHz)				
LSA	**TRAI's Valuation**	**TRAI's recommended Reserve Price**	**Reserve price fixed by DOT**	**Auction price**
Delhi	800.48	640	640	640
Mumbai	981.44	727	727	727
Kolkata	303.24	160	160	160
Andhra Pradesh	487.51	390	390	390
Gujarat	446.51	385	385	385
Karnataka	239.49	192	192	192
Maharashtra	637.98	510	510	510
Tamilnadu	217.92	174	174	174
Haryana	98.91	57	57	57

Kerala	196.32	157	157	157
Madhya Pradesh	178.47	143	143	143
Punjab	162.95	157	157	157
Rajasthan	265.94	266	266	266
U. P. (East)	261.77	251	251	251
U.P. (West)	201.22	161	161	161
West Bengal	92.29	74	74	74
Assam	80.25	64	64	No Bid
Bihar	191.67	136	136	136
Himachal Pradesh	32.10	24	24	24
J&K	36.98	15	15	No Bid
North East	37.64	15	15	No Bid
Orissa	59.10	47	47	47

Auction of 900 MHz

(Rs. in crore per MHz)

LSA	TRAI's Valuation	TRAI's recommended Reserve Price	Reserve price fixed by DOT	Auction price
Delhi	730.63	585	585	No Bid
Mumbai	864.05	691	691	No Bid
Kolkata	276.82	221	221	No Bid
Andhra Pradesh	521.78	417	417	No Bid
Gujarat	465.96	373	373	373
Karnataka	297.46	238	238	No Bid
Maharashtra	654.04	523	523	No Bid
Tamilnadu	293.13	235	235	235
Haryana	127.46	102	102	No Bid
Kerala	248.75	199	199	199
Madhya Pradesh	244.07	195	195	No Bid
U. P. (East)	326.93	262	262	262
U.P. (West)	263.54	211	211	No Bid
West Bengal	154.81	124	124	124
Assam	103.76	83	83	No Bid
Bihar	251.13	201	201	201
Himachal Pradesh	45.86	37	37	37
North East	56.65	23	23	23
Orissa	107.99	86	86	86

Auction of 1800 MHz

(Rs. in crore per MHz)

LSA	TRAI's Valuation	TRAI's recommended Reserve Price	Reserve price fixed by DOT	Auction price
Delhi	457.42	457	457	457
Mumbai	560.82	561	561	561
Kolkata	173.28	173	173	173
Andhra Pradesh	278.58	279	279	279
Gujarat	272.85	273	273	273
Karnataka	136.85	109	109	109

Maharashtra	364.56	365	365	365
Tamilnadu	124.53	100	100	100
Haryana	56.52	57	57	57
Kerala	112.18	95	95	95
Madhya Pradesh	101.98	95	95	95
Punjab	94.90	88	88	88
Rajasthan	105.36	105	105	No Bid
U. P. (East)	152.64	153	153	153
U.P. (West)	114.99	115	115	115
West Bengal	52.73	53	53	53
Assam	45.86	46	46	46
Bihar	109.52	88	88	88
Himachal Pradesh	18.34	18	18	18
J&K	21.13	15	17	17
North East	21.51	13	17	17
Orissa	33.77	27	27	27

Auction of 2100 MHz

(Rs. in crore per MHz)

LSA	**TRAI's Valuation**	**TRAI's recommended Reserve Price**	**Reserve price fixed by DOT**	**Auction price**
Delhi	635.11	635	635	No Bid
Mumbai	528.50	528	528	No Bid
Kolkata	143.82	115	115	No Bid
Andhra Pradesh	231.22	185	185	No Bid
Gujarat	226.46	181	181	No Bid
Karnataka	113.59	91	91	No Bid
Maharashtra	390.93	391	391	No Bid
Tamilnadu	394.37	394	394	No Bid
Haryana	63.05	63	63	No Bid
Kerala	202.91	203	203	No Bid
Madhya Pradesh	84.65	68	68	No Bid
Punjab	104.32	104	104	No Bid
U. P. (East)	126.40	126	126	No Bid
U.P. (West)	95.44	76	76	No Bid
West Bengal	43.77	35	35	35
Assam	38.06	30	30	30
Bihar	98.59	99	99	No Bid
Himachal Pradesh	15.22	12	12	No Bid
J&K	15.08	13	13	No Bid
North East	17.85	6	6	6
Orissa	43.56	44	44	No Bid

Auction of 2300 MHz

(Rs. in crore per MHz)

LSA				

	TRAI's Valuation	TRAI's recommended Reserve Price	Reserve price fixed by DOT	Auction price
Delhi		164	164	164
Mumbai		167	167	167
Kolkata		38	38	38
Andhra Pradesh		78	78	78
Gujarat		70	70	70
Karnataka		112	112	112
Maharashtra		72	72	72
Tamilnadu		151	151	151
Haryana		8	8	8
Kerala		20	20	20
Madhya Pradesh		9	9	9
Punjab		21	21	21
Rajasthan		6	6	6
U. P. (East)		9	9	9
U.P. (West)		12	12	12
West Bengal		6	6	6
Assam		2	2	2
Bihar		7	7	7
Himachal Pradesh		1	1	1
J&K		1	1	1
North East		1	1	1
Orissa		5	5	5

Auction of 2500 MHz (Rs. in crore per MHz)				
LSA	**TRAI's Valuation**	**TRAI's recommended Reserve Price**	**Reserve price fixed by DOT**	**Auction price**
Delhi		164	164	No Bid
Mumbai		167	167	No Bid
Kolkata		38	38	No Bid
Andhra Pradesh		78	78	No Bid
Gujarat		45	45	No Bid
Karnataka		98	98	No Bid
Maharashtra		66	66	No Bid
Tamilnadu		132	132	No Bid
Punjab		24	24	No Bid
Bihar		7	7	No Bid
Himachal Pradesh		1	1	No Bid
J&K		1	1	No Bid

Note: The LSAs where no spectrum has been put on auction have not been included in the above tables.

Annexure 3.2

Status of Sale of Spectrum in March 2021 Auction

LSA	700 MHz		800 MHz		900 MHz		1800 MHz		2100 MHz		2300 MHz		2500 MHz	
	% of spectrum sold of spectrum put for auction	D and S of spectrum31	% of spectrum sold of spectrum put for auction	D and S of spectrum	% of spectrum sold of spectrum put for auction	D and S of spectrum	% of spectrum sold of spectrum put for auction	D and S of spectrum	% of spectrum sold of spectrum put for auction	D and S of spectrum	% of spectrum sold of spectrum put for auction	D and S of spectrum	% of spectrum sold of spectrum put for auction	D and S of spectrum
Delhi	0%	No Bid	70%	D < S	0%	No Bid	30%	D < S	0%	No Bid	50%	D < S	0%	No Bid
Mumbai	0%	No Bid	75%	D < S	0%	No Bid	22%	D < S	0%	No Bid	50%	D < S	0%	No Bid
Kolkata	0%	No Bid	80%	D < S	0%	No Bid	7%	D < S	0%	No Bid	50%	D < S	0%	No Bid
Andhra Pradesh	0%	No Bid	45%	D < S	0%	No Bid	26%	D < S	0%	No Bid	50%	D < S	0%	No Bid
Gujarat	0%	No Bid	80%	D < S	100%	D = S	22%	D < S	0%	No Bid	100%	D = S	0%	No Bid
Karnataka	0%	No Bid	73%	D < S	0%	No Bid	81%	D < S	0%	No Bid	50%	D < S	0%	No Bid
Maharashtra	0%	No Bid	83%	D < S	0%	No Bid	23%	D < S	0%	No Bid	100%	D = S	0%	No Bid
Tamilnadu	0%	No Bid	73%	D < S	57%	D < S	94%	D < S	-	-	50%	D < S	0%	No Bid
Haryana	0%	No Bid	88%	D < S	0%	No Bid	22%	D < S	0%	No Bid	100%	D = S	-	-
Kerala	0%	No Bid	73%	D < S	100%	D = S	55%	D < S	0%	No Bid	100%	D = S	-	-
Madhya Pradesh	0%	No Bid	80%	D < S	0%	No Bid	41%	D < S	0%	No Bid	100%	D = S	-	-
Punjab	0%	No Bid	56%	D < S	-	-	51%	D < S	0%	No Bid	100%	D = S	0%	No Bid
Rajasthan	0%	No Bid	67%	D < S	-	-	0%	No Bid	-	-	100%	D = S	-	-
U. P. (East)	0%	No Bid	40%	D < S	78%	D < S	44%	D < S	-	-	100%	D = S	-	-
U.P. (West)	0%	No Bid	80%	D < S	0%	No Bid	37%	D < S	0%	No Bid	100%	D = S	-	-
West Bengal	0%	No Bid	89%	D < S	69%	D < S	54%	D < S	50%	D < S	100%	D = S	-	-
Assam	0%	No Bid	0%	No bid	0%	No Bid	68%	D < S	50%	D < S	100%	D = S	-	-
Bihar	0%	No Bid	40%	D < S	33%	D < S	91%	D < S	0%	No Bid	100%	D = S	0%	No Bid
Himachal Pradesh	0%	No Bid	50%	D < S	50%	D < S	21%	D < S	0%	No Bid	100%	D = S	0%	No Bid
Jammu & Kashmir	0%	No Bid	0%	No bid	-	-	71%	D < S	0%	No Bid	100%	D = S	0%	No Bid
North East	0%	No Bid	0%	No bid	24%	D < S	95%	D < S	50%	D < S	100%	D = S	-	-
Orissa	0%	No Bid	44%	D < S	73%	D < S	100%	D = S	0%	No Bid	100%	D = S	-	-

D (Demand)< S (Supply) and D=S indicate LSAs where the auction determined price was higher than the reserve price in these LSAs.
Blank- where no spectrum was put to auction

Annexure 3.3

Methodologies and Approaches previously used for Spectrum Valuation

Spectrum Band	Valuation Approach/ Methodology	Date and Para Number of Recommendation on Valuation and Reserve Price of Spectrum
1800 MHz	Producer Surplus Model	Annexure 4.2 of September 2013 Recommendations Para 3.38 of August 2018 Recommendations
	Production Function Approach	Annexure 4.3 of September 2013 Recommendations Para 3.32 of October 2014 Recommendations Para 3.32 of January 2016 Recommendations Para 3.31 of August 2018 Recommendations
	Revenue Surplus Model	Annexure 3.3 of October 2014 Recommendations Para 3.36 of January 2016 Recommendations Para 3.34 of August 2018 Recommendations
	Use of Last auction determined price	Para 3.64 and Annexure 4.4 of September 2013 Recommendations Para 3.26 of January 2016 Recommendations Para 3.24 of August 2018 Recommendations
	Market Data Analysis: Single variable correlation or multiple regression	Para 4.2 to 4.10 and Annexure 4.1 of September 2013 Recommendations Para 3.41 of August 2018 Recommendations
800 MHz	Producer Surplus Model	Annexure 3.2 of February 2014 Recommendations Annexure A of Authority's response of 27 November 2014 to reference received from DoT on February 2014 Recommendations
	Technical Efficiency Approach	Para 3.1 to 3.4 of December 2013 Consultation Paper

		Para 3.22 of August 2018 Recommendations
	Use of last auction determined prices	Para 3.29 of August 2018 Recommendations
	Potential Growth in Data Services	Annexure 3.3 of February 2014 Recommendations Annexure A of Authority's response of 27 November 2014 to reference received from DoT on February 2014 Recommendations
	Use of Auction Determined Prices of 900 MHz in valuation of 800 MHz band	Para 3.68 of February 2014 Recommendations Para 3.42 of January 2016 Recommendations
	Market Data Analysis: Single variable correlation or multiple regression	Annexure 4.1 of September 2013 Recommendations Para 3.16 of January 2016 Recommendations
900 MHz	Technical Efficiency Approach	Para 4.45 to 4.47 of September 2013 Recommendations Para 3.45 of August 2018 Recommendations
	Economic Efficiency Approach	Annexure 4.5 of September 2013 Recommendations Annexure 3.5 of October 2014 Recommendations Para 3.45 of August 2018 Recommendations
	Use of Auction Determined Prices of 800 MHz in valuation of 900 MHz band	Para 3.42 of January 2016 Recommendations Para 3.45 of August 2018 Recommendations
	Market Data Analysis: Single variable correlation or multiple regression	Annexure 4.1 of September 2013 Recommendations Para 3.16 of January 2016 Recommendations
2100 MHz	Technical Efficiency Approach	Para 3.8 to 3.10 of December 2014 Recommendations Para 3.6 and 3.7 of December 2014 Consultation Paper Para 3.22 of August 2018 Recommendations

	Data Usage Growth Model	Para 3.20 - 3.21 December 2014 Consultation Paper Annexure 3.4 of December 2014 Recommendations Para 3.49 of January 2016 Recommendations
	Producer Surplus Model	Annexure 3.3 of December 2014 Recommendations
	Use of Last auction determined price	Para 3.5 - 3.7 of December 2014 Recommendations Para 3.26 - 3.28 of January 2016 Recommendations Para 3.29 of August 2018 Recommendations
700 MHz	Use of Reserve Price of 1800 in valuation of 700 MHz band	Para 3.75 of January 2016 Recommendations Para 3.98 of August 2018 Recommendations
2300 MHz	Indexation of last available auction prices	Para 3.80 to 3.81 of January 2016 Recommendations Para 3.71 of August 2018 Recommendations
	Equal to last recommended Reserve Price	Para 3.71 of August 2018 Recommendations
2500 MHz	Equal to recommended Reserve Price of 2300 MHz	Para 3.85 of January 2016 Recommendations
	Indexation of last available auction prices	Para 3.80 of August 2018 Recommendations
	Equal to last recommended Reserve Price	Para 3.80 of August 2018 Recommendations
3300 - 3600 MHz	Technical efficiency approach	Para 3.129 to 3.130 of August 2018 Recommendations

Annexure 3.4

Details of auctions held in 600 MHz and mmWave bands internationally

S. No.	Country	Spectrum band	Year of auction	Auction Price per MHz per pop (in $)
i.	Canada	600 MHz	2019	1.25
ii.	USA	27.500 – 28.350 GHz	2018/2019	0.0026
iii.	South Korea	28 GHz	2018	0.0048
iv.	Italy	26 GHz	2018	0.0032
v.	USA	24.25 – 24.45 GHz and 24.75–25.25 GHz	2019	0.0088
vi.	Finland	26GHz	2020	0.0017
vii.	Taiwan	28GHz	2020	0.0014
viii.	Australia	26 GHz	2021	0.0089
Source: GSA Database				

Annexure 4.1

INTERNATIONAL SCENARIO ON SPECTRUM FOR PRIVATE CELLULAR NETWORKS

1. A number of countries in various parts of the world including Asia, Europe and North America have spectrum initiatives underway for private networks.

2. GSA in its report[129] of September 2021 on 'Private Mobile Network' has identified 55 countries/territories with private network deployments based on LTE or 5G where 5G-suitable private network spectrum licenses have been assigned. In addition, there are private mobile network installations in various offshore locations serving the oil and gas industries, as well as on ships.

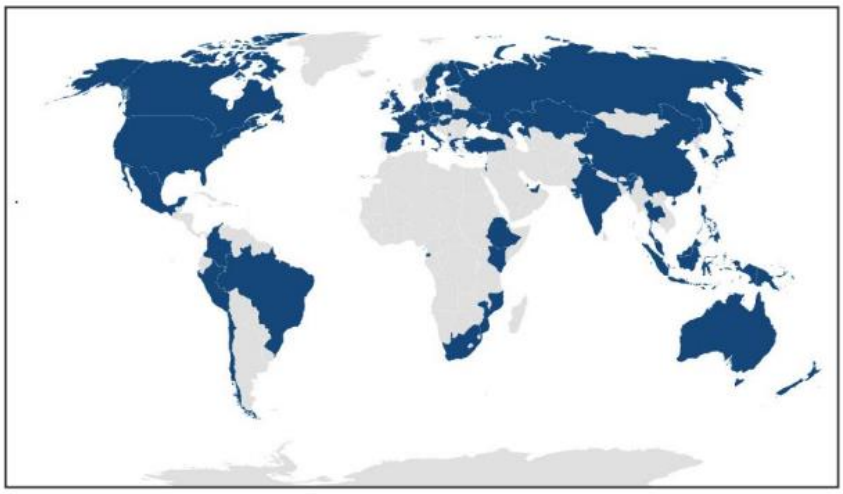


Figure: Countries/territories investing in private mobile networks (licences, pilot projects, deployments and launches

This annexure contains a brief discussion on international approaches taken towards private network in different countries.

[129] GSA: Private Mobile Networks Executive Summary (September 2021)

Australia

3. The ACMA adopted a mix of license types, namely spectrum, apparatus, and class licensing measures in the 26/28 GHz band, to facilitate a broad range of wireless broadband use cases[130]. These licence types authorize access to spectrum. Each of these licenses have differing characteristics with respect to the allocation method commonly used, approach to pricing, associated level of exclusivity and interference environment[131]. In general, the ACMA does not specifically set aside spectrum for private entities and generally develop technology flexible arrangements.

4. A spectrum licence authorises the use of a specific frequency band within a defined geographic area for up to 20 years. Spectrum licences have been utilised for most bands used to deploy commercial mobile broadband networks. Whereas an apparatus licence authorises operating under a specific radiocommunications service type, in a specific frequency range, and generally at a specific geographic location for a period of up to 20 years. It is typically issued 'over-the-counter' in accordance with coordination rules developed by the ACMA. Class licences are a standing authorization to use spectrum without the need to apply to the ACMA for access, so long as the conditions of that licence are met. These conditions can be technical or geographic and pertain to the type of use, class of user or interference environment[132].

5. Regarding 26 / 28 GHz, spectrum licenses were applicable for the 25.1–27.5 GHz range that was auctioned in April 2021. Apparatus licensing is a licensing option for small-area, multi-device deployments, including for proposed 5G applications. Australia-wide apparatus licenses were arranged in the 24.7–25.1 GHz and 27.5–30 GHz ranges before the auction. After the auction, apparatus licenses were provided in the

[130] ACMA: Allocation of apparatus licences in the 26 GHz and 28 GHz bands (October 2020)
[131] Spectrum options optimized for local area wireless broadband services (August 2021)
[132] ibid

25.1–27.5 GHz in all areas other than those specified for spectrum licensing. Thus, a total of 5300 MHz of spectrum is available for apparatus licensing across the frequency range 24.7–30 GHz.

6. The overview of planning arrangements in the 26/28 GHz bands are given in following figure.

Figure: Overview of planning arrangements in the 26/28 GHz bands

C1/C2: Class licensing arrangements for WBB services (subject of a separate consultation process).

S1/S2: Spectrum licensing (subject of a separate allocation process).

A1: Apparatus licensing (Australia-wide) restrictions on the number of base stations to manage interference by preventing wide and dense deployments.

A2: Apparatus licensing (outside specified areas[133]).

A3: Apparatus licensing (outside specified areas).

A4 (inside specified areas): Restricted to FWA/FSS on a primary access basis and ubiquitous FSS on a secondary access basis. Additional conditions to protect domestic FSS uplinks.

A5 (outside specified areas): Restricted to fixed wireless on a secondary basis and for primary FSS use (fixed gateway and ubiquitous earth stations). Additional conditions to protect domestic FSS uplinks.

A6 (Australia-wide): Restricted to fixed wireless on a secondary basis[134] and for primary FSS use (fixed gateway and ubiquitous earth stations). Additional conditions to protect domestic FSS uplinks.

A7 (Australia-wide): Restricted to the operation of earth stations only.

7. The Area-Wide License (AWL) transmitter licence type can authorise the operation of one or more radiocommunications devices within a defined geographic area at a frequency or frequencies specified on the licence, subject to the conditions included in the licence. The interference with other services is primarily managed using technical conditions that apply to the geographic and frequency boundary of the licence. The

[133] 'Specified areas' for A2, A3, A4 and A5 are large population centers as named in the Radiocommunications (Spectrum Re-allocation – 26 GHz Band) Declaration 2019.
[134] For both A4 and A5, class-licensed ubiquitous FSS earth stations are contingent upon an appropriate space receive apparatus licence being in place.

licences may be used for a wide range of purposes, uses, services, applications, and technologies, subject to the technical framework for the relevant band set out in Radiocommunications Assignment and Licensing Instructions (RALIs) and licence conditions. For space communications, AWLs will authorise earth stations to communicate with space receive stations on space objects. The licences are capable of being adapted to a variety of technologies and/or uses, with different sized areas and frequency bandwidths. A number of AWLs, adjacent in geography, frequency or both, can be consolidated into a single transmitter licence, with boundary conditions applying to the boundary of the aggregated licence.

8. In most cases, the minimum amount of spectrum applicants can apply for is one 50 MHz channel. One AWL cell is equivalent to one 'HCIS 00' level cell (Hierarchical Cell Identifier Scheme), which is about 500 x 500 meters. Therefore, the minimum cell/channel combination in most cases is a 50 MHz channel with a 500 x 500-meter cell[135]. The maximum amount of spectrum is constrained by the amount of spectrum available in the band. However, ACMA may adjust the amount of spectrum offered or offer no spectrum to one or more applicants if there is competing demand.

9. There are two types of fees applicable to apparatus licenses. Administrative charges to recover the direct costs of spectrum management, and Annual apparatus license taxes to recover the indirect costs of spectrum management and to provide incentives for efficient spectrum use. Indirect costs are those that cannot be directly attributed to individual licensees.

10. The annual apparatus licence tax is implemented in 24.7 to 25.1 GHz frequency range and in areas other than those designated for spectrum

[135] ACMA: Allocation of apparatus licences in the 26 GHz and 28 GHz bands (October 2020)

licensing in the 25.1 to 27.5 range, and in the 27.5 to 30 frequency range and is calculated as follows:

AWL tax = $/MHz/pop price x Bandwidth (MHz) x Population of geographic area

where, $/MHz/pop price - Tax rate for one MHz of spectrum per head of population. The apparatus license tax is $0.0003/MHz/pop.

Bandwidth - Total amount of spectrum in MHz authorized by the license.

Population - Population (Based on the 2016 Census) of the geographic area, defined in terms of the HCIS[136] system, authorized by the license. The population is based on the aggregate population of all the geographic cells to be authorised by the licence.

11. *Co-existence Measures:* Spectrum licenses were provided in the 25.1–27.5 GHz range through auction, and Area-Wide Apparatus (AWLs) licenses for localized use were issued in 24.7–25.1 GHz, 27.5–30 GHz and 25.1–27.5 GHz in all areas other than those specified for spectrum licensing[137]. Further, existing services in these bands include international satellites, and Space Receive Stations in 25.1-27.5 GHz; Earth Receive Stations in 25.5-27 GHz; Domestic satellite in 27-27.5 GHz; and Fixed Point-to-Point Services in 27.5-29.5 GHz[138]. Therefore, to ensure interference free co-existence, the AWL licensees must abide by technical restrictions and administrative provisions[139].

12. Considering spectrum in the 3700–4200 MHz band is the subject of considerable interest, ACMA has developed a plan for an arrangement in the 3700-4200 MHz bands suitable for local area wireless broadband applications (which include private networks). Under this, ACMA is introducing arrangements for local area wireless broadband (LA WBB) in 3700–3800 MHz in remote areas, and in 3800–4000 MHz Australia-wide on a shared basis with existing fixed satellite service (FSS) and

[136] HCIS - Hierarchical Cell Identifier Scheme

[137] ACMA - Allocation of apparatus licences in the 26 GHz and 28 GHz bands (OCTOBER 2020)

[138] ACMA - 26 GHz (25.1–27.5 GHz) band spectrum licence technical framework - Consultation paper (JULY 2020)

[139] ibid

fixed point-to-point (PTP) service types and maintaining apparatus licensing in 4000–4200 MHz for PTP and FSS only.

Finland

13. Finland has set aside dedicated spectrum for private and local networks[140] in the 2.3 GHz band (2300-2320 MHz) and 26 GHz band (24.25 – 25.1 GHz). Besides, sub-licensing of 3.4-3.8 GHz is allowed through local permission via operator lease[141].

14. ***2.3 GHz Band:*** Under Regulation 4Z / 2020M, added secondary allocation to the frequency band 2300-2320 MHz for private radio networks based on mobile communication technology (so-called Private-LTE)[142]. These networks are intended to be used locally, for example, in factories, ports, airports, power plants and mines for their own operations. In July 2020, Finland issued its first private cellular license for industrial LTE and 5G at 2.3 GHz. It granted a 20 MHz spectrum (2300–2320 MHz) to the state-owned energy company Fortum Power and Heat to use at its power plant in Loviisa[143]. It was the first time that the Finnish government released spectrum directly to enterprises outside of the licensed mobile operators.

15. ***3.5 GHz Band:*** Currently, TRAFICOM has granted a local spectrum license for 60 MHz in the range 3,640–3,700 MHz to Aalto University for 5G research and development purposes[144].

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140 https://www.traficom.fi/sites/default/files/media/file/Heidi%20Himmanen_Paikalliset%205G%20verkot%20.pdf

141 HEAVY READING | QUALCOMM | PRIVATE 5G NETWORKS FOR INDUSTRIAL IOT | JULY 2019

142 https://www.lausuntopalvelu.fi/FI/Proposal/Participation?proposalId=3bf8ce50-287d-476c-a0ac-44211d32f6e0

143 https://enterpriseiotinsights.com/20200707/channels/news/finland-issues-first-private-lte-5g-licence-urges-industry-to-pile-in

144 https://www.emerald.com/insight/content/doi/10.1108/DPRG-12-2020-0178/full/html

16. ***26 GHz Band:*** In the 26 GHz band, 850 MHz (24.25-25.1 GHz) has been reserved for local/regional vertical players and R&D or educational usage[145]. The upper part of the 26 GHz (25.1-27.5 GHz) band was auctioned in June 2020[146], while the lower part of the band was left out of the auction.

17. *Fee Structure:* TRAFICOM Frequency Fee formula[147] is currently used to determine the annual frequency fee for all spectrum licenses in Finland.

Frequency Fee = C1 x Cinh x C6b x B0 x S x P

Where, C1 = Frequency Band Coefficient. This coefficient enables frequency fees to be adjusted to the usability of the licence holder's frequency band. It varies from 2 to 0.2 from sub-GHz to mmWave.

Cinh = (POP_PC/ POP_FIN) (1 km^2 / APC)*
POP_PC is the population of the postal code area
POP_FIN is the total population of Finland
1 km^2 the constant area of the license
APC the area in km^2 of the postcode.
C6b = System Coefficient, defined according to the scaled number of mobile radio transmitters in the system
B0 = Relative Bandwidth
S = Basic Fee Coefficient (Type of radio equipment used)
P = basic fee

Germany

18. Germany is one of the frontrunners in 5G local network licensing, which plays a key role in the country's larger 5G strategy for industrial applications. This is reflected in Bundesnetzagentur's (BNetzA), the national Regulator, actions to release spectrum for local licensing in the 5G mid-band (3.7-3.8 GHz) as well as the 26 GHz band (25.1-27.5 GHz)[148].

[145] Stimulating demand for 26 GHz in Europe July 2021, Plum Consulting
[146] https://5gobservatory.eu/5g-spectrum-auction-concluded-in-finland/
[147] Location Dependent Spectrum Pricing of Private LTE and 5G Networks in Europe Topias Kokkinen, Heikki Kokkinen , Seppo Yrj¨ol¨a ,Adrian Kliks, Research Square, April 2020

[148] https://digitalregulation.org/spectrum-licensing-local-and-private-networks-in-germany/

19. ***3.7-3.8 GHz:*** In November 2019, Germany opened 100 MHz in the 3.7-3.8 GHz band for 5G local spectrum licenses. Interested applicants could apply for up to 100 MHz of spectrum, in 10 MHz blocks, using time division duplex (TDD), for use in a defined coverage area.

20. *Allocation Method:* Applications include plans that demonstrate that the spectrum requested would be used efficiently to ensure effective use. As conveyed by BNetZa, default license duration is 10 years, but there is a plan to align their regulation with §49 of the European Electronic Communications Code (EECC) which may result in default duration of 15 years. Further, discussions are undergoing even to allow a license duration until 31st December 2040. The spectrum must be used within one year of assignment and any transfers must be approved by BNetzA[149].

21. BNetzA has endeavored to make the local licenses available to a wide audience and has set broad eligibility requirements such as to possess the expertise and financial resource to build and operate private network, to be the owner or lessee of the property on which the private network is to be installed etc. and annual fees tied to criteria of use.

22. *Pricing:* Annual fees for the use of the spectrum apply and are calculated according to the amount of bandwidth, size and location of the coverage area requested, and duration of the spectrum license.[150] The fee for 3.7-3.8 GHz band is calculated in each individual case using the following fee formula[151]:

[149] ibid
[150] ibid
[151] https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/EN/2019/20191031_LokalesBreitband.html

Fee = 1000 + B * t * 5 * (6a1 + a2)

Where,

1,000 indicates the basic amount in €,
B denotes the bandwidth in MHz (min. 10 to max. 100 MHz),
t is the duration of allocation in years (e.g., 10 years),
a is the area in km² with a differentiation between the settlement and traffic area (a1) and other areas (a2).

23. Several industrial players have already applied for local licences, including Bosch, Siemens, BMW, Volkswagen, BASE SE, and Deutsche Lufthansa[152].

24. ***26 GHz[153]:*** It was decided to issue local licenses in 24.25 – 27.5 GHz band, as a general assignment approach was not considered feasible based on incumbent use and protection requirements. The BNetzA published the Administrative Regulation on Frequency Allocations for Local Broadband Frequency Uses in the 24.25 - 27.5 GHz Frequency Range in December 2020[154]. After considering the existing users in the band, BNetzA proposed that the intended applications be split into two sub-bands[155]:

Sub-band	**Intended Applications**	**Existing Users**	**Eligibility**
24.25-26.5 GHz	Mobile broadband applications (e.g., urban hotspots, fixed wireless access (FWA) to rural areas)	Fixed point-to-point links (24.25-26.5 GHz)	Requested area should be limited only to the area to be supplied with service

[152] https://digitalregulation.org/spectrum-licensing-local-and-private-networks-in-germany/
[153] ibid
[154] Stimulating demand for 26 GHz in Europe; July 2021; Tony Lavender, Val Jervis, Aude Schoentgen, Laura Wilkinson; July 2021
[155] https://digitalregulation.org/spectrum-licensing-local-and-private-networks-in-germany/

Sub-band	Intended Applications	Existing Users	Eligibility
26.5-27.5 GHz	Local applications tied to a property or land (e.g., industrial, agricultural and forestry 5G applications)	Earth-Exploration Satellite (EESS) (25.5-27 GHz)	Own or rent/lease property

25. The framework proposes to assign spectrum in blocks of 200 MHz, although smaller blocks in multiples of 50 MHz can also be requested. Applicants should state the start and end date of use and licenses may be issued for up to 10 years, with the possibility of renewal[156].

26. *Allocation Method:* Licenses are provided by direct application[157] and are awarded on a First Come First Served (FCFS) basis[158]. Allocation is done in each case as an individual administrative act since it is necessary to coordinate future use with existing radio services. Applicants need to submit applications describing the intended frequency usage information including a description of the area (no maximum size is stipulated) and justification for the requested bandwidth[159].

27. The Authority assumes that the requested bandwidths will be a maximum of 800 MHz based on currently available equipment parameters. However, for more bandwidth, more details are needed to justify it to keep spectrum hoarding in check. Another safeguard is the "use it or lose it" principle. The use must commence within 12 months, otherwise the allocation can be revoked. In case of cross-plot use, the authority requires information on progress after 6, 9 and 12 months[160].

[156] ibid
[157] https://www.athonet.com/private-lte/
[158] Stimulating demand for 26 GHz in Europe, Plum Consulting, July 2021
[159] https://fuenf-g.de/en/2021/02/19/frequenzvergabe-im-26-ghz-band-hat-begonnen/
[160] ibid

28. *Pricing:* According to the Federal Network Agency, the fee is calculated in each individual case using the following fee formula:

Fee = 1000 + B * t * 0.63 * (6a1 + a2)

- 1,000 indicates the basic amount in euros,
- B denotes the bandwidth in MHz (min. 50 MHz),
- t the duration of the allocation in years (e.g., 15 years),
- The area in km² with a differentiation between the settlement and traffic area (a1) and other areas (a2).[161]

29. It may be noted that, to differentiate between settlement and traffic areas (a1) and other areas (a2), the BNetzA uses the definition of the *Federal Statistical Office*[162]. The fee formula is designed to ensure optimum and efficient use of the spectrum. The larger the bandwidth, and larger the area covered by the usage, the higher the fee. The base amount has been chosen so as not to create an obstacle for business models such as those of start-ups, SMEs, or agricultural enterprises.

30. *Co-existence Measures:* In Germany[163], local licensees in the 3.7-3.8 GHz band must ensure interference-free use, including by coordinating with other geographically near local users and protecting existing users in the band (e.g., FSS earth stations). Also, in 26 GHz (24.25 – 27.5 GHz) for local licenses, local users must operate on a non-interference basis and protect existing services for example, fixed point-to-point links in 24.25-26.5 GHz, Earth-Exploration Satellite (EESS) Service in 25.5-27 GHz.

31. The 3.7-3.8 GHz band is for vertical uses only and must be applied to a specific economic unit, such as a trade fair or industrial estate. This means that the band cannot be used by MNOs and regional operators.

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161 https://www.bundesnetzagentur.de/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OeffentlicheNetze/LokaleNetze/lokalenetze-node.html

162 https://statistik.thueringen.de/datenbank/definitionen.asp?tabID=zt000534#methode

163 https://digitalregulation.org/spectrum-licensing-local-and-private-networks-in-germany/

However, the 26 GHz frequencies can be used by verticals as well as MNOs and regional operators.[164]

Hong Kong

32. ***28 GHz band:*** The Office of the Communications Authority (OFCA) set aside 400 MHz from 27.95 – 28.35 GHz as Shared Spectrum[165] under a newly created Localized Wireless Broadband Service (LWBS) License with less stringent requirements than conventional public mobile services[166]. The LWBS Licence has been created for the establishment, maintenance and operation of networks and systems for the provision of innovative wireless broadband services using the Shared Spectrum based on 5G or other advanced mobile technologies.

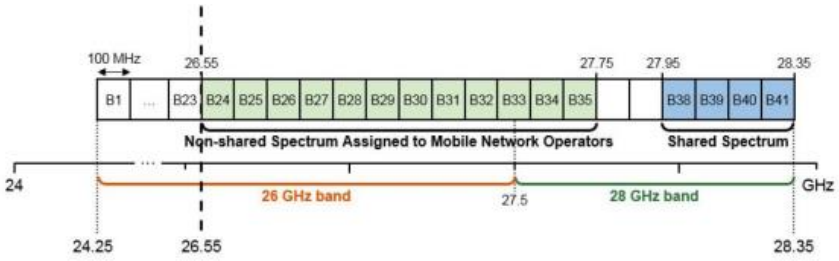

Figure: Band Plan for the 26/28 GHz Bands[167]

33. *Eligible Applicants:* In 26/28 GHz band, licensees designated for providing large scale public mobile services will not be eligible for the Shared Spectrum which is in 28 GHz. Moreover, Shared Spectrum licensees must not deploy the spectrum assigned on a wholesale or retail basis to provide conventional public mobile services. However, mobile services provided for some specialized applications such as

[164] https://www.telcotitans.com/deutsche-telekomwatch/dt-and-bnetza-lock-horns-over-private-5g-licences/3489.article
[165] Guidelines for Submission of Applications for Assignment of Shared Spectrum in the 26 GHz and 28 GHz Bands; OFCA; September 2021
[166] https://www.ofca.gov.hk/en/news_info/press_releases/index_id_1953.html
[167] Joint Statement of the Communications Authority and the Secretary for Commerce and Economic Development; Allocation of the 26 GHz and 28 GHz Bands to Mobile Service and the Associated Arrangements for Spectrum Assignment and Spectrum Utilization Fee; December 2018

cargo and fleet management, electronic monitoring, etc. to selected groups of users are not considered as "conventional public mobile services"[168].

34. *Method of Allocation*: The assignments will be made on a first-come-first-served basis[169]. The applicant should specify the detailed description of all services to be provided, the identity and number of target users, expected service launch date, implementation schedule, arrangements for offering wholesale and/or retail services to the public, and amount of Shared Spectrum applied for, with justifications provided. The OFCA will examine the proposal according to licensing criteria such as business plan, financial capability, technical soundness and QoS, managerial and technical expertise, service quality and charges, etc., and decide whether to grant the license to the applicant[170].

35. *License Details:* The Shared Spectrum will be assigned on a geographically sharing basis for use in different specified locations such as university campuses, industrial estates, airport, technology parks, etc. It may also be used to support fixed wireless access or smart city applications in scattered locations. The aggregate network coverage of these licenses is limited to 50 square kilometers. The Localized Wireless Broadband Service (LWBS) Licence will be a non-carrier licence with a set of less stringent licence conditions as compared with the Unified Carrier Licence (UCL). The LWBS License and the spectrum assignment will be for a period of five years and may be extended for a further period of up to five years. Spectrum cap of 400 MHz would be imposed on any

[168] ibid
[169] ibid
[170] Guidelines for Submission of Applications for Assignment of Shared Spectrum in the 26 GHz and 28 GHz Bands; OFCA; September 2021

person acquiring the Shared Spectrum. The Shared Spectrum is not subject to network and service rollout obligations[171].

36. *License Fee:* The current annual license fee payable on the issue and on each anniversary of the issue of an LWBS License in each year while the license remains in force shall be the sum of the items given in the table below, where applicable[172].

	Particulars	**Annual license fee**
1	Fixed fee	HK$100,000
2	For each 100 LWBS devices connected by radiocommunications means to the network established and maintained under the LWBS license	HK$200
3	For the 1st to the 50th base station installed for the service	HK$1000 per base station
	For the 51st to the 100th base station installed for the service	HK$500 per base station
	For the 101st base station installed for the service and any other base stations	HK$100 per base station
4	For every 1 kHz or part thereof of frequency then assigned to the licensee	HK$1

37. The OFCA decided that the 26/28 GHz bands will be assigned administratively. For such spectrum not released through auction or other market mechanisms, the Spectrum Policy Framework provides that the SUF may be set to reflect the opportunity costs of the spectrum, with a view to encouraging spectrum users to put the spectrum assigned to them to efficient use and/or to return unused or underutilized spectrum to the CA for assignment to other users. The Spectrum Utilization Fee (SUF) will only be charged if more than 75% of the spectrum in these frequency bands is assigned or occupied. The

[171] https://www.coms-auth.hk/filemanager/statement/en/upload/480/joint_statement_st_052018.pdf
[172] Guidelines for Submission of Applications for Assignment of Shared Spectrum in the 26 GHz and 28 GHz Bands; OFCA; September 2021

level of SUF for the Shared Spectrum will be set at $1,080 per MHz per annum given the limited geographic scope the Shared Spectrum can be applied in and with a view to encouraging the introduction of innovative services by new market entrants[173].

Malaysia

38. ***26/28 GHz:*** In Malaysia, the assignment of 26/28 GHz bands was conducted in two methods:

1) It was decided to assign the 24.9-26.5 GHz frequency bands through a tender process (beauty contest) to licensees on a nationwide basis[174].

2) The remaining frequency range of 26.5 -28.1 GHz was decided to be assigned to any party (including non-licensees) for deploying localized and/or private networks for industrial and enterprise services and applications such as healthcare, ports, transportation, manufacturing, agriculture, public safety, and smart city projects[175]. The spectrum set aside for local/private networks entailed four blocks of 400 MHz (totaling 1600 MHz)[176].However, proceedings for the same have been delayed[177].

39. *Eligible Applicants:* Any licensee in the frequency range of 24.9-26.5 GHz will not be eligible to apply for the remaining frequency range of 26.5 -28.1 GHz.

[173] ibid
[174] https://www.mcmc.gov.my/en/media/press-releases/final-report-on-allocation-of-spectrum-bands-for-m
[175] Final Report Allocation of spectrum bands for mobile broadband service in Malaysia, MCMC, Dec. 2019
[176] MCMA - Allocation of spectrum bands for mobile broadband service in Malaysia (31 Dec 2019)
[177] Private Mobile Networks: November 2020| GSA

40. *Allocation Method:* The assignment will be issued by way of Apparatus Assignment, on a first-come first-served basis[178]. Apparatus Assignment includes rights to use a specified spectrum to operate a specified kind of network facility, and assignment period of up to 5 years or lesser[179].

41. *Pricing:* The Apparatus Assignment Fees have two components:

- **Fixed Fees** which are essentially applied per station differentiated on the basis of service. Details can be found in the document mentioned[180].
- **Variable Fees** which are based on the bandwidth used

	Annual fees with respect to bands per Apparatus (RM)		
Bandwidth (per channel) (kHz)	*less than 30 MHz*	*30 MHz up to 3 GHz*	*More than 3 GHz*
0 - 5	42	90	60
5 - 12	52	110	70
12 - 25	62	130	90
25 - 100	113	230	130
100 - 200	186	380	200
200 - 1,000	264	520	280
1,000 – 3,500	342	680	360
3,500 – 7,000	420	840	440
7,000 – 14,000	498	1,000	510
14,000 – 28,000	576	1,160	590
28,000 – 60,000	654	1,300	670
36,000 – 54,000	732	1,470	750
54,000 or greater	810	1,620	830

Figure: Variable Fees for Apparatus License[181]

South Korea[182]

42. The Ministry of Science and ICT (MSIT) in Korea announced the "Private 5G network frequency supply plan" in June 2021. It simultaneously

[178] Final Report Allocation of spectrum bands for mobile broadband service in Malaysia, MCMC, Dec. 2019
[179] https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2015/Aug-ITP/Presentations/Malaysian%20Spectrum%20Licensing%20Framework_Stella%20Jeevamani%20Navaratnam.pdf
[180] https://www.esccom.org.sz/publications/notices/docs/GENERAL-NOTICE-NUMBER-12-Spectrum-Pricing-Consultation-v2.17.pdf
[181] ibid
[182] https://www.netmanias.com/en/?m=view&id=blog&no=15139

supplied the Sub-6 GHz (4.7 GHz) band along with the mmWave (28 GHz) band to activate the deployment of the private 5G network.

43. *Applicant Details:* The applicant for allocation must be the land/building owner, lessee, or a third party entrusted by the owner; the lessee and entrusted third party require the consent of the owner. Companies that directly build private 5G networks designate frequencies through interference analysis according to the current wireless station establishment permit procedure.

44. ***4.7 GHz Band:*** 100 MHz width (4.72-4.82 GHz) of the 4.7 GHz band was secured in consideration of the industry demand, and the appropriate bandwidth will be supplied according to the request of the demanding company, by dividing it into 10 blocks with a 10 MHz width.

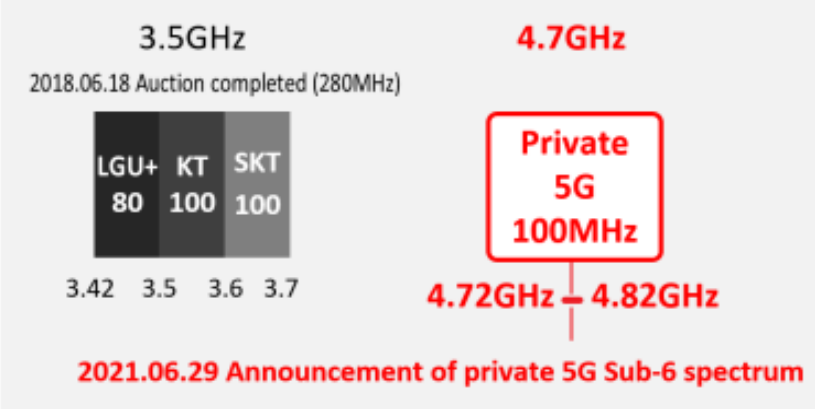

Figure: Sub-6 GHz band arrangements[183]

45. ***28 GHz:*** The 600 MHz width (28.9-29.5 GHz) is divided into twelve 50 MHz-wide blocks, and the appropriate bandwidth will be supplied according to the request of the demanding company.

[183] ibid

Figure: 28 GHz band arrangements[184]

46. *Fee Structure:* The private 5G network frequency is used in a limited area of land/building units, so the competitive demand for the spectrum is limited. Therefore, a price allocation method that imposes government-calculated consideration rather than an auction is applied. The fee is calculated in each individual case using the following fee formula:

Fee = basic amount x (5a1 + a2 +1) x duration x BW

basic amount*: 4.7 GHz band (100,000KRW / 10MHz), 28GHz band (50,000KRW / 50MHz)*
area *(a1, a2) in km²: metropolitan area(a1), other areas (a2)*
duration*: the duration of the allocation in years*
BW*: the number of BW blocks. BW block (4.7GHz band: 10MHz*, 28GHz band: 50MHz)

Sweden

47. The Swedish Post and Telecom Authority (PTS) has developed a proposal for conditions for local licenses in the 3720–3800 MHz and 24.25–25.1 GHz bands. It envisages applications from industries, mining, ports, warehouses, and hospitals. The purpose of the conditions is to allow local applications in an efficient and robust

[184] ibid

manner, thereby enabling innovation and development, as well as contributing to further deployment of 5G in Sweden[185].

48. ***3720-3800 MHz:*** PTS intends to enable local permits for the use of 80 MHz of spectrum in the 3720–3800 MHz range. These will be awarded and managed through an administrative process[186].

49. ***26 GHz band:*** PTS initiated consultations on the demand for 5G frequencies in the 24.25–27.5 GHz bands. In December 2019, it stated that it intended to allocate parts of the spectrum range for both local and large scale 5G use, as soon as possible. In its consultation launched in April 2020, it proposed to authorize the use of 850 MHz of spectrum at 24.25–25.1 GHz for local 5G services before the end of 2021, with licenses valid to end of 2025 and limited to indoor use[187].

United Kingdom

50. In UK, OFCOM decided to dedicate the 3.8-4.2 GHz, 1800 MHz, and 2300 MHz, and the lower 26 GHz band (24.25 – 26.5 GHz) for local deployments through Shared Access licenses. Private networks may also operate on unused licensed spectrum through the newly introduced Local Access licenses[188].

[185] https://www.pts.se/en/news/radio/2021/consultation-regarding-conditions-for-local-5g-licences/
[186] https://www.5g-networks.net/5g-technology/private-5g-4g-and-shared-spectrum/
[187] ibid
[188] Enabling wireless innovation through local licensing|OFCOM|July 2019

Uses	1800 MHz shared spectrum	2300 MHz shared spectrum	3.8-4.2 GHz	Lower 26 GHz band	Licensed mobile spectrum
Private network	✓ (narrowband)	✓	✓	✓ (indoor)	✓
Mobile coverage (rural)	✓	certain locations	×	×	✓
Mobile coverage (indoor)	✓	✓	×	✓	✓
Fixed wireless access	×	×	✓	✓	✓

Figure: Potential Uses of the Band Made Available[189]

51. *Shared Access License:* The two types of Shared Access License include Low Power License, which will be used to deploy multiple base stations within a 50-meter radius, and Medium Power License, which will authorize users to deploy a single base station in a wide area. It was proposed that the license would be for an indefinite duration, subject to the payment of an annual license fee. A short term license of less than 1 year can also be issued, priced on a pro-rata basis, with a minimum cost of £32. The license is subject to a one-month revocation notice. The licenses can be revoked for spectrum management purposes, or if licensees are in breach of their license conditions[190]. Equipment would have to start transmitting within six months of the license being issued and continue to be operational afterwards.

52. The four different spectrum bands are made available using the Shared Access license and are called "the shared access bands". The frequency range and spectrum made available for each of these bands is summarized in the following table.

[189] ibid
[190] ibid

Band	Frequency Range	Spectrum Available
1800 MHz	1781.7-1785 MHz/ 1876.7-1880 MHz	2 x 3.3 MHz
2300 MHz	2390-2400 MHz	10 MHz
3.5 GHz	3.8-4.2 GHz	390 MHz
26 GHz	24.25-26.5 GHz	2.25 GHz

Frequency Ranges and Available Spectrum of Shared Access bands[191]

53. ***3.8-4.2 GHz:*** For the 3.8-4.2 GHz band, different size channel bandwidths up to 100 MHz will be allotted, in line with the 3GPP standard for base station transmission and reception (band n77)[192].

54. ***26 GHz:*** The shared access approach for the lower 26 GHz band will enable deployment of new 5G indoor applications, for example for industrial users, without prejudicing any future outdoor use. Licensees can deploy the required number of indoor base stations in a circular area with a 50-metre radius[193].

55. *Application Process:* To apply for a Shared Access License, an application form should be submitted, in which the prospective user mentions the relevant band, location, bandwidth and power required. OFCOM then carries out a technical assessment to ensure that there would be no interference between the new deployment and other users' equipment, and accordingly assigns a frequency. Once the user pays the license fee for the same, OFCOM issues the per area/per base station license[194].

[191] Shared Access licence: guidance document|OFCOM|July 2019
[192] ibid
[193] ibid
[194] ibid

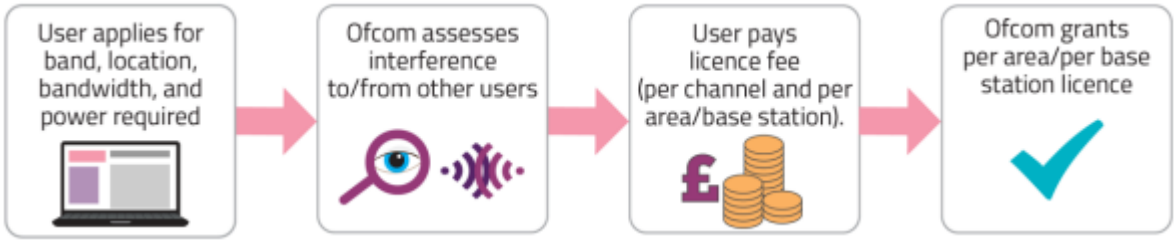

Figure 1.5: Shared Access licence application process[195]

56. *Fee Structure:* For the 1800 MHz, 2300 MHz, and 3.8-4.2 GHz bands[196], the annual license fee charged is based on the bandwidth used is:

- *£80 per 10 MHz for 3.8-4.2 GHz*
- *£80 for 2300 MHz shared spectrum (10 MHz) and 1800 MHz shared spectrum (2 x 3.3MHz)*

For the lower 26 GHz band[197], the fee charged does not change based on the bandwidth since more spectrum is available in the band. The annual license fee is £320 regardless of bandwidth.

57. *Co-existence Measures:* In United Kingdom[198], the existing users in the Shared Access bands such as 2300 MHz are Amateur radio, Programme Making and Special Events (PMSE), in 3.8-4.2 GHz are Fixed links, Earth Stations, fixed broadband and in 26 GHz are PMSE, fixed links, Earth Stations, unlicensed SRDs. While issuing a shared access license, OFCOM carries out a technical assessment of interference possibilities to and from other licensees in these bands. Moreover, to manage the interference environment, the license contains terms which enable OFCOM to request for change of frequency from time to time.

58. *Local Access License* [199]: Under this licensing approach, prospective new users wishing to access specific mobile frequencies that are not

[195] Shared Access licence: guidance document (OFCOM)
[196] Enabling wireless innovation through local licensing | OFCOM | July 2019
[197] Shared Access licence: guidance document | OFCOM | July 2019
[198] Enabling wireless innovation through local licensing | OFCOM | July 2019

[199] Local Access licence: guidance document (OFCOM)

being used in a given location can apply to OFCOM for a license. OFCOM will assess the likely impact of introducing a new user in that location and will discuss with the relevant MNO(s) before deciding whether to issue a new licence. These applications for short-term access to licensed mobile bands will have a default period of three years. It entails a one-off license fee of £950. The license will be available within any frequency band covered by the Mobile Trading Regulations, viz.:

- 791-821 MHz paired with 832-862 MHz ("800 MHz band")
- 880-915 MHz and 925-960 MHz ("900 MHz band")
- 1452-1492 MHz ("1400 MHz band")
- 1710-1781.7 MHz and 1805-1876.7 MHz ("1800 MHz band")
- 1900-1920 MHz ("1900 MHz band")
- 1920-1980 MHz and 2110-2170 MHz ("2100 MHz band")
- 2350-2390 MHz ("2300 MHz band")
- 2500-2690 MHz ("2600 MHz band")
- 3410-3600 MHz ("3.4 GHz band").

United States of America

59. In USA, there are multiple ways in which private enterprises can deploy their own networks, and the Federal Communications Commission (FCC) does not regulate such use, for example, private enterprises can:
    - Lease spectrum from license holders in their geographic area via the secondary market and build their own network
    - Work with a U.S. mobile operator to build and deploy a network for their internal use.
    - Use combination spectrum available for unlicensed/shared use – including 3.5 GHz band under the Citizens Broadband Radio Service (CBRS).
    - Rely on any combination of the above (e.g., using unlicensed Wi-Fi in tandem with a mobile operator's licensed spectrum).

60. ***3.5 GHz*:** Spectrum particularly in 3.5 GHz band is available for unlicensed/shared use under CBRS. It is a three-tiered priority allocation structure and authorization framework to accommodate shared use of 150 MHz of spectrum in the 3550-3700 MHz range[200].

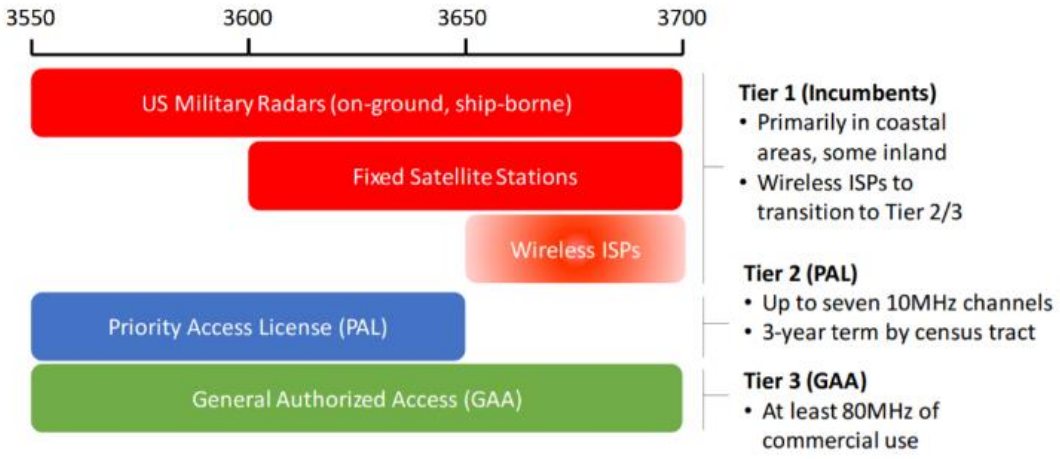

Figure: CBRS 3-Tiered Shared Spectrum Licensing Structure[201]

A brief description of the 3-Tiered structure is as follows[202]:

Tier 1 Incumbent Access	Users include federal, military, and historical satellite service users (FSS)[203]. They receive protection from interference by the lower tiers
Tier 2 Priority Access	Priority Access Licenses (PALs), renewable every 10 years, are licensed on a county-by-county basis through spectrum auctions. Each PAL consists of a 10 MHz channel within the 3550-3650 MHz band. They must accept interference from Tier-1 but protected from Tier-3.
Tier 3 General Authorized Access	A GAA user may use any portion of the CBRS band not assigned to a higher tier (e.g., the 3650-3700 MHz band). It may also

200 https://www.fcc.gov/35-ghz-band-overview
201 https://www.federatedwireless.com/wp-content/uploads/2017/09/Mobile-Experts-CBRS-Overview.pdf
202 https://www.fcc.gov/35-ghz-band-overview
203 https://www.5gamericas.org/wp-content/uploads/2021/08/Private-Enterprise-Networks.pdf

	opportunistically use any unused Priority Access channel[204]. Must accept interference from each other as well as upper tiers

CBRS bands are assigned dynamically by a Spectrum Access System (SAS), which keeps track of channel assignments as well as high priority pre-emptive users and assigns channels according to FCC rules[205].

61. *Utility for Private Networks:* More than 200 organizations are PAL users, and some intend to use their license for private enterprise purposes. GAA users can request access dynamically to use the spectrum via approved SAS operators[206]. Thus, GAA enables enterprises to build and operate their own private LTE networks at mines, factories, warehouses, airports, stadiums, college campuses and other facilities and locations without needing a license[207].

[204] ibid
[205] ibid
[206]Private Mobile Networks: November 2020| GSA
[207] https://www.sierrawireless.com/iot-blog/new-cbrs-band/