भारतीय दूरसंचार विनियामक प्राधिकरण

Telecom Regulatory Authority of India

Recommendations

on

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

11th April 2022

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CHAPTER–I: INTRODUCTION

1.1 The Department of Telecommunications (DoT), through its letter dated 13th September 2021 **(Annexure-1.1)**, 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 were 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, 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 of 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 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/clarifications sought vide TRAI letter dated 27th September 2021 were provided by DoT vide its letters dated 2nd November 2021, 27th November 2021 and 2nd December 2021. While providing additional information/clarifications, in the context of pricing, DoT vide its letter dated 2nd November 2021, informed that:

> *"(a) 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.*
>
> *(b) 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.*
>
> *(c) 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.*
>
> *(d) In the recently concluded spectrum auction 2021, only 37.1% of spectrum put up to auction was acquired by TSPs.*

(e) 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.

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

1.6 As regards information on 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, through letter dated 27th November 2021, DoT 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.

1.7 Subsequent to release of Consultation Paper, DoT through its letter dated 2nd December 2021, forwarded a copy of the MIB letter dated 29th November 2021 providing information on details of the MIB transmitters, their locations, and coordinates (latitude-longitude), exact keep out distance required to be maintained at each location. As per the information forwarded by DoT, MIB transmitters working in the frequency range 526-582 MHz are located in 83 locations across India and the keep out distance required to be maintained from IMT ranges between 50 km to 150 km. This letter was uploaded on the TRAI website alongside the Consultation paper on 'Auction of spectrum in the frequency bands identified for IMT/5G' as additional information for the information of the stakeholders.

1.8 Subsequently, DoT through its letter dated 22nd February 2022 **(Annexure-1.3)** informed that additional spectrum has been made available in 800 MHz, 900 MHz and 1800 MHz bands. Further, DoT has sought TRAI recommendations on need to review channel plan in 800 MHz and number of spectrum blocks that can be made available for IMT while providing the recommendations in response to DoT's reference dated 13.09.2021. This letter was uploaded on TRAI website alongside the Consultation Paper as additional information for the stakeholders and discussions with the TSPs were also held.

BACKGROUND

1.9 Spectrum assignment in 800 MHz, 900 MHz and 1800 MHz was being initially done administratively, while spectrum in 2100 and 2300 MHz bands were assigned through auction mechanism for the very first time in 2010. After the Hon'ble Supreme Court of India judgment dated 2nd February 2012, spectrum assignment for access services in all the bands is being done through auction process. Since 2012, total six auctions have been held for assignment of spectrum in various access bands. A summary of the spectrum auctioned in various access spectrum bands since 2012 is given in the Table 1.1.

Table 1.1
Access Spectrum Auctions conducted in India since 2012

Sl. No.	Year	Spectrum bands	Spectrum put to auction	Spectrum sold
1.	November 2012	1800 MHz (paired)	295 MHz	127.5 MHz
		800 MHz (paired)	95 MHz	No bidder
2.	March 2013	900 MHz (paired)	46 MHz (Delhi, Mumbai and Kolkata LSAs)	No bidder
		1800 MHz (paired)	57.5 MHz (Delhi, Mumbai, Karnataka and Rajasthan)	No bidder
		800 MHz (paired)	95 MHz	30 MHz
3.	February 2014	900 MHz (paired)	46 MHz (in 3 LSAs - Delhi, Mumbai and Kolkata)	46 MHz
		1800 MHz	385 MHz	307.2 MHz

		(paired)		
4.	March 2015	800 MHz (paired)	108.75 MHz	86.25 MHz
		900 MHz (paired)	177.8 MHz	168 MHz
		1800 MHz (paired)	99.2 MHz	93.8 MHz
		2100 MHz (paired)	85 MHz (5 MHz in 17 LSAs)	70 MHz
5.	October 2016	700 MHz (paired)	770 MHz (35 MHz in 22 LSAs)	No bidder
		800 MHz (paired)	73.75 MHz (in 19 LSAs)	15 MHz (in 4 LSAs)
		900 MHz (paired)	9.4 MHz (4 LSAs-Bihar, Gujarat, UP(E), UP(W))	No bidder
		1800 MHz (paired)	221.6 MHz (in all LSAs except Tamilnadu)	174.8 MHz (in 19 LSAs)
		2100 MHz (paired)	360 MHz (20 MHz in 6 LSAs, 15 MHz in 16 LSAs)	85 MHz (in 12 LSAs)
		2300 MHz (unpaired)	320 MHz (20 MHz in 16 LSAs)	320 MHz
		2500 MHz (unpaired)	600 MHz (40 MHz in 8 LSAs, 20 MHz in 14 LSAs)	370 MHz (in 20 LSAs)
6.	March 2021	700 MHz (paired)	660 MHz (30 MHz in 22 LSAs)	No bidder
		800 MHz (paired)	230 MHz (in all LSAs)	150 MHz (in 19 LSAs)
		900 MHz (paired)	98.8 MHz (in 19 LSAs)	38.4 MHz (in 9 LSAs)
		1800 MHz (paired)	355 MHz (in all LSAs)	152.2 MHz (in 21 LSAs)
		2100 MHz (paired)	175 MHz (in 19 LSAs)	15 MHz (in 3 LSAs)
		2300 MHz (unpaired)	560 MHz (40 MHz in 6 LSAs, 20 MHz in 16 LSAs)	500 MHz (in 22 LSAs)
		2500 MHz (unpaired)	230 MHz (40 MHz in 2 LSAs, 30 MHz in 1 LSA, 20 MHz in 3 LSAs, 10 MHz in 6 LSAs)	No bidder

1.10 In the last spectrum auction, held in March 2021, entire 660 MHz (paired) in 700 MHz band, 80 MHz (paired) in 800 MHz band, 60.4 MHz (paired) in 900 MHz band, 202.8 MHz (paired) in 1800 MHz band, 160 MHz (paired) in 2100 MHz band, 60 MHz (unpaired) in 2300 MHz, 230

MHz (unpaired) in 2500 MHz band remained unsold. Further, some additional spectrum has been made available by DoT in 800 MHz, 900 MHz, and 1800 MHz bands. In the present reference dated 13th September 2021, DoT has proposed to auction spectrum in these bands again. In addition, DoT has included new bands viz. 526-698 MHz, 3300-3670 MHz and 24.25-28.5 GHz. LSA-wise details of the spectrum availability have been discussed in Chapter-II.

CONSULTATION PROCESS

1.11 The Authority issued Consultation Paper on the subject on 30th November 2021, wherein specific issues related to band plans, quantum of spectrum, block size, spectrum cap, roll-out obligations, eligibility conditions for participating in the Auction, terms and conditions for surrender of spectrum, spectrum payment terms and various valuation methods for estimation of 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 were raised. In addition, issues relating to spectrum for private networks were also raised in the consultation paper. Issues were also raised on identification, development and proliferation of 5G use cases. Written Comments on the Consultation Paper were invited from the stakeholders by 28th December 2021 and counter-comments by 11th January 2021. However, considering the requests from the stakeholders, the last date for submission of comments and counter comments was extended till 10th January 2022 and 24th January 2022 respectively. The Authority received comments from 41 stakeholders and counter comments from 18 stakeholders, which are available on TRAI's website www.trai.gov.in. An Open House Discussion (OHD) was conducted on 8th February 2022 through online mode, which was participated by stakeholders including TSPs, Industry Associations – Indian and Global, Satellite operators, Solution providers, Consultants, and Individuals. After the OHD the stakeholders were given time till 15th

February 2022 to provide additional comments/justifications, if any. Additional comments were received from 25 stakeholders.

STRUCTURE OF THE RECOMMENDATIONS

1.12 The Recommendations have been divided into six Chapters. The current Chapter provides a brief background to the subject. The second Chapter deals with the quantum of spectrum to be auctioned, band plans, preferable block-size for auction, roll-out obligations, spectrum cap, eligibility conditions for participating in the auction, terms and conditions for surrender of spectrum etc. The third chapter deals with the valuation and reserve price of spectrum. The fourth chapter deals with the issues relating to spectrum for private cellular captive networks. The fifth chapter deals with the issues related to 5G use cases and broad ecosystem development. The sixth chapter provides the summary of recommendations.

CHAPTER-II: AUCTION RELATED ISSUES

A. SPECTRUM AVAILABILITY AND BAND PLANS

2.1 This section discusses the availability of spectrum and band plans in various access 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.

(i) New Spectrum Bands

2.2 For the spectrum bands, which DoT has proposed to auction for the first time viz. 526-698 MHz, 3300-3670 MHz and 24.25-28.5 GHz bands, band plans and spectrum availability in each of these bands have been discussed below:

526 - 698 MHz

2.3 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:

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 for a few areas/locations.

2.4 TRAI through its letters 27th September 2021 and 8th October 2021, 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**: DoT in its reference had mentioned that this band will be available for IMT/5G and rural point to point links. DoT was requested to clarify whether these two use cases are going to coexist. The coexistence/interference studies and any other relevant information in this regard were also sought.

c) Information on planned proposal / submission of India (DoT) to the ITU/ APT spectrum group in respect of possible band plan for 500 and 600 MHz band.

2.5 In its response, DoT 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. Further, subsequent to the release of Consultation Paper, DoT through its letter dated 2nd December 2021 forwarded a copy of the MIB letter dated 29th November 2021 providing information on details of the MIB transmitters, their locations, coordinates (latitude-longitude), and exact keep out distance required to be maintained at each location. In the said letter of MIB, it was mentioned that at present frequency band 526-582 MHz is being used by Prasar Bharati (DD) for providing Terrestrial TV Broadcasting, many Analogue, Digital Ready and Digital Terrestrial TV Transmitters are operating in this band. It was further mentioned that the old outlived Analogue Terrestrial TV (ATT) Transmitters are already being rationalized/phased out for migration towards digital.

2.6 While ITU has identified spectrum in 470-698 MHz as an IMT band in Region 2 & Region 3 (India is in 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 is noticed that no band plans have been defined so far for 526-582 MHz and 582-617 MHz bands. Thus, development of ecosystem for IMT in 526-617 MHz frequency range will take some time.

2.7 In this background, stakeholders were asked to give their opinion on (i) whether spectrum bands in the frequency range 526-617 MHz be put to auction in the forthcoming auction, (ii) If yes, then which band plans and duplexing configuration be adopted in India, else, what should be the timelines for adoption of these bands for IMT. Suggestions to make these bands ready for adoption for IMT, were also sought.

Comments received from the stakeholders

2.8 Most of the stakeholders were of the view that spectrum under these bands should not be included in the forthcoming auction. Some of the stakeholders further submitted that while band plan(s) is yet to be defined by 3GPP for this frequency range and there is no ecosystem, availability of this band for 5G India would give way for 3GPP to consider this band in near future; therefore, it should be reserved for IMT in line with ITU identifications. Reasons cited in justification are given below:

- Presently there is no supporting ecosystem for this band. This band is still under developmental phase for 5G, and band plans are awaited from 3GPP.
- 526-617 MHz range is of high importance to IMT services. Region-3 has already identified this for IMT, and Region-1 is considering this for IMT services. 3GPP has also undertaken various studies for suitability of this band for 5G services as part of ongoing Rel.17 and Rel.18 work. This range of spectrum must remain available for IMT services introduction as soon as specification and IMT identification work is completed.
- Additional spectrum for 5G below 1 GHz is also being discussed under Agenda Item 1.5 of WRC-23 for ITU Region 1 (EMEA Region). The nation should go with globally harmonized bands and wait for direction from the next WRC.
- There is a need for sufficient measures to be taken to mitigate any form of interference to Cable TV and broadcasting sector while auctioning of sub-gigahertz band (<1 GHz) for IMT services.

- While the said band has been identified for IMT services in India (along with broadcasting services), it is important that before putting the said band for IMT spectrum auction with a condition to use it for 5G/IMT in coordination with MIB, Government should optimally rearrange the assignment of spectrum to Prasar Bharati and other Govt. agencies. Post conducting this exercise, to vacate most of the spectrum in the said band, the available spectrum (without any interference) should be considered for the auction to deploy IMT services.

2.9 One of the stakeholders submitted that at present frequency band 526-582 MHz is being used for providing Terrestrial TV Broadcasting. Many Analogue, Digital Ready and Digital Terrestrial TV Transmitters are operating in the band. Also, Digital ready transmitters are under installation in UT of J&K for which the WPC has provided DL in this band only. Therefore, frequency band 526-617 MHz band should not be put for auction in forthcoming auction unless the existing services and future plans of terrestrial broadcasting are taken care of. Another stakeholder opined that Frequency bands of 470-694 MHz (224 MHz) must be earmarked and reserved for DTT services.

2.10 Two stakeholders submitted that these bands should be put to auction in the forthcoming auction. It was further submitted that all spectrum that can be put to use in public or private communication networks should be auctioned and spectrum in the frequency range 526-617 MHz is no exception.

2.11 Some of the stakeholders were of the view that since APT is working on a regional band plan for 600 MHz band (APT 600), portion 612-617 MHz should be included as part of the 600 MHz band.

2.12 As regards timelines for adoption of these bands (526-582 MHz and 582-617 MHz) for IMT and to make these bands ready for adoption for IMT, the following suggestions were made by the stakeholders:

- India could lead market development by getting it harmonized in ITU & 3GPP as part of 5G evolution or 6G technology.
- Ecosystem would still need to be triggered starting from the Rel.17 470-698 MHz post band definition. Guidance from administrations of large markets like India can play a decisive role in industry decisions to implement a new ecosystem. Specification work is still ongoing for Rel.17 and subsequently ecosystem developments will be critical factor in determining target timelines for deployment considerations. It is expected that post the band allocation and UE ecosystem triggering; it is likely to be mid of year 2023 before the spectrum can be a usable commodity.
- The portion of this band (526-612 MHz) can be adopted and put up for future auction based on the outcomes and developments of WRC-23 AI 1.5
- A detailed proposal should be sent to ITU through Indian Administration for discussion by the intended beneficiary of the frequency band.
- There should be discussion and decision in ITU/APT. Accordingly, manufactures can be encouraged to develop products.
- We should work with the APT for the development of a regional band plan for the band 526-612 MHz, keeping in view the regional band plan for 612-703 MHz.

2.13 One of the stakeholders submitted that the timeline for adoption of these bands for IMT would depend on meeting out the following conditions:

(i) The requirements of Terrestrial TV services in the frequency band 470-582 MHz are finalized.

(ii) Coordination for having enabling clause of identification of suitable band below 698 MHz for IMT in India is completed.

(iii) The process of identifying globally harmonized band for IMT below 698 MHz by ITU is completed.

Analysis

2.14 As already mentioned above, 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 is noticed that no band plans have been defined so far for 526-582 MHz and 582-617 MHz bands. Thus, development of ecosystem for IMT in 526-617 MHz frequency range will take some time.

2.15 Further, as per the information forwarded by DoT, MIB transmitters working in the frequency range 526-582 MHz are located in 83 locations across India and the keep out distance required to be maintained from IMT ranges between 50 km to 150 km. With the given number of MIB transmitters and keep out distance requirement, utilization of this band for IMT in coordination with MIB will be very difficult, if not impossible.

2.16 Most of the stakeholders are of the view that these bands should not be put to auction in the forthcoming auction but be reserved for IMT. In view of the forgoing discussion, the Authority concurs with the views of the stakeholders.

2.17 Further, APT is actively working to develop a regional band plan for 600 MHz for APT region. 3GPP has also conducted a study (3GPP TR 38.860 V17.0.0 (2021-09) Technical Report on 'Study on Extended 600 MHz NR band (Release 17)') and proposed option B1 and B2 in this band. Both the options are being considered in APT. For India, 3GPP option B1 seems to be appropriate as it will provide additional 5 MHz of paired spectrum in this band, making the total availability of 40 MHz of paired spectrum. As per option B1, 600 MHz band can be extended at both ends by 5 MHz (612-652/663-703). Further details are discussed in the next section. Further, some of the stakeholders have also suggested that since APT is working on a regional band plan for 600 MHz band (APT 600), portion 612-617 MHz should be included as part of the 600MHz band. The Authority concurs with this view.

2.18 For an early adoption of these bands, the Authority is of the view that DoT should liaise with the APT, ITU and 3GPP for development of a regional band plan for the band 526-612 MHz, keeping in view the regional band plan (APT 600) being developed for 612-703 MHz and declare the timeline for vacation of this band and adoption of this band for IMT services so that ecosystem starts developing.

2.19 To enable use of 526-582 MHz for IMT deployment, DoT should come out with a plan for refarming this band to be utilized for IMT deployments. DoT should work with MIB to prepare a plan for an early migration from Analogue to Digital Transmission, so that major part of the frequency band from 526-582 MHz can be vacated for IMT services. Considering that ITU has identified spectrum in 470-698 MHz as an IMT band in Region 2 & Region 3, DoT may adopt a holistic approach and review the entire frequency range starting from 470 MHz to 582 MHz.

2.20 In case, complete refarming of 526-582 MHz frequency range for IMT is not feasible, DoT may explore the possibility of this band being used for IMT as well as for broadcasting by MIB on coexistence basis. Refarming of this frequency range for IMT may be performed in a phased manner so that as and when some frequency carriers are vacated, the same can be auctioned for IMT services.

2.21 Further, LTE-based 5G Terrestrial Broadcast is a broadcast system designed and standardized by 3GPP[2], wherein cellular based networks could be used for Terrestrial Broadcasting. Using this technology, the broadcast services can be provided through LTE/5G IMT network. DoT in consultation with MIB may explore use of 5G terrestrial broadcast to replace MIB transmitters for efficient and effective use of this frequency range.

[2] https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3500

2.22 In view of the above, **the Authority recommends that:**

a) **Considering the facts that presently (i) band plan(s) for the frequency range 526-612 MHz is yet to be defined by 3GPP/ITU, (ii) development of ecosystem for IMT in 526-612 MHz frequency range will take some time and (iii) MIB is using 526-582 MHz band extensively across the country for TV transmitters; the 526-612 MHz frequency range should not be put to auction in the forthcoming auction.**

b) **As per the propagation characteristics, lower frequency bands provide wider and deeper coverage, which could be very useful in enhancing terrestrial mobile coverage, particularly for in-building coverage and rural coverage. ITU has already identified this frequency range for IMT services. Therefore, frequency range 526-612 MHz should be reserved for IMT services.**

c) **DoT should come out with a plan for refarming 526-582 MHz band to be utilized for IMT deployments. To make 526-582 MHz band available for IMT, DoT should work with MIB to prepare a plan for an early migration from Analogue to Digital Transmission, so that the frequency band from 526-582 MHz can be vacated for IMT services. Considering that ITU has identified spectrum in 470-698 MHz as an IMT band in Region 2 & Region 3, DoT may adopt a holistic approach and review the entire frequency range starting from 470 MHz to 582 MHz.**

d) **In case, complete refarming of 526-582 MHz frequency range for IMT is not feasible, DoT may explore the possibility of this band being used for IMT as well as for broadcasting by MIB on coexistence basis. Refarming of this frequency range for IMT may be performed in a phased manner so that as and when some frequency carriers are vacated, the same can be auctioned for IMT services.**

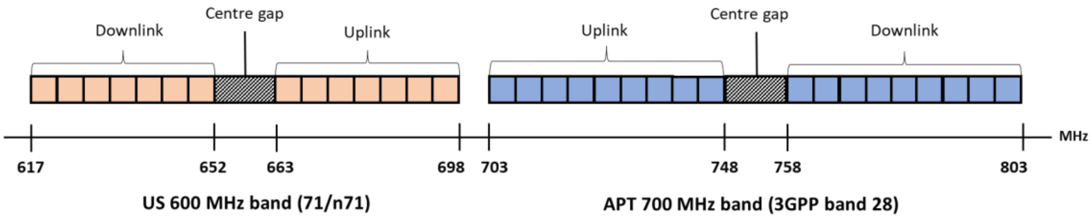
e) **Considering the work going on in the APT to develop a regional band plan for 600 MHz (APT 600) for APT region, portion 612-617 MHz should be included as part of the 600 MHz band.**

f) **DoT should liaise with the APT, ITU and 3GPP for development of a regional band plan for the band 526-612 MHz and declare the timeline for vacation of this band and adoption of this band for IMT services so that ecosystem starts developing.**

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

2.24 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 was felt appropriate to examine these bands together. The frequency arrangement of these band plans is shown below:

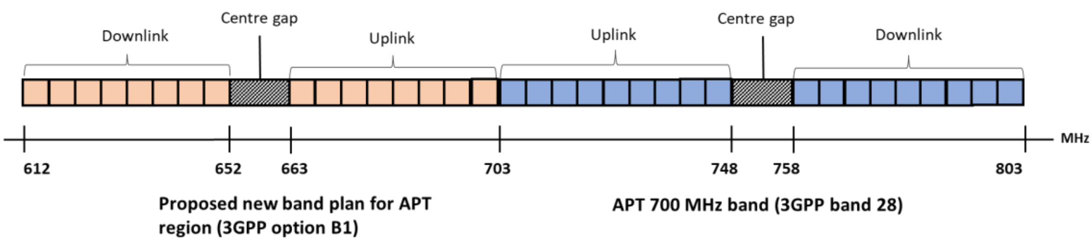
Chart 2.1: frequency arrangement of US 600 MHz band (n71) and 3GPP band 28



[3] https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11374.html#s3

2.25 As can be seen from the Chart 2.1 above, between these two band plans (i.e., Band 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. One of the stakeholders 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, the new 2 x 40 MHz band plan will provide 80 MHz of spectrum as against 70 MHz (2 x 35 MHz) as per band n71. In the 3GPP TR 38.860 V17.0.0 (2021-09) Technical Report[4] 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 (3GPP option B1) 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



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

2.26 A harmonized frequency arrangement facilitates economies of scale resulting in the availability of affordable equipment. Therefore, it is essential to follow an internationally harmonized 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.

2.27 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.

2.28 With this background, the stakeholders were asked to give their views on whether 600 MHz spectrum band be put to auction in the forthcoming auction and if yes, then which band plan and duplexing configuration be adopted in India.

Comments received from the stakeholders

2.29 Most of the stakeholders submitted that 600 MHz spectrum band should be put to auction in the forthcoming auction, whereas a few stakeholders opined that 600 MHz spectrum band should not be put to auction in the forthcoming auction.

2.30 One of the stakeholders not in support of including 600 MHz band in the forthcoming auction submitted that sub-GHz spectrum remained unsold last time, and DoT should plan to provide this spectrum for trial and in this way clear understanding of the ecosystem can be made.

Other stakeholders not in support of putting this band to auction in the forthcoming auction have submitted that an alternate band plan '3GPP option B1' that will provide 80 MHz of spectrum as against 70 MHz as per n71 may be adopted. Though the proposed band plan will result in better spectrum utilization, the alternate band plan '3GPP Option B1' has not been adopted yet either by 3GPP or the APT region and there is no ecosystem currently available. If the existing band plan 71/n71 defined by ITU/3GPP for 600 MHz band is adopted, it will lead to wastage of 5 MHz spectrum.

2.31 The stakeholders who supported auctioning of spectrum are of the opinion that 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 of this band would be beneficial for the TSPs as well as to the consumers. It was opined that 600 MHz is critical to complement low band 5G requirements.

2.32 One of the stakeholders was of the view that this band would give an immense boost to rural broadband coverage and enhance Government reach for path-breaking societal interventions in the rural hinterland. It has been suggested that the incentive-based approach for 600 MHz could be adopted and 600MHz spectrum be given free of cost to operators with stringent rollout obligations to cover economically unviable and uncovered areas.

2.33 One stakeholder mentioned that the ecosystem would grow in whole band range (612-703 MHz) as soon as 3GPP develops band plan.

2.34 One stakeholder mentioned that the 600 MHz band is used to provide broadcast services and IMT networks shall not cause harmful interference to existing services that are working in the allocated spectrum bands. Another stakeholder opined that there should not be geographical isolation or additional filtering requirement from mobile base stations operating in the 617-698 MHz band for co-existence with the terrestrial TV transmitters deployed in the 526-582 MHz band.

Comments on Band Plan to be adopted

2.35 Some of the stakeholders are of the view that globally defined spectrum band configuration (n71) for 600 MHz spectrum should be adopted in the current auctions. As far as the new band plan (APT 600) is concerned, depending on the take up of spectrum in the auction and the status of adoption of the APT proposal, the new band plan could be considered in future auctions.

2.36 Some of the stakeholders suggested that the extended 600 MHz band be put in forthcoming auction, that is, 600 MHz band range should start from 612 MHz up to 703 MHz which will maximize the available spectrum to 2x40 MHz arrangement. One of these stakeholders further submitted that in future APT-600 band is likely to witness larger adoption.

2.37 One of the stakeholders submitted that new band plan (3GPP option B1) for 600 MHz band should be put to auction may be this year or after one year. The regional plan (APT) for the said spectrum should be finalized first so as to get the benefit of harmonization and scale.

2.38 Another stakeholder mentioned that AWG is currently considering the best option (B1 starting as 612 and B2) and allow for the flexibility for either approach to be taken until a harmonized decision is made.

2.39 One of the stakeholders submitted that entire 600 MHz band (612-703 MHz) should be put to auction in the forthcoming auctions. In addition, for better global harmonization, it is also important to have this band identified for IMT through a Footnote in Section 5 of the Radio Regulations at WRC-23. The stakeholder further suggested that Indian administration should submit a suitable proposal to the WRC-23. Given these developments in 3GPP, APT and the specific situation in India that favors utilization of the full 40+40 MHz, Option B1 should be preferred. An announcement of an auction by India will further boost these efforts and lead to early adoption of this band plan by 3GPP.

Analysis

2.40 As already discussed, for 617-698 MHz band, ITU/3GPP have defined frequency arrangement with FDD configuration viz. band 71/n71 also known as US 600, which is based on reverse duplexing configuration to maintain compatibility with band 28 (700 MHz band plan adopted in India). This band plan has been adopted by some countries such as USA, Mexico, Canada, Hong Kong.

2.41 While FCC, USA was planning to adopt 600 MHz band, Time Division Duplexing (TDD) configuration was also examined. The FCC found that specific uplink and downlink bands that support Frequency Division Duplex ("FDD") technologies were best suited for the new 600 MHz Band at the time in light of current technology, the Band's propagation characteristics, and potential interference issues present in the Band. Though some operators argued that broad global adoption, improved spectrum efficiency, and more dynamic use of communications channels are sufficiently advantageous to adopt an unpaired, TDD framework for the 600 MHz Band, the FCC was unconvinced. It felt that, although TDD operations do not require a duplex gap, TDD operations use five to 10 percent of their spectrum capacity as overhead for time domain duplex guard time intervals, and therefore, are not necessarily more efficient than FDD operations. Also, TDD has link budget constraints, resulting in less uplink coverage at the cell edge than an FDD system.

2.42 Since ecosystem for IMT is available in 71/n71 band, one obvious choice could be to adopt this band in India. However, since band 71/n71 is based on reverse duplexing, there is no reason to waste the 5 MHz spectrum between band n71 and band 28. It may be noted that in case of US the band plan for lower 700 MHz band begins from 698 MHz, thus, there is no gap between 600 MHz band (71/n71) and 700 MHz band.

2.43 Considering the fact that APT is actively working to come out with a harmonized band plan for APT region for 600 MHz band and as per the output document no. AWG-29/OUT-02 dated 29th March 2022, AWG has made the following recommendations to 3GPP -

a. B1 is the preferred option for APT and be referred to as the 'APT 600 MHz' band.
b. AWG invites 3GPP to immediately start work on the technical specifications to support Option B1.
c. B2 may be considered as an option for later standardization should it be required (in a 35 MHz + 35 MHz configuration).

2.44 Adoption of APT 600 (option B1) will lead to utilization of additional 5 MHz of paired spectrum as the APT 600 band is being extended on upper side from 698 MHz to 703 MHz and on lower side from 617 MHz to 612 MHz. The proposed band plan available will be 612-652 MHz paired with 663-703 MHz.

2.45 In case India adopts band plan n71 (US 600) for 600 MHz band, the available ecosystem will be useful for immediate deployment. However, 5 MHz from 698 to 703 MHz will go waste and India will stand out by not adopting APT 600 – leading to non-harmonized band plan in the Region as it will be very difficult to go back and adopt APT 600 later as duplex gap will change and all the spectrum assignments will require change; thereby requiring change in network radio part as well as consumer devices.

2.46 Moreover, considering that APT Wireless Group (AWG) has invited 3GPP to immediately start work on technical specifications to support Option B1 and 3GPP has already conducted a study on 'Extended 600 MHz NR band (Release 17)' [3GPP TR 38.860 V17.0.0 (2021-09) Technical Report, wherein option B1 and B2 were proposed for this band, the release of technical specifications may not take too long. Further, with the decision of APT, the work on development of device ecosystem would have already begun.

2.47 In view of the above, **the Authority recommends that for 600 MHz frequency range 612-703 MHz, Band Plan APT 600 (Option B1) should be adopted in India. It is also proposed that entire 40 MHz (paired) spectrum [612-652 MHz/663-703 MHz] should be put to auction in the forthcoming auction.**

3300 - 3670 MHz

2.48 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.

2.49 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 is 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

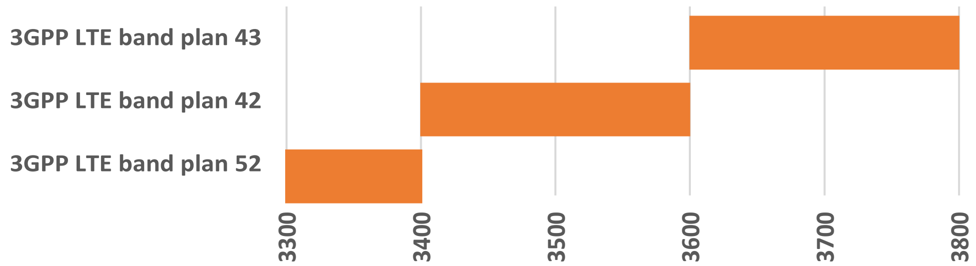
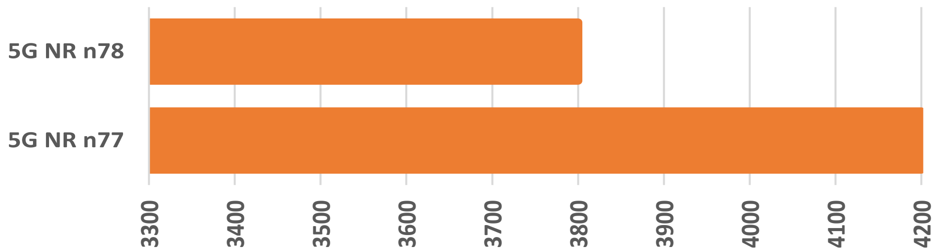


Chart-2.4: 3GPP Channel arrangements for 5G-NR



2.50 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. With this view, the stakeholders were requested to comment on the which band plan should be adopted for 3300-3670 MHz frequency range.

Comments received from the stakeholders

2.51 Some of the stakeholders have favored adoption of band plan n77 which covers larger range (3300-4200 MHz) as it will take care of future requirements when some more spectrum is made available for IMT. Further, it is opined that it will provide benefit of volume of scales on cost of devices and equipment while deploying the services which will make services affordable. One of the stakeholders has suggested that ideally, 200 MHz per operator be made allocated in the long term in this band.

2.52 However, majority of stakeholders favored adoption of band plan n78 (3300-3800 MHz). Reasons cited in justification are:

a. Consistent with global trend
b. According to GSA reports, over 800 devices support band n78 which has highest share of all 5G spectrum bands from ecosystem development perspective.
c. As has been adopted by more than 150 networks globally, offers the economies of scale.
d. Most suitable and covers the entire identified band with least overlap with non-IMT identified spectrum from NFAP.

2.53 One of the stakeholders suggested that if in future more spectrum is made available above 3670 MHz for 5G in India, then the operators may decide to opt for band n77 which also has an existing ecosystem. However, a few stakeholders opined that in case additional spectrum is made available in future, it may be done in band n77.

2.54 One of the stakeholders submitted that most devices support both n78 and n77 and hence all such devices can operate in this frequency range 3300-3670 MHz.

2.55 Some of the stakeholders having interest in broadcasting and satellite have raised their concerns regarding possible interference due to reduction of guard band between IMT and satellite services from 100 MHz to 30 MHz. Submissions made by these stakeholders are:

a) This allocation of frequencies to 5G services beyond the current NFAP-18 upper limit of 3600 MHz will lead to serious disruption of Satellite services for media and broadcast in the 3700-4000

MHz band. Today over 600 licensed satellite channels over India operate in this band. The disruption occurs due to the following reasons:

(i) The power received from satellite at receiver LNB (Low Noise Block) is much lower (~60 dB lower) than that of 5G Terrestrial signals which operate at a very heavy power level. This leads to the overloading of the LNBs of satellite Antennas and no signal can then be received.

(ii) Simultaneous use of the band by Satellite and Terrestrial 5G services is not possible.

b) The impact of reducing 100 MHz guard band to 30 MHz has two implications:

(i) Filters of 3700-4200 MHz, even if used, cannot filter out these out of band emissions as these falls in the 3700-4200 MHz band.

(ii) LNB Overdrive: The LNBs used in Cable Headends, which are typically designed for 3400-3900 MHz, would get overdriven (saturated) due to high terrestrial transmissions. This overdrive could have been prevented by the use of filters of 3700-4200 MHz but with Out of Band Emissions (OOBE) falling in the pass band of filters, the interference will lead to complete loss of signals.

c) Telecom Service Providers and DPOs (Cable operators, MSOs, DTH operators) be mandatorily required to install band pass filters in order to ensure that minimum disruption to broadcasting services.

2.56 One of the stakeholders submitted that C-Band Satellite downlink is being used by Prasar Bharati for Networking and Distribution. Any interference from IMT will also affect the C-Band Satellite Downlink reception by the receiving ends be it DD Centers, DD DTH, Other DTH

Operators/MSOs/LCOs who are using the C-Band Downlink of DD Services for mandatory carriage on their platforms.

Analysis

2.57 While majority of the stakeholders opined that n78 should be adopted, some stakeholders are of the view that n77 should be adopted considering that it is wider band.

2.58 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. As per GSA, as of December 2021, total number of devices (announced) supporting band n78 and n77 were 842 and 653, respectively. However, most of the devices support both the band plans.

2.59 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. Another view could be to adopt n78, which as of now has better ecosystem in terms of number of devices. Third option could be to give a freedom to the TSPs to adopt any band plan i.e., n77 or n78, based on their business decision and commercial considerations. While both the available bands i.e., n77 (3300-4200 MHz) and n78 (3300-3800 MHz), go beyond the frequencies earmarked for IMT in India, the TSPs will be utilizing the frequencies assigned to them for IMT and will deploy sharp Spectrum Mask for IMT transmitters with an out-of-band PFD limits considering the spectrum range earmarked for IMT, as recommended in the subsequent paras.

2.60 As TDD based duplexing has been adopted for the frequency range 3300-3670 MHz, with adoption of second option, the TSPs would be able to deploy the network equipment based on the band plan chosen by them; however, since most of the user devices support both the bands i.e., the entire frequency range, there will not be any issue in respect of user devices. Therefore, the Authority is of the view that it would be appropriate that both the band plans i.e., n77 and n78 should be permitted and flexibility be given to the TSPs to adopt any band plan i.e., n77 or n78, based on their business/commercial considerations.

2.61 In view of the above, **the Authority recommends that unlike FDD band plans where duplex gap is fixed for a given band plan, TDD band plans are flexible; therefore, in frequency range 3300-3670 MHz, both the band plans i.e., n77 and n78 should be permitted and flexibility be given to the TSPs to adopt any band plan i.e., n77 or n78, based on their business/commercial considerations.**

2.62 As regards the issues raised by some of the stakeholders that allocation of frequencies to 5G services beyond 3600 MHz will lead to serious disruption of Satellite services for media and broadcast in the 3700-4000 MHz band, it is noted that traditionally Fixed Satellite Service (FSS) earth stations operated in the 3400-4200 MHz C-band spectrum range. In India, this frequency range was mainly used for receiving the broadcasting channels and television channels by MSOs and DTH operators. As the entire range 3300/3400-4200 MHz was being used earlier for C-Band satellite receive earth stations, the traditional bandpass filter deployed at receiving antenna covers the entire range 3400-4200 MHz. IMT emissions in the 3300-3670 MHz are likely to saturate the Low Noise Block (LNB) of the FSS earth station which traditionally operates in the 3400-4200 MHz, even if the mobile 5G signal is having a 30 MHz band gap with satellite frequencies. However, this interference issue can be resolved if the satellite receive earth stations, being deployed by MSOs and DTH operators, make use of sharp cut-off bandpass filters operating in 3700-4200 MHz range. Further, in order to avoid unwanted Out of Band Emissions (OOBE) of the IMT stations falling within the FSS operating band 3700-4200 MHz, TSPs should be mandated for having a sharp Spectrum Mask for IMT transmitters with an out-of-band PFD limits. Considering the interference concerns raised by the stakeholders, TRAI through its letter dated 22nd February 2022, referred the matter to DoT, which in its response through letter dated 10th March 2022 mentioned that co-existence studies are being carried out which address DoS analysis regarding co-existence of satellite and IMT services in C-band, considering 30 MHz guard band between IMT and TV received terminals in 3700-4200 MHz. DoT further mentioned that as per the outcome of the study so far, it has been concluded that introduction of a cavity filter on the Television Receive-Only (TVRO) systems can make these systems co-exist with IMT/5G.

2.63 Further, the interference to broadcasting signals in C-band from 5G testing was experienced by one of the stakeholders in the month of December 2021. TRAI received a complaint from one of the stakeholders (M/s Sai Vision Cable network) regarding interference to broadcasting signals in C-band from 5G trails. The complaint was forwarded to DoT to examine the matter. DoT got the matter examined and submitted its response vide letter dated 10th March 2022, wherein it was mentioned that M/s Sai Vision Cable network has 8 no. of teleports and they operate around 3300-4200 MHz. To mitigate interference from 5G signals, they are now using 5G filter. It was further mentioned that it has been concluded that introduction of a cavity filter on the TVRO systems can make this system coexist with IMT/5G.

2.64 In view of the above, **the Authority recommends that:**

a) As the IMT emissions in the 3300-3670 MHz may saturate the Low Noise Block (LNB) of the FSS earth station which traditionally operates in the 3400-4200 MHz, there is a need to make use of high-quality bandpass filters operating in 3700-4200 MHz range. Therefore, DoT should ask the Ministry of Information and Broadcasting (MIB) to take appropriate action

and sensitize the MSOs, DTH operators, and other users to ensure the use of high-quality bandpass filters operating in 3700-4200 MHz range to avoid interference from IMT stations.

b) In order to avoid unwanted out of band emissions of the IMT stations falling within the FSS operating band 3700-4200 MHz, DoT should prescribe for having a sharp Spectrum Mask for IMT transmitters with an out-of-band PFD limit.

24.25 to 28.5 GHz

2.65 DoT through its reference dated 13th September 2021, for the first time proposed to include 24.25 – 28.5 GHz band amongst the bands to be auctioned in the forthcoming auction. DoT also informed that 24.25 to 28.5 GHz band will be used 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.

2.66 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 (3GPP band plan n257/n261) for IMT/5G. However, Europe has decided to go for 26 GHz band (3GPP band plan n258) for IMT/5G. Therefore, ecosystem is getting developed in both these bands.

2.67 All the band plans viz. n257, n258 and n261 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 only TDD configuration-based band plans in mmWave spectrum bands.

2.68 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. Considering the frequency range covered by the bands, band n261 is a subset of band n257. Therefore, for India, the band plans of interest would be n258 and n257.

2.69 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.

2.70 With this background, stakeholders were asked to comment on whether TDD based configuration be adopted for 24.25 to 28.5 GHz frequency range and considering that there is an overlap of frequencies in the band plans n257 and n258, how the band plan(s) along with its frequency range be adopted.

Comments received form the Stakeholders

2.71 All the stakeholders who responded on the duplexing scheme were of the view that TDD based configuration should be adopted for 24.25-28.5 GHz frequency range.

2.72 Regarding band plan, while some of the stakeholders suggested to consider 24.25-27.5 GHz as n258, and 27.5-28.5 GHz as n257, other stakeholders were of the opinion that for the purpose of deployment flexibility, based on the continuous blocks assigned to the operator, it may be left to the operators to choose between n257 and n258.

2.73 Some of the stakeholders suggested that post auction, operators be allocated contiguous spectrum in single band instead of spreading across n257 and n258.

2.74 One of the stakeholders opined that to leverage the mmWave and help the handset ecosystem develop faster, it would be better to allocate the spectrum to all operators in one band first, unless there is a spill over.

2.75 One stakeholder submitted that considering the importance of mmWave band for true 5G experience, entire band from 24.25-29.5 GHz be reserved for IMT/5G service and further, instead of reserving 1 GHz (28.5 GHz to 29.5 GHz) for satellite-based communication services, include this in current auction for a flexible use, that is, the buyer should be allowed to use it for terrestrial communication or satellite-based communication or both.

2.76 Some stakeholders suggested that spectrum be put to auction only after harmonization and ensuring that it is interference-free. Adequate protection zone/guard band provisioning be considered for satellite gateway operations at critical locations to ensure smooth operations for both the sectors.

2.77 Many stakeholders having interest in satellite services submitted that given the criticality of the spectrum band above 27.5 GHz for the satellite industry, and unsubstantiated needs for more capacity than 3.25 GHz already in offer in the 26 GHz band (n258), TRAI should recommend the DoT to only auction the frequency range 24.25-27.5 GHz. Reasons citied in support of their submission were:

a. 27.5-28.5 GHz band is a globally allocated FSS band with several satellites with associated earth stations already in operation. Furthermore, given the importance of the band for FSS worldwide, WRC-15 in identifying frequency bands to be studied as potential candidate bands for IMT/5G decided not to consider the 27.5-31 GHz band as a candidate band for IMT/5G.

b. Band 27.5-29.5 GHz has been protected by the ITU for satellite broadband services, including earth stations in motion (ESIM) at WRC-19, and is under study for expanded satellite use in WRC-

23 Agenda Items 1.16 (non-geostationary ESIM) and 1.17 (satellite-to-satellite links). Use of 27.5-28.5 GHz spectrum band for 5G/IMT would be inconsistent with the Radio Regulations which are internationally binding treaty obligations.

c. The Parliamentary "Standing Committee on Information Technology (2020-21)" in its report on "India's Preparedness for 5G" has reference for use of the spectrum for 5G IMT only up to 27.5 GHz and not up to 28.5 GHz.

d. Spectrum from 24.25 to 27.5 GHz would provide 3.25 GHz of spectrum for TSPs, which is sufficient if we consider 400-800 MHz of spectrum per operator.

e. It is also opined that offering 27.5-28.5 GHz band for auction will not meet economic, technical, and long-term policy outcomes because there is a global lack of demand for 5G IMT in the 28 GHz.

f. Depriving usage of 27.5-28.5 GHz frequency band for satellite services will significantly reduce the communication & broadband potential of India and its exclusive use for IMT/5G will lead to an inefficient use of spectrum.

g. Given the massive, on-going global investments in 28 GHz satellite systems, India will be artificially limiting its own ability to access the satellite capacity that will be available in this band to deliver broadband-for-all.

h. 28 GHz band starting from 27.5 GHz is being utilized by satellites for broadband and mission critical government services. If this satellite spectrum is further reduced, it would impact the serving capacity and offered quality of services in the uncovered regions which are hard to serve from the terrestrial networks.

i. As 27.5-29.5 GHz (28 GHz) band is used extensively around the world for satellite services, hundreds of GEO satellites and thousands of non-geostationary ("non-GEO") satellites have been and are continuing to be launched using this frequency band to provide a wide range of broadband satellite services.

j. 28 GHz band for satellite communications has seen satellite operators' financial commitments, deployment decisions, and operational strategies, being cemented to deliver ubiquitous connectivity to end-users via satellite-enabled broadband. Therefore, it is suggested that additional spectrum beyond 26 GHz band, should only be brought to auction when there is sufficient justification by the MNOs for the need and compliance to roll-out obligation of the initial spectrum that they may acquire through the current auction is fulfilled.

2.78 Some of the stakeholders while suggesting that the spectrum from 27.5-28.5 be excluded from the auction for IMT/5G, have further suggested that limit use of the 27.5-28.5 GHz frequency range only to private captive network on a non-interference basis to satellite systems.

2.79 One of the stakeholders was of the view that Satellite and Terrestrial services cannot co-exist in the 28 GHz band.

2.80 Some of the stakeholders made the following suggestions in case it is decided not to exclude 27.5-28.5 GHz from auction for IMT:

a. India should prioritize the assignment of lower mmWave spectrum before impinging on satellite services in 27.5-28.5 GHz and allow greater satellite access to the band.

b. maintain access to the band for FSS and especially gateway feeder links, that is, Gateways need to be protected by an exclusion zone (of appropriate radius depending on the case) and with the conditions put on IMT base stations that they operate only below the horizon as any operation above the horizon can cause interference to the satellites that are orbiting.

c. WRC-19 Resolution 242 contain power limits for IMT/5G transmitters in the 24.25-27.5 GHz band. Should India decide to consider portions of the 27.5-28.5 GHz band for IMT/5G, the same limits should be imposed for this band also.

d. Maintain access to subscriber terminals in the band 27.5-28.5 GHz with appropriate coordination criteria (secondary basis).

e. Maintain access to ESIMs (In-flight and maritime terminals) in the band 27.5-28.5 GHz with appropriate sharing conditions.

Analysis

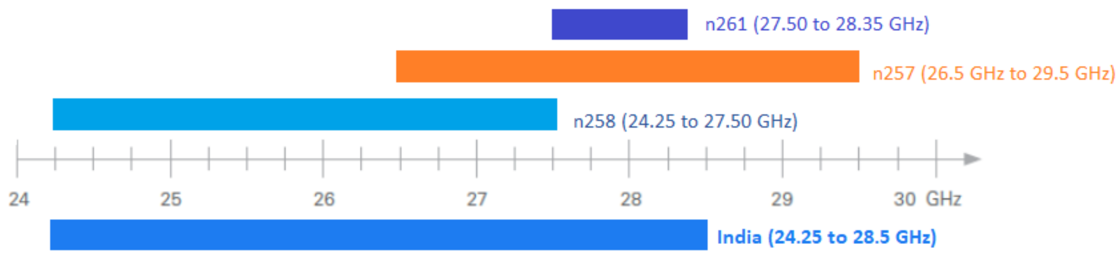
2.81 As already discussed, while in WRC-19, 24.25 – 27.5 GHz has been identified for IMT, some of the countries such as USA, Japan, Korea have also opened up some spectrum in 28 GHz band (26.5 – 29.5 GHz) for IMT/5G. However, Europe has decided to go for 26 GHz band. Therefore, ecosystem is getting developed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

2.82 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). All the three band plans are TDD-configuration based. Higher frequency bands are generally used for enhancing capacity and lowering latency. TDD based configuration gives the flexibility to decide the ratio between uplink and downlink based on the use case, the spectrum is being deployed. Further, 3GPP has defined this band only for TDD configuration-based band plans in mmWave spectrum bands. All the stakeholders who have responded on the duplexing scheme are of the view that TDD based configuration should be adopted for 24.25-28.5 GHz frequency range.

2.83 **Considering the global trend and 3GPP TDD configuration-based band plans availability, the Authority recommends that TDD based configuration should be adopted for spectrum 24.25 to 28.5 GHz.**

2.84 As already discussed, that there is no single band plan, which covers the entire frequency range identified by India. However, there are three band plans viz, n257 n258 and n261, which cover part of the frequency range identified by India and there are some overlaps 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



2.85 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. As per the information published by GSA, device ecosystem (as of December 2021) in spectrum bands n257 and n258 is depicted in the table given below:

Table 2.1

Device ecosystem (as of December 2021) in spectrum bands n257 and n258

Band plan	**Number of devices announced**	**Number of devices commercially available**
n258 (24.25-27.5 GHz)	41	27
n257 (26.5 - 29.5 GHz)	31	20

2.86 As already mentioned, ecosystem is developing fast in 26 GHz band (n258) as well as 28 GHz band (n257). As per GSA report, as of

December 2021, 140 operators in 24 countries/territories have been assigned mmWave spectrum (often on a regional basis) enabling operation of 5G networks and 28 operators in 16 countries/territories are known to be already deploying 5G networks using mmWave spectrum. As regards device ecosystem, as of May 2021, 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)] were announced, which has increased to 214 as at the end of December 2021. Charts given below presents band-wise details of the count of operators investing in key 5G spectrum bands as at the end of December 2021 and number of announced device models known to support 5G bands as of end of December 2021, as published by GSA. However, the user devices generally support both the bands viz. n257 and n258.

Chart 2.6: Count of operators investing in key 5G spectrum bands (end December 2021)

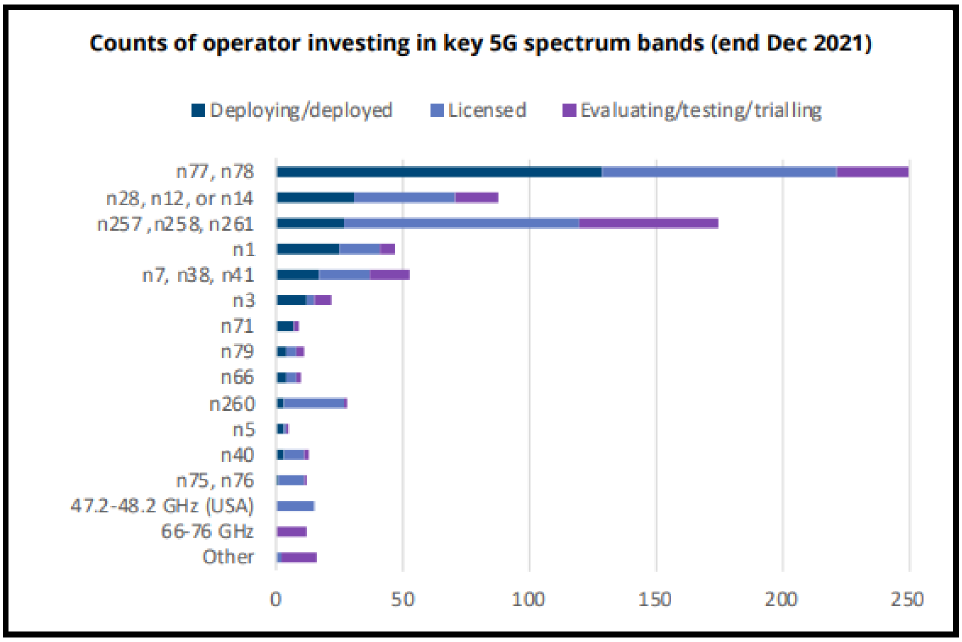
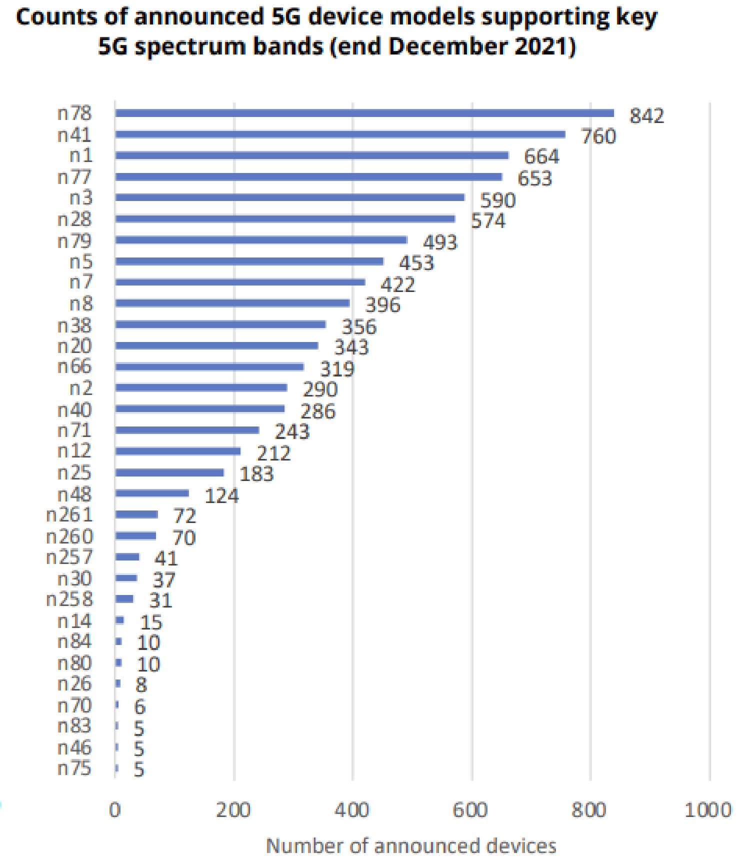


Chart 2.7: Number of announced device models known to support 5G bands (end December 2021)



2.87 As noted above, two band plans i.e., n257 (26.5 GHz to 29.5 GHz) and n258 (24.25 to 27.50 GHz), covers the frequency range identified by India and there are some overlaps of frequencies in these band plans. Therefore, both these band plans will have to be permitted in India. As regards overlap of frequencies in these two band plans, one option is to freeze the frequencies for each band plan so that there is no overlap i.e. the overlapping frequency range of 26.5-27.5 GHz could be made part of one of these two bands. As per the suggestion made by some of the stakeholders, band n258 should be adopted for frequency range from 24.25 to 27.5 GHz and band n257 from 27.5 to 28.5 GHz. However, in case this suggestion is adopted and if one TSP gets some spectrum in n257 and some chunk in n258, it will be difficult for such TSP to deploy separate network units for each band. Other option is to have a flexible approach i.e. allow the TSPs to decide which band plan to be adopted based on the frequencies assigned to it and other business/commercial considerations. As TDD based duplexing has been recommended for the entire frequency range i.e., 24.25-28.5 GHz, the TSPs would be able to deploy the network equipment based on the band plan chosen by them; however, since the user devices generally support both the bands, there may not be any issue in respect of user devices. Therefore, the Authority is of the view that it would be appropriate to go with the second option as it gives flexibility to the TSPs.

2.88 In view of the above, **the Authority recommends that in frequency range 24.25-28.5 GHz MHz, flexibility be given to the TSPs to adopt any band plan i.e., n257 or n258, based on the frequencies assigned to them and other business/commercial considerations.**

2.89 As regards concerns raised by the satellite industry regarding earmarking of 27.5 to 28.5 GHz exclusively for IMT/5G, the matter has been examined in detail. It is noted that USA was the one of the few early adopters of 28 GHz band for IMT. While FCC[5] was planning to auction 27.5-28.35 (850 MHz), the Commission was disinclined to automatically grant co-primary status for all FSS operations in the 27.5-28.35 GHz band, principally because it would be inconsistent with the development of terrestrial mobile service in the band. With respect to gateways, however, the Commission proposed that satellite operators could acquire terrestrial flexible use licenses enabling them to exclude terrestrial operators that might be subject to interference from within the license area. It was proposed that satellite operators be allowed to take advantage of four market-oriented mechanisms to operate their earth stations without the obligation to protect terrestrial stations: purchase geographic area licenses at auction, acquire such licenses from existing licensees, obtain partitioned segments of existing geographic area licenses from existing licensees, or enter into

[5] https://docs.fcc.gov/public/attachments/FCC-16-89A1.pdf

contractual agreements with nearby licensees. The satellite Industry made their submission and some of the key submissions were:

(i) County-sized geographic service areas are far too large for their needs and that terrestrial license holders will be reluctant to sell them access to smaller, partitioned areas, either because they see satellite operators as competitors or because their own needs in the evolving 5G landscape are difficult to foresee.

(ii) Requiring satellite operators to participate in spectrum auctions would violate the Open-market Reorganization for the Betterment of International Telecommunication Act (ORBIT Act).

2.90 After due examination, FCC decided to maintain the current status of FSS, create new opportunities for continued expansion of FSS earth stations on a protected basis. FCC noted that the ability of satellite earth stations and terrestrial operations to coexist in close proximity to each other has two significant ramifications. First, it should be possible for satellite and terrestrial services to share the 28 GHz band with de minimis impairment of each other's operations. Second, the disparity between the county-sized license areas established for 28 GHz Upper Microwave Flexible Use Service (UMFUS) licensees and the extremely small areas required for FSS earth stations makes it inappropriate to rely exclusively on a market-based mechanism for assigning rights to FSS earth stations, although this option is retained as one means through which FSS operators may expand. In addition to acquiring the terrestrial license rights, it was decided to continue to authorize gateway satellite earth stations under the existing first-come, first-served basis, subject to compliance of following conditions:

a. First, no more than three locations in each county will be authorized where FSS may deploy earth stations on a protected basis.

b. Second, an FSS applicant must demonstrate in its license application that the permitted interference zone around its earth station, which will be defined as the contour within which FSS licensees generate a power flux density (PFD), at 10 meters above ground level, of no more than -77.6 dBm/m2/MHz, together with any pre-existing earth stations located in the same county on a protected basis, will, in the aggregate, cover no more than 0.1 percent of the population of the county license area where the earth station is located.

c. Third, the applicant must show that the permitted interference zone does not infringe upon any major event venue, arterial street, interstate or U.S. highway, urban mass transit route, passenger railroad, or cruise ship port.

d. Fourth, prior to filing its application, if there is an existing 28 GHz UMFUS licensee in the county where it is proposing to locate its earth station, the earth station applicant must coordinate its operation with the existing UMFUS licensees. The purpose of the coordination is to ensure that the earth station will not interfere with existing facilities operating under the UMFUS license. It is expected that UMFUS licensees will cooperate in good faith in the coordination process and only raise objections if there is a legitimate concern about interference to existing UMFUS facilities or failure to comply with the criteria listed above.

2.91 From the above, it can be inferred that while 850 MHz spectrum in 28 GHz band (27.5-28.35 GHz) was put to auction for flexi-use at county-level, satellite operators could take part in the auction to acquire the spectrum. However, protection for existing and future satellite gateways (earth to space) was also provisioned on coexistence basis on first come first serve basis.

2.92 Some of the stakeholders have in their comments and representations to TRAI have submitted that in case 27.5-28.5 GHz is set aside for IMT, the throughput of the satellites operating/planned in this band, will go down by half, which may affect their business viability. It has been suggested by some of these stakeholders that as done in US, coexistence of IMT and satellite would be a feasible option i.e., protection can be provided for the existing satellite gateways and for future gateways permission, some provisions could be created in the form of guidelines. It has further been submitted that propagation characteristics of mmWave spectrum are such that the signal range is very small and the use cases it will support are likely to be area specific and therefore, coexistence should not be an issue.

2.93 As informed by DoT, it has been decided that a total 4.25 GHz (24.25 to 28.5 GHz) has been earmarked for IMT. As per the stakeholders, 3.25 GHz is sufficient to meet the likely demand for IMT service. It is noted that 27.5 to 28.5 GHz has not been identified by ITU for IMT. However, DoT has already decided to assign the same for IMT. DoT must have had justifiable reasons for this decision. Having said this, the Authority is of the view that 28 GHz band should be put up for assignment only if the total spectrum sold in mmWave spectrum is more than 3.25 GHz (as available in 26 GHz band).

2.94 It is noted that 4.25 GHz spectrum in mmWave has been earmarked for IMT and in future further spectrum ranges in mmWave are likely to be developed for IMT. The mmWave network deployment is expected to be more focused on meeting capacity demand across various geographies. High propagation loss makes seamless coverage a challenge and so deployments will be more likely to be kind of hotspots, urban micro cells and FWA. Therefore, the network deployment in mmWave is not likely to be ubiquitous. The most important deployments of mmWave are likely to be (but not limited to):

a. Fixed wireless access (FWA)
b. Public hotspots
c. Stadiums
d. Venues/special events
e. Small cells within existing macro layers

2.95 As regards need for satellite-based services, India is a diverse country, geographic conditions of different places are very different and it may not be possible to connect all the places through terrestrial networks; therefore satellite-based connectivity may be the only possibility in far-flung and remote areas. The propagation characteristics of mmWave spectrum are such that the range of radio waves is very short. Considering the likely network deployment and propagation characteristics of mmWave band, it is possible for IMT and satellite gateways (Earth-to-space) to coexist. This would be a win-win situation, i.e. increased spectrum utilization and both the services being made available to the users.

2.96 In this regard, it is noted that for the mission 'Connect India' identified under NDCP 2018, one of the strategies envisaged, for making adequate spectrum available, is *'promoting the co-use/ secondary use of spectrum'* (Para 1.2(b)(viii)) and for efficient spectrum utilization and management, one of the strategies envisaged is *'deploying dynamic database systems for allocation/ interference management'* (Para 1.2(c)(ii) of NDCP-2018).

2.97 Offering the 27.5-28.5 GHz band exclusively for IMT may result in the reducing the serving capacity of the satellite systems. The way forward is the co-existence of IMT Stations and Satellite Earth Stations in 27.5-28.5 GHz frequency range. To mitigate the possible interference due to coexistences of 5G/IMT systems and satellite earth stations (earth to space) in 27.5 to 28.5 GHz, the Satellite Earth Station Gateway should be permitted to be established in this frequency range at uninhabited or remote locations on case-to-case basis, where there is less likelihood of 5G IMT services to come up. Stakeholders have suggested an exclusion zone of minimum 2 Km around such earth stations. While FCC[6] was planning to auction 27.5-28.35, EchoStar and ViaSat both estimated that terrestrial mobile stations could be deployed as close as 170 meters to their Earth-to-space transmitters in the 28 GHz band.

[6] https://docs.fcc.gov/public/attachments/FCC-16-89A1.pdf

With respect to terrestrial operations, AT&T, Nokia, Samsung, T-Mobile, and Verizon estimated that the necessary separation distances between FSS earth stations and terrestrial deployments are between 50 and 400 meters depending on the type of earth stations. Therefore, the exclusion zone required could be less than one kilometer. DoT should prescribe the exclusion zone requirement for co-existence of IMT and satellite earth stations in 27.5-28.5 GHz frequency range. There are lot of such uninhabited or remote areas in India where such exclusion zones can be created for earth station. This can be made possible by creating a software defined automated process on a portal having database of coordinates of the IMT base stations in mmWave. The geofencing coordinates of the proposed earth station can provide the feasibility results through the portal for establishing the earth station. Spectrum dues can be revised on pro-rata basis for the mobile operator holding spectrum in the LSA, in which the permission for establishing earth station is given, in the same frequency range on account of creation of exclusion zone.

2.98 The Authority noted that some of the stakeholders have submitted that WRC-19 Resolution 242 contain power limits for IMT/5G transmitters in the 24.25-27.5 GHz band and should India decide to consider portions of the 27.5-28.5 GHz band for IMT/5G, the same limits could be made applicable for this band also.

2.99 WRC-19 Resolution 242 resolved as under:

> *"1 that administrations wishing to implement IMT consider use of the frequency band 24.25-27.5 GHz identified for IMT in No. 5.532AB, and the benefits of harmonized utilization of the spectrum for the terrestrial component of IMT, taking into account the latest relevant ITU-R Recommendations;*
>
> *2 that administrations shall apply the following conditions for the frequency band 24.25-27.5 GHz:*

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

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

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

4 that the operation of IMT within the frequency band 24.25-27.5 GHz shall protect existing and future EESS (passive) systems in the frequency band 23.6-24 GHz;

5 that IMT stations within the frequency range 24.25-27.5 GHz are used for applications of the land mobile service."

2.100 It is further noted as the WRC-19 Resolution 750, to provide protection to EESS (passive) prescribes certain limitations, which becomes even stringent after 1st September 2027. The unwanted emission power level considered for 24.25-27.5 GHz frequency range in terms of TRP (integral of the power transmitted from all antenna elements in different directions over the entire radiation sphere), is mentioned below:

"-33 dBW in any 200 MHz of the EESS (passive) band for IMT base stations. A limit of -39 dB(W/200 MHz) will apply to IMT base stations brought into use after 1 September 2027. This limit will not apply to IMT base stations which have been brought into use prior to this date. For those IMT base stations, the limit of -33 dB(W/200 MHz) will continue to apply after this date.

-29 dBW in any 200 MHz of the EESS (passive) band for IMT mobile stations. A limit of -35 dB(W/200 MHz) will apply to IMT mobile stations brought into use after 1 September 2027. This limit will not apply to IMT mobile stations which have been brought into use prior to this date. For those IMT mobile stations, the limit of -29 dB(W/200 MHz) will continue to apply after this date."

2.101 In India, 24.25-28.5 GHz identified for IMT includes 27.5-28.5 GHz, which was not part of the above resolutions as ITU has identified 24.25-27.5 GHz for IMT. Further, WRC-19 Resolution 242 provides protection to Satellite (FSS) receiver from IMT service operating in 24.25-27.5 GHz. Few countries who have launched IMT in n257/n261 band have done so prior to release of these resolutions in WRC-19. However, they have also considered certain measures for protection to Satellite (FSS) receiver. As regards, WRC 19 Resolution 750 w.r.t. power limitations to provide protection to EESS (passive), the frequency range from 24.25 to 28.5 GHz will be auctioned as a single band and similar IMT deployments will be taking place in the entire band from 24.25 to 28.5 GHz, the conditions/limitations should apply equally for the entire band. Therefore, the Authority is of the view that the provisions of the WRC-19 Resolution 242 to provide protection to Satellite (FSS) receiver and Resolution 750 w.r.t. power limitations to provide protection to EESS (passive), applicable for 24.25-27.5 GHz band, should also be appropriately made applicable for 27.5-28.5 GHz frequency range.

2.102 In view of the above, **the Authority recommends that**

a. **As mmWave spectrum is going to be used for capacity requirement, its deployment is not likely to be ubiquitous rather it is more likely to be kind of hotspots or urban micro cells. Therefore, IMT Stations and Satellite Earth Stations Gateway (Earth to Space) can co-exist in 27.5-28.5 GHz frequency range. The Satellite Earth Station Gateway should be permitted to be established in frequency range 27.5-28.5 GHz at uninhabited or remote locations on case-to-case basis, where there is less likelihood of 5G IMT services to come up.**

b. **DoT should prescribe the exclusion zone requirement for co-existence of IMT and satellite earth stations (Earth to space) in 27.5-28.5 GHz frequency range.**

c. **DoT should create a software defined automated process on a portal having database of coordinates of the IMT base stations in mmWave. The geofencing coordinates of the proposed earth station in 27.5-28.5 GHz can provide the feasibility results through the portal for establishing the earth station.**

d. **Access to 27.5-28.5 GHz should also be allowed for Earth Stations In Motion (ESIMs) for In-flight and Maritime terminals, with appropriate sharing conditions, as in such cases, the operation would be geographically separated from terrestrial IMT.**

e. **Spectrum dues for 27.5-28.5 GHz frequency range can be revised on pro-rata basis for the mobile operator holding spectrum in the LSA, in which the permission for establishing earth station is given in the same frequency range, on account of creation of exclusion zone.**

f. **Provisions of the WRC-19 Resolution 242 to provide protection to Satellite (FSS) receiver and Resolution 750 w.r.t. power limitations to provide protection to EESS (passive), applicable for 24.25-27.5 GHz band, should also be made appropriately applicable for 27.5-28.5 GHz frequency range.**

(ii) Existing bands

2.103 Spectrum availability and band plans for various spectrum bands, which were part of part of the earlier auction process (existing bands), are discussed below:

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

2.104 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.

2.105 As per the 3GPP band plan B28, 45 MHz (paired) spectrum can be utilized 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 totaling 660 MHz on pan-India is available for commercial use that can be put to auction.

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

2.106 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.

2.107 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 block 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 2.2(a)

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
KOL	12.50	10.00	2.50	-	2.50
MUM	10.00	7.50	2.50	-	2.50
AP	13.75	6.25	7.50	-	7.50
GUJ	6.25	5.00	1.25	-	1.25
KTK	13.75	10.00	3.75	-	3.75
MH	15.00	12.50	2.50	-	2.50
TN	13.75	10.00	3.75	-	3.75
HR	10.00	8.75	1.25	-	1.25
KL	13.75	10.00	3.75	-	3.75
MP	12.50	10.00	2.50	-	2.50
PB	11.25	6.25	5.00	-	5.00
RAJ	7.50	5.00	2.50	-	2.50
UP (E)	12.50	5.00	7.50	-	7.50
UP (W)	12.50	10.00	2.50	-	2.50
WB	11.25	10.00	1.25	1.25	2.50
AS	2.50	-	2.50	-	2.50
BH	12.50	5.00	7.50	-	7.50
HP	10.00	5.00	5.00	-	5.00
J&K	2.50	-	2.50	-	2.50
NE	2.50	-	2.50	-	2.50
OD	11.25	5.00	6.25	-	6.25
TOTAL	**230.00**	**150.00**	**80.00**	**1.25**	**81.25**

2.108 On examination of the information provided by DoT on frequency-wise spectrum allocation in 800 MHz band, it was observed that a total of 1.8 MHz of spectrum (available in disjoint small chunks less than the block size of 1.25 MHz individually), has been marked as guard band. Further, 800 MHz spectrum band was initially 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. Therefore, in the consultation paper related on 30th November 2021, it was mentioned that if harmonization exercise is carried out and these are made contiguous, additional spectrum can be made available in all the LSAs. With this view, comments of the stakeholders were sought on the need to revisit the existing provision for guard band.

2.109 Through its letter dated 22nd February 2022, DoT has, *inter-alia*, sought TRAI recommendations on need to review channel plan in 800 MHz and number of spectrum blocks that can be made available for IMT while providing the recommendations in response to DoT's reference dated 13.09.2021. While seeking recommendations, DoT in its letter dated 22nd February 2022 has mentioned as under:

a. after the introduction of LTE technology in 800 MHz band, there are no more CDMA networks operating in the band. In view of the current trend of LTE networks in 800 MHz band and existing holdings of TSPs/Government in different service areas, channel plan in 800 MHz band can be revised from existing channel bandwidth of 1.23 (paired) to 1.25 MHz (paired) and frequency carriers assigned to TSPs/Government may be revised accordingly. As a result, inter operator guard band may also be removed due to inherent characteristic of LTE Technology, which may result in availability of upto 16 spectrum blocks in place of existing 14 carriers in each of the 22 LSAs.

b. Revision in channel plan in 800 MHz band was discussed with TSPs. While M/s RJIL has agreed to revision of channel plan and making available total 16 spectrum blocks, M/s Bharti and M/s Vodafone have raised their concerns towards possibility of interference from downlink (higher power) of 800 MHz band (869-889 MHz) to uplink (lower power) of 900 MHz band (890-915 MHz) in case of making available 16 blocks in 800 MHz band, due to slightly reduced band gap between 800 MHz (downlink) and 900 MHz (uplink) band. Guard band requirement being demanded by M/s Bharti and M/s Vodafone is around 1.6 MHz. In case it is decided to allot all 16 blocks (each of 1.25 MHz), the guard band available will be 1.5 MHz (for 5 MHz LTE carrier in both 800 MHz and 900 MHz band), instead of 1.6 MHz being demanded by them. If demand of M/s Bharti and M/s Vodafone is agreed to, only 15 blocks will be available for allotment. In any case, spectrum availability in each LSA will increase by at least 1 block of 1.25 MHz.

c. With regard to existing assignments in 800 MHz band, no additional payment is required to be made by the incumbent spectrum holders as market price for block size of 1.25 MHz has already been charged on them.

2.110 Accordingly, spectrum availability in 800 MHz band can go up as per the details given below:

Table No. 2.2(b)

Enhanced spectrum availability in 800 MHz band

LSA	Existing spectrum availability (with 14 blocks)	Enhanced spectrum availability (with 15 blocks)	Enhanced spectrum availability (with 16 blocks)
DEL	3.75	5.00	6.25
KOL	2.50	3.75	5.00
MUM	2.50	3.75	5.00
AP	7.50	8.75	10.00
GUJ	1.25	2.50	3.75
KTK	3.75	5.00	6.25
MH	2.50	3.75	5.00
TN	3.75	5.00	6.25
HR	1.25	2.50	3.75
KL	3.75	5.00	6.25
MP	2.50	3.75	5.00
PB	5.00	6.25	7.50
RAJ	2.50	3.75	5.00
UP (E)	7.50	8.75	10.00
UP (W)	2.50	3.75	5.00
WB	2.50	3.75	5.00
AS	2.50	3.75	5.00
BH	7.50	8.75	10.00
HP	5.00	6.25	7.50
J&K	2.50	3.75	5.00
NE	2.50	3.75	5.00
OD	6.25	7.50	8.75
Total	**81.25**	**108.75**	**136.25**

2.111 In the consultation paper, comments of the stakeholders were sought on the need to revisit the existing provision for inter-operator guard band in 800 MHz band, and most of the stakeholders were of the view that there is no need for provision of guard band. Some of the stakeholder submitted that in case any change is proposed in channel plan/block size it should be ensured that guard band between 800 MHz and 900 MHz should be continued to be maintained at 1.6 MHz to ensure no adverse impact on the continuity of telecom operations & millions of subscribers being served by 900 MHz band. DoT in its letter dated 22nd February 2022 has also mentioned that inter-operator guard band provisioning is no longer required as 800 MHz band is now being used for LTE services. As regards guard band requirement between 800 MHz and 900 MHz band, this issue was discussed with the TSPs and their submissions are summarized below:

a) One of the TSPs in favour of making 16 blocks of 1.25 MHz each available in 800 MHz band, made the following submissions:
    - While the 15 carrier option can be achieved without disturbing the inter band Guard band between 800 MHz and 900 MHz band of 1.6 MHz, the 16 carrier option will lead to reduction in inter band Guard band by 0.5 MHz. Considering the economic value of spectrum in 800 MHz band, the 16 carrier band plan should be adopted.
    - LTE technology is deployed in both 800 MHz and 900 MHz bands and the inherent guard band of LTE channel bandwidth gets added to the inter band guard band of 1.1 MHz (i.e. 889-890.1 MHz). With this inherent guard band of LTE channels at both 800 MHz band and 900 MHz band ends, it will create sufficient separation varying from 1.6 MHz to 1.85 MHz, which is sufficient to remove any possibility of inter-band interference between 800 MHz downlink and 900 MHz uplink, as cut off filters for 900 MHz uplink needs only 1.5 MHz guard band.
    - Notwithstanding the above option, in case the Authority is keen to address certain apprehensions of 900 MHz band spectrum holders, however unfounded, then the optimum solution will lie not in destroying a full carrier in 800 MHz band with 15 carrier band plan, but to extend the inter band Guard band upwards by 0.5 MHz i.e. the start of uplink frequencies in 900 MHz band can be shifted upwards by 0.5 MHz. Shifting of start of 900 MHz band by 0.5 MHz will have practically no adverse impact on existing spectrum holding in 900 MHz band.

- For optimum deployment of LTE technology in 800 MHz band, the carrier size in the multiples of 5 MHz is required. Thus, implementing a 15 carrier band plan would not be optimum as it would lead to wastage of 3 carriers across LSA. Considering the current spectrum availability, as per the WPC letter dated 22nd February 2022, if we implement 15 carrier band plan then in 10 LSAs, the spectrum availability will remain at 3.75 MHz, rendering them useless to a new TSP or for an additional channel for existing TSP. Whereas under a 16 carrier band plan, the spectrum in these 10 LSAs will be sellable with a minimum Exchequer revenue impact in excess of Rs 10,000 Crore at current reserve price, failing which it will result into exchequer loss in excess of Rs 10,000 Crore.

b) Stakeholders demanding 1.6 MHz guard band between 800 MHz and 900 MHz bands, made the following submissions:

- The 3GPP band 8 spectrum of 25 + 25 MHz (without E-GSM spectrum) was first to get allocated mainly for GSM services and in some countries the E-GSM spectrum of additional 10 + 10 MHz was allocated at a later date. As there is some spectrum overlap between the downlink of band 5 and the uplink of the 3GPP band 8, only partial spectrum of the 3GPP band 5 got allocated.

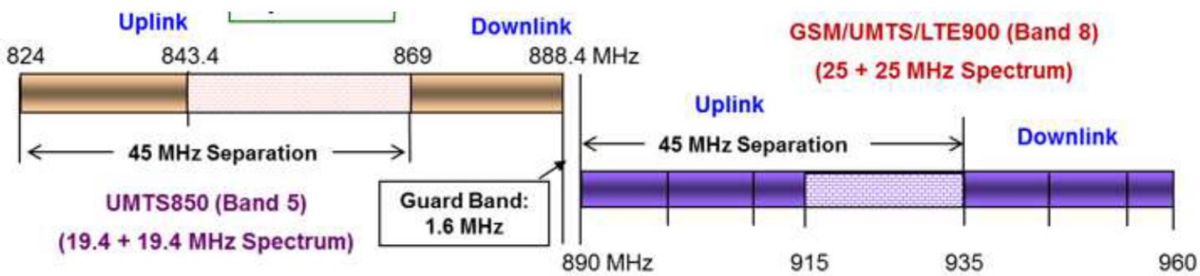


Figure: Spectrum allocation option between 3GPP Band 5 and Band 8

- Globally, at least 2.5 MHz of guard band is defined in countries where both 800 MHz & 900 MHz band are being used. Countries like Australia which had a guard band of 1.6 MHz between Band 5 and Band 8, increased the same to 2.5 MHz to reduce the inter-band interference. Similarly in Malaysia, 6 MHz (874 – 880 MHz) is kept as guard band between B5 and B8. Thailand is also keeping 6 MHz as the guard band (884 to 890 MHz) under its new allocation plan.

- In case 16 blocks are made available in 800 MHz band, it will adversely impact the existing operators having spectrum and running operations in 900 MHz band. Existing operators in 900 MHz band have deployed GSM as well as LTE in various LSA's. If the above proposal is implemented, it will lead to reduction of band spacing between 800 MHz and 900 MHz band (from 1.665 MHz to 1 MHz) and will lead to interference in existing deployed 900 band radios, thus impacting millions of subscribers across the country.
- More than 500K sites (across Airtel, VI & BSNL networks) with existing 900 MHz radios would need to be re-designed and changed. This would cause not only cause disruptions in the networks along with degradation of the QoS and customer experience for millions of customers across the country. It would also lead to additional cost burden to the operators using 900 MHz band.
- The operators providing services in 900 MHz band have already deployed networks in the 900 MHz band by investing heavily over the last 25 years. It will be a massive loss to TSPs operating in 900 MHz band who have acquired this spectrum with value of approx. INR 1,46,875 Crores (considering the 20-year period allocation).
- It is requested that considering the cost & service impact on existing deployed network in 900 MHz, change of guard band from 1.665 MHz to 1 MHz should not be implemented and the existing guard band of 1.665 MHz should be maintained between 800 MHz & 900 MHz spectrum bands.

- Currently the frequency spectrum plan in India, for B5 (800 MHz) DL is 869.415 MHz - 888.435 MHz and B8 (900 MHz) has UL from 890 MHz to 915 MHz. Additionally, 900 MHz band is used both for GSM and LTE operations starting from 890 MHz. The end point in 800 MHz was kept at 888.435 MHz considering previous CDMA allocations. With 800 MHz transmission ending at 888.435 MHz, there were filters deployed in 900 MHz radios, which was rejecting any transmission from 800 MHz starting from 888.435 MHz. These receive filters are hardware based and cannot be programmed through software. Any transmission beyond 888.435MHz would be received by the band pass filter.
- Further, reducing the 3 spots (of 200 KHz) from 900 MHz, would reduce total 900 MHz band to 24.4 MHz, which implies that in future the last 5 MHz of 900 MHz band will be unusable for LTE and would thus seriously limit capabilities of the operators to acquire further spectrum in 900 MHz. For instance, in Andhra Pradesh circle, available spectrum in 900 MHz band is 5.2 MHz. If 0.6 MHz is removed for provision of guard band, then spectrum availability will reduce to 4.6 MHz.
- In summary, 850 MHz spectrum can be put to use till 888.4 MHz, retaining guard band of 1.6 MHz. In order to maximize spectrum for auction in 850 MHz band, block size of 0.25 MHz can be made in 850 MHz band, which would have following benefits
    a. Maximize spectrum availability to 19.25 MHz in 850 MHz band
    b. Will be able to accommodate usage of 3MHz channel bandwidth, which is not possible with channel bandwidth of 1.25MHz
    c. Would not disturb 900 MHz band receivers & operations

Analysis

2.112 DoT in its letter dated 22.02.2022, *inter-alia*, mentioned that after the introduction of LTE technology in 800 MHz band, there are no more CDMA networks operating in the band. It was further mentioned that in view of the current trend of LTE networks in 800 MHz band and existing holdings of TSPs/Government in different service areas, channel plan in 800 MHz band can be revised from existing channel bandwidth of 1.23 (paired) to 1.25 MHz (paired) and frequency carriers assigned to TSPs/Government may be revised accordingly. As mentioned earlier, the Authority in its consultation paper dated 30th November 2021, has mentioned 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. Accordingly, comments of the stakeholders were sought on the need to revisit the existing provision for guard band. Most of the stakeholders were of the opinion that there is no need for inter-operator guard band and this provision of guard band should be done away with.

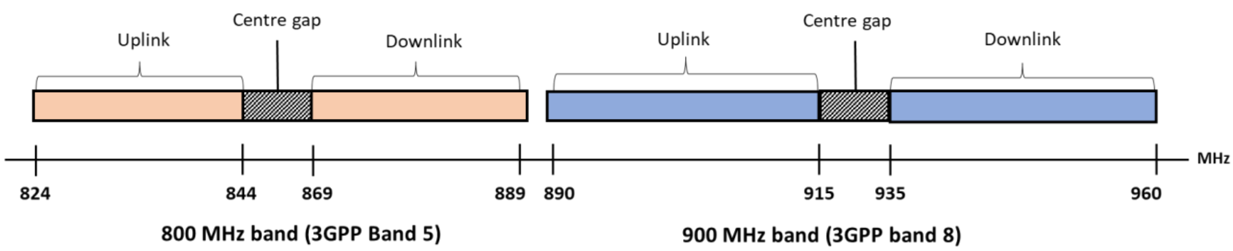
2.113 The Authority has noted the decision of DoT conveyed vide letter dated 22nd February 2022 that no additional payment is required to be made by the incumbent spectrum holders as market price for block size of 1.25 MHz has already been charged on them.

2.114 In view of the above, **the Authority recommends that considering that with the closure of CDMA services, 800 MHz band is being utilized for LTE, which does not require separate provision of inter-operator guard band, the channel plan of 800 MHz band be revised from existing channel bandwidth of 1.23 MHz to 1.25 MHz and the provision of guard band should be done away with.**

2.115 Further, DoT through its letter dated 22nd February 2022 also sought TRAI recommendations on the number of spectrum blocks that can be made available for telecom services in 800 MHz band. In this regard, it is observed that in case spectrum blocks, each of 1.25 MHz, across the entire band i.e., 824-844/869-889 MHz are carved out, total availability can go up by 2 blocks (from 14 to 16) in each LSA.

2.116 However, Bharti and Vodafone who are operating in 900 MHz bands, which starts from 890 MHz are of the opinion that if assignment in 800 MHz band are made till 889, this will result in reducing the inter-band guard band between 800 MHz band 900 MHz band, which will cause severe interference resulting in call drops and other quality of service issues. As submitted by the TSPs, the existing bandpass filter deployed by the TSPs operating in 900 MHz band are hardware based i.e. non-tunable.

2.117 Band plans for 800 MHz and 90 MHz bands are depicted below:



2.118 Actual frequency assignment:

800 MHz band - UL: 824.415 to 843.435 DL: 869.415 to 888.435

900 MHz band - UL: 890.1 to 914.9, DL: 935.1 to 959.9

2.119 From the above, it is observed that since frequency assignment in 800 MHz band stops at 888.435 and 900 MHz band starts at 890.1, there is a gap of 1.665 MHz between 800 & 900 MHz bands in addition to the in-built guard band provision in LTE carriers.

2.120 DoT in its letter dated 22nd February 2022 has mentioned that in case it is decided to allot all 16 blocks (each of 1.25 MHz), the guard band available between 800 MHz and 900 MHz bands will be 1.5 MHz (for 5 MHz LTE carrier in both 800 MHz and 900 MHz band), instead of 1.6 MHz as being demanded. However, as per the submissions of the TSPs operating in 900 MHz band, currently, 900 MHz band is being used for provision of GSM services as well as LTE services. Therefore, the assumption made by DoT that only LTE is operating in 800 MHz as well as 900 MHz, does not seem to be valid. Moreover, as submitted by the TSPs, the existing bandpass filters deployed in 900 MHz band are hardware based and are designed considering an inter-band gap (between 800 MHz and 900 MHz bands) of 1.6 MHz.

2.121 Having said that, the Authority is of the view that the demand of some of the TSPs, for a guard band of 1.6 MHz between 800 MHz and 900 MHz bands, needs to be examined practically through field trials. Therefore, it would be prudent that DoT gets this requirement verified by performing limited field trials and decide based on the results of the limited field trails.

2.122 In view of the above, **the Authority recommends that**

a) **As regards assignment of the last block from 887.75-889 MHz, DoT should carry out limited field trial to ascertain the inter-band guard band requirement between 800 & 900 MHz bands. In case, the outcome of the field trial shows that the assignment can be made till 889 MHz without causing any interference to existing users in 900 MHz band, the last block in each LSA can also be put to auction, else the last block with reduced size (considering the guard band requirement) can be put to auction. In case, it is not possible to conduct and conclude the study before forthcoming auction, the forthcoming auction should be conducted considering 15 blocks of 1.25 MHz each as total availability of spectrum in 800 MHz band and later on decision about the last block can be taken and included in the subsequent spectrum auction.**

b) **DoT should carry out harmonization exercise in 800 MHz band immediately after conducting the auction so that frequencies assigned to the TSPs are in contiguous manner and any vacant spectrum is available towards the end of the spectrum band.**

Further, the spectrum harmonization exercise should be completed within a time frame of not more than 6 months from the date of conclusion of Auction.

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

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

2.124 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.

2.125 Subsequently, DoT vide their letter dated 22nd February 2022, conveyed that recently, Indian Railways in 23 States / UTs has surrendered spectrum earmarked to them in 900 MHz band which has resulted in availability of additional 1.6 MHz (paired) quantum of spectrum in 900 MHz in 7 LSAs namely Andhra Pradesh, Himachal Pradesh, Karnataka, Kerala, North East, Orissa, Tamilnadu LSAs.

2.126 Further, certain quantum of spectrum reserved for Government's use in 900 MHz at certain locations spread across 6 LSAs namely Gujarat, Haryana, Jammu and Kashmir, Punjab, Rajasthan and Uttar Pradesh (West) LSAs is also available now for auction. In Gujarat, Haryana, Punjab LSAs, this spectrum is available for assignment with immediate effect, whereas in other 3 LSAs this spectrum will be available for assignment latest by 1st July 2022.

2.127 In view of above surrender / vacation, spectrum availability in 900 MHz band in certain LSAs has increased. The details of spectrum availability are given in Table 2.2 below:

Table 2.3

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
KOL	4.20	-	4.20	-	4.20
MUM	2.20	-	2.20	-	2.20
AP	3.60	-	3.60	1.60	5.20
GUJ	4.20	4.20	-	3.00	3.00
KTK	3.80	-	3.80	1.60	5.40
MH	4.20	-	4.20	-	4.20
TN	17.60	10.00	7.60	1.60	9.20
HR	0.80	-	0.80	4.60	5.40
KL	4.60	4.60	-	1.60	1.60
MP	5.80	-	5.80	-	5.80
PB	-	-	-	2.60	2.60
RAJ	-	-	-	5.20	5.20
UP (E)	6.40	5.00	1.40	-	1.40
UP (W)	2.40	-	2.40	4.60	7.00
WB	5.20	3.60	1.60	-	1.60
AS	5.80	-	5.80	-	5.80
BH	10.40	3.40	7.00	-	7.00
HP	5.20	2.60	2.60	1.60	4.20
J&K	-	-	-	7.60	7.60
NE	5.00	1.20	3.80	1.60	5.40
OD	5.20	3.80	1.40	1.60	3.00
TOTAL	**98.80**	**38.40**	**60.40**	**38.80**	**99.20**

2.128 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 and spectrum assignment to the TSPs is also non-contiguous. 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. Therefore, **the Authority recommends that DoT should carry out harmonization exercise in 900 MHz band immediately after conducting the auction and such exercise should be completed within a time frame of not more than 6 months from the date of conclusion of Auction.**

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

2.129 India has adopted FDD configuration based 3GPP band 3 for 1800 MHz spectrum band. This band has emerged as one of the most preferred bands for LTE. Corresponding 5G band defined by 3GPP is band n3.

2.130 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. Further, DoT vide its letter dated 27th November 2021 informed that some additional spectrum has been made available for auction.

2.131 Subsequently, DoT vide its letter dated 22nd February 2022, conveyed that the additional 10 MHz made available in Haryana LSA, is available for assignment in entire Haryana LSA except Sirsa (with safe keep off distance). The required safe keep distance around Sirsa is being determined and will be communicated subsequently.

2.132 In view of above, details of spectrum availability are given in Table 2.3 below:

Table 2.4
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
KOL	14.40	1.00	13.40	10.00	23.40
MUM	15.60	3.40	12.20	10.00	22.20
AP	16.40	4.20	12.20	-	12.20
GUJ	17.80	4.00	13.80	-	13.80
KTK	24.80	20.20	4.60	-	4.60
MH	22.20	5.00	17.20	-	17.20
TN	19.40	18.20	1.20	-	1.20
HR	23.20	5.00	18.20	10.00*	28.20
KL	18.20	10.00	8.20	15.00	23.20
MP	18.80	7.80	11.00	-	11.00
PB	19.40	9.80	9.60	-	9.60
RAJ	16.80	-	16.80	-	16.80
UP (E)	18.80	8.20	10.60	-	10.60
UP (W)	23.20	8.60	14.60	-	14.60
WB	7.00	3.80	3.20	-	3.20
AS	6.80	4.60	2.20	-	2.20
BH	8.60	7.80	0.80	-	0.80
HP	22.80	4.80	18.00	-	18.00
J&K	14.00	10.00	4.00	-	4.00
NE	3.80	3.60	0.20	-	0.20
OD	7.60	7.60	-	15.00	15.00
TOTAL	**355.00**	**152.20**	**202.80**	**60.00**	**262.80**

* Available for assignment in entire Haryana LSA except Sirsa (with safe keep off distance)

2.133 On examination of the information provided by DoT on frequency-wise spectrum allocation in 1800 MHz band, it is observed that in some of the LSAs, vacant spectrum is not available in contiguous manner and spectrum assignment to the TSPs is also non-contiguous. 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. Therefore, **the Authority recommends that DoT should carry out harmonization exercise in 1800 MHz band immediately after conducting the auction and such exercise should be completed within a time frame of not more than 6 months from the date of conclusion of Auction.**

2.134 From the information provided by DoT on frequency-wise spectrum allocation in 1800 MHz band, it is further 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. In some LSAs (for example, Gujarat LSA), this guard band has been kept next to vacant spectrum, which does not seem to be required. Since block size for 1800 MHz band is 0.2 MHz, the spectrum availability can go up by 0.2 MHz in each LSA. Therefore, **the Authority recommends that DoT should examine whether the guard band of 0.2 MHz provisioned in 1800 MHz band in each LSA, can be done away with and wherever feasible, 0.2 MHz may be included in the forthcoming auction.**

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

2.135 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, most of the TSPs have closed/closing 3G services and migrated/migrating to LTE in this band. Corresponding 5G band defined by 3GPP is band n1.

2.136 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 2.5
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	-
KOL	10.00	-	10.00	-
MUM	10.00	-	10.00	-
AP	15.00	-	15.00	-
GUJ	10.00	-	10.00	-
KTK	10.00	-	10.00	-
MH	5.00	-	5.00	-
TN	-	-	-	-
HR	5.00	-	5.00	-
KL	5.00	-	5.00	-
MP	10.00	-	10.00	-
PB	5.00	-	5.00	-
RAJ	-	-	-	-
UP (E)	-	-	-	-
UP (W)	10.00	-	10.00	-
WB	10.00	5.00	5.00	-
AS	10.00	5.00	5.00	-
BH	5.00	-	5.00	-
HP	15.00	-	15.00	-
J&K	5.00	-	5.00	-
NE	10.00	5.00	5.00	-
OD	10.00	-	10.00	-
TOTAL	**175.00**	**15.00**	**160.00**	**160.00**

2300 MHz Band (2300- 2400 MHz)

2.137 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.

2.138 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 2.6
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	-
KOL	20.00	10.00	10.00	-
MUM	20.00	10.00	10.00	-
AP	20.00	10.00	10.00	-
GUJ	20.00	20.00	-	-
KTK	20.00	10.00	10.00	-
MH	20.00	20.00	-	-
TN	20.00	10.00	10.00	-
HR	40.00	40.00	-	-
KL	20.00	20.00	-	-
MP	20.00	20.00	-	-
PB	40.00	40.00	-	-
RAJ	40.00	40.00	-	-
UP (E)	40.00	40.00	-	-
UP (W)	40.00	40.00	-	-
WB	20.00	20.00	-	-
AS	20.00	20.00	-	-
BH	20.00	20.00	-	-
HP	20.00	20.00	-	-
J&K	40.00	40.00	-	-
NE	20.00	20.00	-	-
OD	20.00	20.00	-	-
TOTAL	**560.00**	**500.00**	**60.00**	**60.00**

2500 MHz (2500-2690 MHz)

2.139 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.

2.140 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 2.7
Spectrum availability (unpaired in MHz) in 2500 MHz Band

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

B. Quantum of spectrum to be put to auction in the forthcoming auction

2.141 While providing details of each spectrum band referred by DoT i.e. 526-698 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3670 MHz, 24.25-28.5 GHz bands, the stakeholders were requested to comment on whether entire available spectrum in each band be put to auction in the forthcoming auction.

Comments received from the stakeholders

2.142 While many of the stakeholders opined that all available spectrum except 526-612 MHz band should be included in the forthcoming auction, some of the stakeholders were of the view that all available spectrum in each band, should be put to auction in the forthcoming auction.

2.143 One of the stakeholders further submitted that limiting the amount of spectrum available can lead to higher prices, due to artificial scarcity. Another stakeholder suggested that there should be an attempt to make maximum spectrum available for deployment of 5G after suitably protecting incumbent operations in each of the adjacent bands.

2.144 One stakeholder suggested that there could be an annual plan for supply of spectrum in next five years through auctions so as the TSPs can take a considered decision keeping the financial aspects in focus. A few stakeholders were of the opinion that spectrum put to auction should be harmonized and interference-free. One of the stakeholders suggested that the issues related with 526-617 MHz bands and 3300-3670 MHz bands be preferably resolved before auctioning those bands.

2.145 Some of the stakeholders suggested to reconsider whether the entire 3300-3670 MHz spectrum is truly needed for 5G/IMT. 3600-3670 MHz should be excluded from auction as 300 MHz of spectrum in the 3300-3600 MHz band be more than enough to support India's mid-band 5G spectrum requirements, while preserving the 3600-4200 MHz band for productive and valuable satellite services. Another stakeholder suggested that the terrestrial mobile industry commonly estimates that 80 to 100 MHz per mobile network operator (MNO) would be required for such services. If 3600-3670 MHz is not excluded from auction, prioritize assignment of lower mid-band spectrum before impinging on satellite services in 3600-3670 MHz. If, despite the sound policy arguments to the contrary, India insists on auctioning the 3600-3670 MHz GHz band for 5G, India may use a two-stage auction process to gauge total spectrum demand first, and then prioritizing the assignment of the lower parts of the band to meet this demand to avoid unnecessarily impacting the satellite-occupied band in 3600-3670 MHz. This will ensure that in-use satellite bands are not disturbed.

2.146 Some of the stakeholders suggested that the spectrum from 27.5-28.5 GHz be excluded from the auction for IMT/5G

2.147 One stakeholder suggested that some part of spectrum be reserved for private 5G networks in line with global practices to enable Industry 4.0. Further, since higher frequency bands (e.g. mmWave) have high RF propagation loss which in turn supports better frequency reuse for TSPs hence, reserving some part of mmWave band for private 5G will not impact the consumer/public 5G services to be offered by the TSPs using their public network.

Analysis

2.148 World-over, the Telecommunications has been recognized as an important tool for socio-economic development of a nation. It is one of the prime support services needed for rapid growth and modernization of various sectors of the economy. Spectrum is one of the most important and crucial ingredients for wireless communication services. With the increasing demand for data services and uptake of data hungry applications, the need for spectrum has been ever increasing. With the uptake of 4G in the country, the data usage has increased exponentially in India. Total mobile data usage has increased from 462 petabytes in quarter ending September-2016 to 34608 petabytes in quarter ending December 2021, thereby showing an increase of about 75 folds. With the exponential growth in data usage, India has become one of the countries with highest mobile data usage. To keep pace with the increasing demand of data services, it is essential that sufficient amount of spectrum in globally harmonized bands is made available and auctioned at regular intervals. Further, it is equally important that at least a 5-year roadmap on spectrum likely to be made available for

IMT in each year and likely date/month of auction is made public. Such a spectrum roadmap will provide certainty, enable the bidders to take informed decisions and may also encourage new entrants.

2.149 In addition to the spectrum bands earmarked for IMT in India, there are certain additional bands which are already identified by ITU for IMT services. Further, few additional bands are under consideration in WRC-23 for IMT identification. Details are given below:

(i) Bands already been identified by ITU for IMT services, which should be explored for its early availability to the service providers in India.

- 4800-4990 MHz
- 37-43.5 GHz
- 45.5-47 GHz
- 47.2-48.2 GHz
- 66-71 GHz

(ii) Frequency bands under consideration in WRC-23 for IMT identification

- 3600-3800 MHz
- 6425-7125 MHz
- 10-10.5 GHz

2.150 In view of the above, **considering that there are certain additional bands which are already identified by ITU for IMT services and few additional bands are under consideration in WRC-23 for IMT identification, the Authority recommends that DoT should explore the possibility to make these bands available for IMT services at the earliest and come out with a spectrum roadmap for opening up of new bands for IMT to meet the future demand. At least a 5-year roadmap on spectrum likely to be made available for IMT in each year and likely date/month of auction should be made public. Such**

a spectrum roadmap will provide certainty, enable the bidders to take informed decisions and may also encourage new entrants.

2.151 To meet the future demand due to increasing data usage, uptake of M2M, and role 5G is likely to play in different industry verticals, the Authority is of the view that the DoT should explore the possibility to make the above-mentioned bands available for IMT services at the earliest and come out with a spectrum roadmap for opening up of new bands for IMT.

2.152 Some of the spectrum bands viz. 3300-3670 and 24.25-28.5 GHz to be auctioned in the forthcoming auction, are likely to be used for 5G services, for which sufficient spectrum in globally harmonized bands is a prerequisite. Further, in existing bands, the TSPs may like to enhance their spectrum holding considering the increasing data consumption. Requirements and priorities of different TSPs could be different i.e., to strengthen their existing 4G services, launch 5G services, some new operator may like to come in straight with 5G. Therefore, to give flexibility and choice to the TSPs, it will be prudent to include entire available spectrum in each band in the forthcoming auction.

2.153 As regards the concerns of the broadcasting and satellite industry, necessary provisions have been created in the recommendations made in earlier sections.

2.154 For 526-612 MHz, it has already been recommended (in the earlier section of this recommendation) that it should not be put to auction in the forthcoming auction. As regards 600 MHz band, the Authority has recommended (in the earlier section of this recommendation) that band plan APT 600 (option B1) should be adopted and 40 MHz (paired) spectrum should be put to auction in the forthcoming auction. With respect to rest of the spectrum bands i.e., 700 MHz, 800 MHz, 900 MHz, 1800 MH, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3670 MHz and 24.25-28.5 GHz bands, the Authority is of the view that entire available spectrum should be put to auction in the forthcoming auction.

2.155 The Authority also notes that the Government is already considering assignment of spectrum to BSNL/MTNL for 5G services.

2.156 In view of the above, **the Authority recommends that in 600 MHz (APT 600 Option B1), 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3670 MHz and 24.25-28.5 GHz spectrum bands, the entire available spectrum should be put to auction in the forthcoming auction. The Authority also notes that the Government is already considering assignment of spectrum to BSNL/MTNL for 5G Services.**

C. BLOCK SIZE

2.157 Block size is the lowest unit of quantum of spectrum, in multiples of which, the spectrum is auctioned/assigned. In other words, block size works as building blocks and while bidding, the TSPs decide the number of blocks to bid in each spectrum band. In some cases, minimum amount of spectrum (in multiples of minimum number of blocks) that a bidder is required to bid is also prescribed.

(i) Existing bands

2.158 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

2.159 As already discussed in an earlier section, 800 MHz spectrum band was initially assigned for deployment of 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. 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. With this background, stakeholders were asked to comment on need for review of the provision of guard band in 800 MHz band and whether is it needed to change the block size for 800 MHz band and if so, then what should be the block size for 800 MHz band and the minimum number of blocks for bidding for existing and new entrants.

2.160 As regards rest of the existing bands, the stakeholders were asked whether 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, then what should be the band-wise block sizes and minimum quantity for bidding.

Comments received from the stakeholders

800 MHz band

2.161 Issues relating to guard band have already been discussed and deliberated in earlier section. As regards block size, the comments of the stakeholders are given below.

2.162 Many stakeholders suggested that the provision for guard band is not required and there is no need for any change in the block size for 800 MHz band and the same may be maintained at 1.25 MHz.

2.163 One of the stakeholders opined that the same spectrum block size and other conditions as in the last auction for 800 MHz may be retained. Changing spectrum plans in the new auction will impact existing operators' strategy to acquire additional spectrum.

2.164 Some stakeholders suggested for block size of 5 MHz as globally, 800 MHz band is being used to deploy LTE services mostly under technology neutral conditions and the block size of 2x5 MHz (UL/DL) in the 800 MHz band will harmonize it with 700 MHz and 600 MHz plans.

2.165 However, one stakeholder is of the opinion that there is no need to change the block size as average amount of spectrum available is less than 5 MHz; keeping block size more than 1.25 may lead to unsold spectrum.

2.166 Another stakeholder opined that while lot sizes of 5 MHz have often been used in the development of auction design for sub-1 GHz auctions around the world, these have always been with the aim of developing a frequency table in which MNOs are comfortable with and, as operators have already acquired spectrum in previous auctions in this band, the same 1.25 MHz block size can be used if the market believes so.

2.167 Another stakeholder mentioned that block size defined earlier for CDMA services has no relevance now, and block size of 200 KHz as prescribed for 900 MHz band can be adopted for better utilization of available spectrum for current and future technologies, if it makes the spectrum more contiguous.

2.168 Another stakeholder suggested that while there is no need to revisit the 1.25 MHz block size, however, there is a need to allot entire quantum of 1.25 MHz to TSPs. This implementation should also cover the existing licensees as they have already paid the auctioned determined price for 1.25 MHz spectrum and therefore are entitled to receive 1.25 MHz spectrum in place of actually allocated 1.23 MHz block size.

<u>700 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands</u>

2.169 Majority of the stakeholders were of the opinion that in the upcoming auction, block sizes and minimum quantity for bidding be kept same as in the last auction.

2.170 Only one stakeholder suggested that an optimal lot size is generally based on the market structure and should be of at least the minimum size a technology can support in a certain band - generally 5 MHz for lower bands and 10 MHz for mid-bands.

Analysis

2.171 Revision in channel plan for 800 MHz band has also been discussed in an earlier section, wherein the Authority has recommended that DoT should do away with the provisions made for guard bands, assign the entire block of 1.25 MHz to the existing spectrum holders and for future assignments, entire 1.25 MHz should be assigned.

2.172 As regards blocks size, most of the stakeholders were of the view that no change is required to be made. While some of the stakeholders have opined that block size should be kept as 5 MHz. Since beginning, assignments in 800 MHz band have been in the blocks size of 1.25 MHz, the spectrum available for auction is also in multiples of 1.25 MHz and in many LSAs availability is less than 5 MHz. Therefore, if block size of 5 MHz is prescribed, most of the spectrum will not be able to put to auction. Therefore, the Authority is of the view that no change be made to the block size for 800 MHz band. However, the successful bidders should be assigned entire block of 1.25 MHz.

2.173 As regards rest of the existing bands, the stakeholders have viewed that no change is required to be made. The Authority concurs with the views of the stakeholders.

2.174 In view of the above, **the Authority recommends that for existing bands the block size and minimum amount of spectrum that a bidder is required to bid for should be prescribed as given below:**

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

(ii) New Bands

526-698 MHz bands

2.175 As already discussed, technical characteristics of the lower frequency bands are such that provide better coverage and in-building penetration. While no band plans have been defined by 3GPP 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).

2.176 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.

2.177 With this background, stakeholders were asked that 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.

Comments received from the stakeholders

2.178 One of the stakeholders suggested that the block size and minimum spectrum should be considered in future auctions as per global development/adoption in this band. Another stakeholder suggested for 200 KHz block size to ensure the best utilization of the limited natural resource.

2.179 A few stakeholders suggested for the block size of 10 MHz, while majority of stakeholders suggested for 5 MHz as the block size. A few stakeholders suggested minimum spectrum for bidding should be prescribed as 10 MHz.

Analysis

2.180 Globally, the 600 MHz band has been auctioned in the block size of 5 MHz (paired). LTE supports channel bandwidth of 1.4 MHz, 3 MHz, 5 MHz and 10 MHz. Most of the stakeholders are also of the view that block size for 600 MHz band should be 5 MHz.

2.181 TRAI recommendations for all sub 1 GHz bands are based on the principle that for new players, ideally block size of 5 MHz should be prescribed.

2.182 Since 600 MHz band will be auctioned for the first time, entire 40 MHz is available, which can be auctioned in the multiples of 5 MHz of 10 MHz. In case blocks size is kept as 5 MHz, a TSP has a choice to acquire 10 MHz by bidding for 2 blocks. Thus, 5 MHz block size will provide flexibility to the TSP.

2.183 In view of the above, **the Authority recommends that considering the global trend and to provide flexibility to the TSPs, block size of 5 MHz should be prescribed for 600 MHz band.**

3300-3670 MHz band

2.184 For 3300-3600 MHz band, TRAI in its recommendations on Auction of Spectrum dated 1st August 2018, 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, had recommended that spectrum in 3300-3600 MHz band should be put to auction in the block size of 20 MHz.

2.185 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.

2.186 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.

2.187 With this background, stakeholders were asked for their opinion about the optimal block size and minimum quantity for bidding in 3300-3670 MHz band.

Comments received from the stakeholders

2.188 Majority of stakeholders have suggested for 10 MHz of block size. Whereas other stakeholders have suggested for 5 MHz/20 MHz/ 40 MHz as the block size.

2.189 While most of the stakeholders were of the view that minimum spectrum for bidding should be kept as one block, some of the stakeholders have suggested minimum spectrum for bidding to be kept 20 MHz/40 MHz/50 MHz.

2.190 Some of the stakeholders suggested that the assignment of the blocks be contiguous and harmonized across all the LSA for each operator. Some of the stakeholders submitted that each operator should have access to around 80-100 MHz of spectrum in 3.5 GHz band to enable the envisaged 5G services.

Analysis

2.191 In its 2018 recommendations, TRAI had originally recommended a block size of 20 MHz. However, in its response to the back reference, wherein DoT had informed that 25 MHz has to be reserved for government use and spectrum available in this band for IMT is 275 MHz, TRAI recommended a block size of 5 MHz, else with 20 MHz block size 15 MHz could not have put to auction.

2.192 Since then, several countries have conducted auction in 3.5 GHz band. On examination of the same, it is observed that many countries have auctioned 3.5 GHz spectrum in block size of 10 MHz, while some have gone for 5 MHz and a few have gone for larger block size of 80 to 130 MHz. Only a few countries have specified minimum spectrum for bidding as 10-40 MHz.

2.193 The Authority is of the view that to provide flexibility to the TSPs, it would be appropriate to keep the block size for 3300-3670 MHz band as 10 MHz. However, considering that 3300-3670 MHz band is likely to be used for 5G services, the TSPs may like to acquire larger chunk of spectrum in this band; therefore, in case a TSP acquires more than one blocks, the assignment of spectrum should be done in a contiguous manner.

2.194 In view of the above, **the Authority recommends that for 3300-3670 MHz band block size of 10 MHz should be prescribed. Further, DoT should ensure that if a TSP acquires more than one block, entire spectrum assigned to a TSP is in contiguous form.**

24.25-28.5 GHz bands

2.195 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.

2.196 As per the standard frozen by 3GPP[7] [ETSI TS 138 104 V16.6.0 (2021-01)], for 5G NR bands n257 and n258, the supported channel 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.

2.197 With this background, stakeholders were asked to provide their opinion about the optimal block size and minimum quantity for bidding in 24.25-28.5 GHz bands.

Comments received from the stakeholders

2.198 In its response, some stakeholders suggested for block size of 50 MHz, many stakeholders suggested for 100 MHz as an optimal block size and a few stakeholders suggested for block sizes in the range of 50-400 MHz.

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

2.199 Regarding minimum quantity for bidding, many stakeholders were of the view that the block size be the minimum quantity for bidding, some stakeholders suggested minimum quantity for bidding from 100 MHz to 800 MHz. Some of the stakeholders have suggested that for a new entrant with no spectrum holdings in any other band, minimum bidding amount be 400 MHz.

Analysis

2.200 While most of the stakeholders have suggested block size of 100 MHz, some have suggested block size of 50 MHz.

2.201 On examination of the global trend, it is observed that that many countries such as USA, Korea, Taiwan, Thailand etc. have kept a block size of 100 MHz, while some have gone for larger block size of 200 to 800 MHz. The countries studied did not specify any minimum quantity for bidding.

2.202 As already mentioned, for bands n257 and n258, the supported channel bandwidth is 50 MHz, 100 MHz, 200 MHz and 400 MHz. Total spectrum available in 24.25-28.5 GHz band is 4250 MHz, which is in the multiples of 50 MHz. Therefore, the Authority is of the view that the block size for 24.25-28.5 GHz band may be kept as 50 MHz, else 50 MHz will not be able to put to auction and remain unsold. This would give flexibility to the TSPs and may also encourage new entrants. However, considering that 25.25-28.5 GHz band is likely to be used for 5G services, the TSPs may like to acquire larger chunk of spectrum in this band; therefore, in case a TSP acquires more than one blocks, the assignment of spectrum should be done in a contiguous manner.

2.203 In view of the above, **the Authority recommends that Block size for 24.25-28.5 GHz band be kept as 50 MHz. Further, DoT should ensure that if a TSP acquires more than one block, entire spectrum assigned to a TSP is in contiguous form.**

D. ELIGIBILITY CONDITIONS FOR PARTICIPATION IN AUCTION

2.204 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[8]. In the present 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

2.205 With this background, stakeholders were asked to give their opinion 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. It was also asked whether existing eligibility conditions for participation in Auction be made applicable for the new spectrum bands proposed to be auctioned or what should be the eligibility conditions for participating in Auction.

Comments received from the stakeholders

2.206 Most of the stakeholders have opined that the eligibility conditions for participation in the forthcoming auction should be kept the same as specified by the NIA for auctions held in March 2021. Further same criteria should be extended for new bands. Some of these stakeholders have further mentioned that the eligibility conditions specified in the NIA 2021 were quite flexible as they allowed all non-licensees to bid for the spectrum so long as they give an undertaking that they will procure a license. One of these stakeholders opined that the present eligibility

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

conditions ensure that only serious players bid for spectrum and put the spectrum to optimal and efficient use after winning.

2.207 One stakeholder suggested that, in addition to the existing eligibility conditions for participation in Auction as specified in the NIA for the spectrum Auction held in March 2021, additional eligibility conditions should be put in place to ensure/encourage that the first few years of 5G rollout in India is through operators, those who have done 5G trials, working with government, security agencies, demonstrated commitment to India use cases and in developing local ecosystem.

2.208 One stakeholder suggested that to facilitate new operators or new players to participate, the eligibility conditions could be suitably relaxed.

2.209 A few stakeholders were of the opinion that, in order to promote competition in the market by having more players owning licensed spectrum and competing in the market leading to more broadband proliferation, ISPs should be allowed to participate and bid in the forthcoming 5G spectrum auction along with TSPs. One eligibility criteria, which includes ISPs as participant should be prescribed for all spectrum bands (new as well as existing bands).

Analysis

2.210 A few of the stakeholders have submitted that ISPs should also be made eligible for participation in spectrum Auction. In this regard, it was noticed that in the year 2010, for the spectrum in 2300 MHz band was auctioned first time and ISP Category A licensees were permitted to bid and use it under ISP license. The spectrum was designated as Broadband Wireless Access (BWA) spectrum. For all other access spectrum bands, ISPs were not eligible to take part in spectrum auction under ISP license.

2.211 After 2010, spectrum in 2300 MHz band came up for auction in 2016. On the basis of TRAI's recommendations, during this auction UASL/

CMTS/ UL(AS)/UL with authorization for Access Services were eligible to participate and ISP licensees were not made part of it. While giving its recommendations in 2016, the following rationale was given for not making ISPs eligible for bidding for spectrum:

> *"Uniform eligibility criteria should be made applicable for all the access spectrum bands. Earlier, it was envisaged that the spectrum in the 2300 MHz bands would be used for wireless broadband services. Over a period of time, the technology and the device ecosystem has evolved and now same technology which is used in other bands can also be used in 2300 MHz band and 2500 MHz band. Therefore, as far as eligibility conditions to participate in an auction is concerned, there is no justification for separate treatment to 2300 MHz and 2500 MHz bands vis-à-vis other access spectrum bands."*

2.212 It may be mentioned that none of the ISPs who acquired 2300 MHz spectrum in the auction held in the year 2010, used such spectrum as an ISP – most of them were acquired by Access service providers and one of them acquired access service authorization to offer LTE services.

2.213 In case an entity (including ISP) is willing to offer 5G based broadband services to enterprise customers or otherwise, it can take Access Service Authorization. In case ISPs are permitted to bid for access spectrum, the spectrum can be utilized only for the services permitted under ISP authorization; therefore, it will lead to inefficient utilization of spectrum. Further, the cost of Access service authorization does not appear to be a hindrance as it may be miniscule in comparison to the cost of deployment of network and cost of spectrum. After the telecom reforms announced in September 2021 by the Government, relaxation has been granted in respect of bank guarantees for the operator, Adjusted Gross Revenue (AGR) has been rationalized by permitting exclusion of non-telecom revenue, KYC reforms have been made. So, it is easier for an

ISP to migrate to/or acquire Access Services authorisation to provide all array of services to the customers.

2.214 TRAI in its recommendations on 'Enabling Unbundling of Different Layers Through Differential Licensing' of August 2021, had recommended to create a new category of license for Access Network Provider under UL. It was also recommended that like Unified Licensee with access service authorization, the Access Network provider be permitted to acquire spectrum through spectrum auctions, subjected to the prescribed spectrum caps, enter into spectrum trading and spectrum sharing arrangement with the other Access Network providers and unified licensees with Access service authorization. If DoT accepts TRAI recommendations on Unbundling of Licensing layers, ISPs will also have an option to take 'Network Service Provider' authorisation or become VNO of a Network provider for delivery of services.

2.215 Further, the Authority notes that DoT vide its letter dated 23rd September 2021 had intimated that DoT will also appropriately address the eligibility conditions for participation in the auction, so that the participants have sufficient financial capacity.

2.216 In view of the above, **the Authority recommends that DoT should take a decision on the TRAI recommendations on "Enabling Unbundling of Different Layers Through Differential Licensing" of August 2021 at the earliest, preferably before conducting the Auction and make suitable provision for Network Service Provider (similar to Access Service providers) in the NIA under eligibility criteria for participating in Auction and other related clauses such as spectrum sharing, spectrum trading, etc.**

E. INTERFERENCE MITIGATION IN TDD BANDS

2.217 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.

2.218 Earlier, the issue of interference in the TDD networks was analyzed 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[9] 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."*

2.219 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,*

[9] 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.

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 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."

2.220 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.

2.221 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.

2.222 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.

2.223 With this background, the stakeholders were asked to give their opinion on whether there is 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. In case, it is required then, whether 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 and if so, what should be the frame structure. Stakeholders were also asked to suggest any other measures to mitigate interference related issues.

Comments received from the stakeholders

2.224 Many stakeholders suggested that considering the multiple techniques for TDD interference mitigation available, management of interferences should be left to the TSPs by mutual coordination without prescribing any guard band. If an agreement is not reached, a general mandatory frame structure may be specified. Some of these stakeholders further submitted that operators may coordinate to use different synchronized frame structures to meet the network requirements. It has also been suggested that it may be recommended that MNOs to deploy synchronized TDD network, at national level as well as at local levels, to avoid additional mitigation and regulatory measures.

2.225 Some of the stakeholders were of the view that as both 4G and 5G uses OFDMA technique which defines inherent guard band within the system, thus, there is no need to prescribe any measure to mitigate possible interference issues in 3300-3670 MHz and 24.25-28.5 GHz TDD bands and therefore use of compatible frame structures is not always possible. Therefore, it should be left to TSPs to manage the interference by mutual coordination.

2.226 One stakeholder suggested that for 3300 – 3670 MHz, continue with the practice of defining frame structure prior to spectrum auction so that service providers are aware of the capacity and coverage. As 5G use cases and network requirements evolve over time, operators should periodically be able to trigger a process to propose changes to the previously agreed TDD synchronization parameters at national, local, or international level; and this process be defined prior to spectrum auction. In the case of mmWave networks, in addition to synchronization and semi-synchronization, an additional option is to allow asynchronous deployments whenever there is no reason to expect excessive interference.

2.227 Another stakeholder submitted that in-band interference within operators arise due to the TDD nature of usage in the 3.5 GHz spectrum and it is critical for all networks to be synchronized in time to avoid any uplink and downlink coordination-based interference among the networks of multiple operators. Based on the experience of TDD usage in B40 (2.3GHz) & B41 (2.5GHz), it is suggested that to avoid inter-system interference in the 3.5GHz & mmWave bands, all networks and sites to be synchronized with GPS signal and all outdoor site deployments should use the same mode of DL/UL configuration which be defined in the NIA.

2.228 One stakeholder proposed that one method to ensure interference free operations in new bands would be to ensure that one TSP gets same spectrum allotment across all licensed service areas. In addition, to mitigate interference issues, all regulation for TDD bands should be similar to the ones prevailing under LTE Band 40 for instance, GPS 1

PPS synchronization and use of identical DL:UL ratio across the operators which be prescribed as part of auction conditions.

2.229 Some of the stakeholders suggested that in case a TSP acquires spectrum in more than one LSA, same frequency spots should be assigned to it in all other LSAs. One of the stakeholders submitted that only interference free spectrum be auctioned.

Analysis

2.230 In 2018, while giving recommendations for 3300-3600 MHz band, TRAI noted the following:

a. 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.

b. If the large contiguous blocks of spectrum are assigned to TSPs, they can manage the interference by mutual coordination.

c. 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.

2.231 In view of the above, following recommendations were made to mitigate interference related issues in 3300-3600 MHz band:

a. *In case a TSP acquires more than one block, the entire spectrum should be assigned to it in contiguous form.*

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.*

2.232 Further, to cater to the different 5G use cases, the TSPs may like to implement Dynamic TDD, wherein each cell in the network can adapt its uplink-downlink ratio depending on the traffic requirement. Prescribing a frame structure with a downlink and uplink configuration could come in way of implementation of dynamic TDD.

2.233 However, in case of multiple service providers environment and spectrum is assigned on LSA basis, possibility of interference on border areas cannot be ruled out. Therefore, there may be a need to synchronize outdoor networks or adjacent frequencies of different TSPs.

2.234 Considering the global trend, 3300-3670 MHz and 24.25-28.5 GHz bands are likely to be used for 5G deployment, and TSPs may like to acquire larger chunk of spectrum in each of these bands. As already recommended that in case a TSP acquires more than one block, the entire spectrum should be assigned in a contiguous manner. Thus, contiguous spectrum assignment will reduce the chances of interference to a large extent. Further, since spectrum is assigned on LSA basis, cross border interference issues could still be there if the overlapping frequency spots have been assigned to different TSPs in neighboring LSAs. This can also be avoided if a TSP is assigned same frequency spots across different LSAs, to the extent possible. Further interference mitigation be left to the mutual coordination between the TSPs.

2.235 In view of the above, **the Authority recommends that to mitigate inter-operator interference in TDD configuration bands, the following measures should be taken:**

a. **In case a TSP acquires more than one block, the entire spectrum should be assigned to it in contiguous form.**

b. **In case a TSP acquires spectrum in more than one LSA, same frequency spots should be assigned to it in all those LSAs, to the extent possible.**

c. **Interference mitigation be left to the mutual coordination between the TSPs.**

F. ROLL-OUT OBLIGATIONS

2.236 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.

(i) Existing bands: 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz bands

2.237 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 should get the required street level coverage.	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.		

2.238 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.

2.239 With this background, stakeholders were asked to give their opinion on 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. In case, they are not appropriate, what changes be made in the roll out obligations for these bands?

Comments received from the stakeholders

2.240 Majority of stakeholders opined that the existing provisions are appropriate and the existing approach which allows fulfilment of rollout obligations using any technology in any band and this approach may be continued.

2.241 Some stakeholders further mentioned that there is no relevance to the concept of rollout obligations for an existing licensee, who has already rolled out its network, as the new spectrum is acquired by it to only augment its network capacity. It has been suggested that for new entrants, roll-out obligations be obligated/mandated and new operators can meet the rollout obligations using the new spectrum bands or through unsold spectrum in other FDD / TDD bands put to auction in the planned auctions.

2.242 One stakeholder submitted that the roll-out obligations may force operators to deploy networks and services faster than economically or commercially sensible to do so which could risk and extensive coverage obligations imposed on all licenses may lead to costly duplication of network infrastructure. Few of the remedies suggested for this includes ‘shared obligations’ on all operators to ensure coverage in rural areas before rolling out to urban areas, or obligations to provide mobile broadband to locations currently lacking access to other forms of broadband, allowing for network and spectrum voluntary sharing, earmarking auction proceeds for to subsidize improved coverage.

2.243 One stakeholder submitted that spectrum leasing would further expand the market by way of more Operators using the licensed spectrum which will strengthen the competition thereby benefitting both the end customer as well as Government. Thus, allowing spectrum leasing would be win-win for all stakeholders.

2.244 One of the stakeholders suggested that the roll out obligations are a relic of the past, must be done away with. However, on expiry of either one year or two, should there be no progress made, let them pay a license fee on notional Adjusted Gross Revenue, which has been prescribed in the Unified License guidelines. That in itself would be a deterrent. It has also been suggested to place a squatting charge for hoarding spectrum or ask to surrender.

Analysis

2.245 All existing TSPs are of the view that no change is required to be made in the roll out obligations. In the forthcoming auction, the existing TSPs may be bidding for spectrum in the existing bands to augment their spectrum holding considering the likely demand. Further, the existing roll out obligations are irrespective of the quantum of spectrum held. In case a new operator enters the market, it should be subjected to similar roll-out obligations to maintain level playing field. However, it is observed that as per the existing roll out obligations applicable for 700 MHz to 1800 MHz bands, 90% of the Metros LSAs are required to be covered in a period of one year. With the changing scenario, the mobile services have transformed from voice centric to data centric. If a new operator enters the market, it is likely to directly deploy the latest technology to fulfil the data centric demand of the customers. Since the Metro LSAs are densely populated, creating new RF infrastructure in metro LSAs to provide a coverage of 90% of the LSA may require more time. Therefore, to facilitate the new entrants in Metro LSAs, the time period to fulfil the minimum roll out obligations may be enhanced to 2 years (40% by the end of 1st year and 90% by the end of 2nd year).

2.246 Further, as per the NIA 2021 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 as per the provisions of NIA for 2021 Auction, are specific to the use of respective bands, which seems to be continuing due to oversight. Therefore, the same needs to be rectified.

2.247 In view of the above, **the Authority recommends that:**

a. **As per the NIA 2021 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 as per the provisions of NIA for 2021 Auction, are specific to the use of respective bands, which seems to be continuing due to oversight. Therefore, DoT should make changes in the roll out obligations for 2100 MHz (Metro LSAs) and 2300/2500 MHz (non-Metro LSAs) to rectify this by removing "using the spectrum in 2100 MHz" and "using 2300/2500 MHz band".**

b. **To facilitate the new entrants, in respect of roll out obligations for 700 MHz, 800 MHz, 900 MHz and 1800 MHz bands, the time period of 1 year for meeting the MRO for Metros LSAs (coverage of 90% of the LSA within one year from the effective date of license or the date of assignment**

of spectrum won in this auction process, whichever is later), should be enhanced to 2 years (40% coverage by the end of 1st year and 90% coverage by the end of 2nd year).

c. **Besides the above, 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 be continued for the forthcoming spectrum auction.**

(ii) New Bands

526-698 MHz

2.248 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.

2.249 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)

2.250 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.

2.251 In this background, stakeholders were asked to give their opinion on associated roll-out obligations for the allocation of spectrum in 526-698 MHz frequency bands and should it be focused to enhance rural coverage.

Comments received from the stakeholders

2.252 One stakeholder opined that the roll-out obligations for spectrum in 526-698 MHz frequency bands should be same as the spectrum in 700 MHz band. However, considering the evolving device eco-system in this band, the Authority may consider giving some additional time to meet minimum roll-out obligations to new TSPs proposing to have stand-alone networks in this band. Whereas, for existing licensees the roll-out obligations met with other bands and technologies will continue to suffice the requirements.

2.253 Another stakeholder opined that since the band plan and other specifics of these bands are yet to be decided, these bands should not be subject to roll out obligations. If the band is auctioned, then it should be left to TSPs to decide the viability of this band rather than enforcing rural coverage objectives. Minimum roll-out obligations met in any band and technology shall be applicable for 5G services as well.

2.254 One of the stakeholders suggested for an incentive-based approach in the 600 MHz band. For example, giving 600 MHz spectrum to operators at a price that recovers the cost of administration but with rollout obligations for them to cover in uneconomic and uncovered areas. Additionally, incentive-based approach could help deploy 600MHz spectrum for the purpose.

2.255 Another stakeholder opined that for the 526-698 MHz bands, it may require considerable time for development of ecosystem. The spectrum in coverage band, that is, 700 MHz band is already lying un-utilized for the last five years. The government should introduce new bands gradually for which the ecosystem is developed, or it is likely to get developed in near future.

2.256 One of the stakeholders suggested that for the lower bands viz. 600 and 700 MHz, there should be obligations for enhancing rural coverage progressively each year. For legacy spectrum bands, Roll-out obligations should be left to the operators depending on their respective business models and plans. However, this may be subjected to boundary conditions of utilization of the spectrum in the given service area within 2 years of allocation, failing which the spectrum would be considered as withdrawn.

2.257 Another stakeholder suggested that that these bands are meant to be used for 5G and therefore, no separate roll out obligation be mandated.

Analysis

2.258 Since propagation characteristics of 600 MHz band are similar to that of 700 MHz band, and both the bands are likely to be used for 5G services, prescribing any rural based rollout obligations may be seen as a deterrent by the potential bidders. Spectrum being technology neutral, it will be appropriate to keep the roll out obligations for 600 MHz band same as that application for 700 MHz band.

2.259 In view of the above, **the Authority recommends that the roll-out obligations and associated conditions for 600 MHz band shall be same as that applicable for 700 MHz band.**

3300-3670 MHz band

2.260 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.

2.261 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 licenses 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.

2.262 With this background, stakeholders were asked to give their opinion on associated roll-out obligations for the allocation of spectrum in 3300-3670 MHz frequency band.

Comments received from the stakeholders

2.263 Many stakeholders were of the opinion that there should not be any roll-out obligations associated with this band. Some of these stakeholders were of the opinion that the present approach of no rollout obligations should be continued if an existing TSP has already met obligations once using any technology in any band. Therefore, there should not be any new or mandatory roll-out obligations in the 3300-3670 MHz band for existing TSPs. For any new entrant, the existing conditions as per NIAs should continue to apply.

2.264 Some of the stakeholders mentioned that the technical characteristics of 3.3-3.67 GHz spectrum band are not conducive for extending the geographical reach due to low in-building penetration and limited coverages. Thus, these are not suitable for extending mobile coverage to uncovered/remote areas. One stakeholder opined that the standards of IMT 2020 are still in the development stage and the maturing of the technology/device ecosystem will take even more time.

2.265 Some of the stakeholders were of the view that for stand-alone operators in the 5G bands of 3300-3670 MHz and 24.25-28.25 GHz spectrum bands, the minimum roll-out obligation compliance requirement can be the same as that of other spectrum bands. However, existing TSPs may take a balanced approach of providing coverage through available spectrum and balancing affordability, traffic demand and business viability. It is also proposed that additional time may be considered to meet MRO to new TSPs proposing to have stand-alone networks in this band.

2.266 One stakeholder mentioned that besides the efficient usage of spectrum for 5G rollout and effective use of spectrum to have a timely widespread deployment of 5G services, it is also essential that the Government of India reviews the feasibility of the MNO's business plans and monitors the implementation of such business plans regularly.

Analysis

2.267 As already mentioned, in 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 losses; therefore, 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.

2.268 Since then, several countries have auctioned spectrum and even commercial launches have taken place. Upon study of the practice adopted in other countries, it is observed that generally, countries have prescribed some rollout obligations for mid-band spectrum - some countries have prescribed coverage based roll out obligations and some have prescribed network deployment based roll out obligations.

2.269 Moreover, the Government has decided that the spectrum will be assigned for a period of 30 years and there is a provision for spectrum trading after 2 years and surrender of spectrum is allowed after 10 years. To ensure that spectrum assigned is put to use at the earliest, it will be prudent to prescribe some roll out obligations which should be realistic and not appear to be a burden on the TSPs.

2.270 The existing TSPs are likely to utilize 3300-3670 MHz band for 5G, initially in NSA mode, using 4G network for core and RAN fallback option, mostly for capacity enhancement requirement or to serve the use cases where ultra-low latency is of prime importance. In other words, this band alone, may not be used for carpet coverage at least in initial period; thus, band specific coverage-based rollout obligations may not be practical. However, nominal network deployment-based rollout obligations should be specified to ensure that the spectrum purchased is put to an efficient use, in a timely manner.

2.271 One way to prescribe number of sites to be deployed in 3300-3670 MHz band is to relate it with the average number of sites deployed for 4G in similar period. However, network roll out of 5G may not be similar to 4G. It may be appropriate to prescribe number of sites to be deployed in a given period as 25% of the number of sites deployed for 4G in similar period. Further, since 3300-3670 MHz band is likely to be used for 5G in India, to maintain level playing field, it will be appropriate that minimum roll-out obligations specified are made applicable for both the existing as well as the new operators. Benefit of 5G should also reach to rural areas targeting economic activities in such areas. Some of the rural SDCAs may also be having economic zones. Therefore, the Authority if of the view that by the end of 5 years, at least 5% of the number of sites to be deployed should be in rural SDCAs (including economic zones).

2.272 The Authority is also of the view that to keep the customers informed, the TSPs should be mandated to publish the network deployment map on their website depicting the areas where the services have been launched using 3300-3670 MHz spectrum band.

2.273 In view of the above, **the Authority recommends that**

a. Band specific minimum roll out obligations for 3300-3670 MHz band for all TSPs i.e., existing as well as the new entrants should be specified as under:

(i) Metros LSAs

Time Period	**Roll Out Obligations**
By the end of 1st year	**Commercial launch of services anywhere in the LSA**
By the end of 3rd Year	**Cumulative number of sites to be deployed: 2800**
By the end of 5th Year	**Cumulative number of sites to be deployed: 4600**

(ii) Non-Metro LSAs

Time Period	**Roll Out Obligations**
By the end of 1st year	**Commercial launch of services in at least 1 city in the LSA**
By the end of 3rd Year	**Cumulative number of sites to be deployed:** **Category A LSAs: 7000** **Category B LSAs: 4600** **Category C LSAs: 2600**
By the end of 5th Year	**Cumulative number of sites to be deployed (at least 5% of the sites to be in rural SDCA, including economic zones):** **Category A LSAs: 10000** **Category B LSAs: 7000** **Category C LSAs: 4700**

b. **To keep the customers informed, the TSPs should be mandated to publish the network deployment map on their website depicting the areas where the services have been launched using 3300-3670 MHz spectrum band.**

c. **Since the Minimum Roll Out Obligations will be equally applicable for all the TSPs i.e., existing as well as the new TSPs, the clause 8.1.4 of the NIA for spectrum auction held in March 2021 on 'Rollout obligation using any technology in any band' shall not be applicable for 3300-3670 MHz band.**

24.25 – 28.5 GHz band

2.274 Frequency range 24.25-28.5 GHz (mmWave) 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.

2.275 With this background, stakeholders were asked to comment on what should be the associated roll-out conditions for the allocation of spectrum in 24.25 to 28.5 GHz frequency range.

Comments received from the stakeholders

2.276 Many stakeholders suggested to continuing with the current approach of prescribing no rollout obligations for a licensee if the licensee has already met these once with any technology. However, for stand-alone operators in the 5G bands of 24.25-28.25 GHz spectrum bands, the MRO compliance requirement can be same as that of other spectrum bands.

2.277 One stakeholder submitted that to adopt technical conditions defined by 3GPP as roll-out conditions. In conjunction with a matter of unwanted emission limit, Resolution 750 (WRC-19) should also be considered for 5G roll-out in India.

2.278 One stakeholder suggested that since mmWave band use will be limited to specific hotspots that require high data rates, roll out obligations be in terms of number of hotspots covered in an LSA.

2.279 Some other stakeholders suggested that no rollout obligations should be associated in mmWave bands. One stakeholder further submitted that propagation characteristics of the band allow TSP for deployment in urban dense areas, and it should be left to the TSP to decide the rollout based on the throughput requirement and business potential in the particular area. Another stakeholder further suggested that technical characteristics of mmWave spectrum bands are not conducive for extending the geographical reach.

Analysis

2.280 As already mentioned, on examination of the practice adopted in other countries, it is observed that generally, certain obligations have been imposed. Further, spectrum will be assigned for a period of 30 years and there is a provision for spectrum trading after 2 years and surrender of spectrum is allowed after 10 years. To ensure that spectrum assigned is put to use at the earliest, it will be prudent to prescribe some roll out obligations which should be realistic and not appear to be a burden on the TSPs.

2.281 mmWave spectrum is typically used for meeting the very high-capacity and ultra low latency requirement. Deployment of mmWave spectrum for IMT is not likely to be ubiquitous as it is likely to be used for creation of hotspots and provision of FWA services. Therefore, prescribing band specific coverage-based rollout obligations may not be appropriate. However, nominal network deployment-based rollout obligations (1/3rd of number of sites required to be deployed for 3300-3670 MHz band) may be specified to ensure that the spectrum purchased is put to an efficient use, in a timely manner. In view of the above, the Authority is of the view that in 24.25-28.5 GHz band, network deployment-based rollout obligations should be 1/3rd of the number of sites required to be deployed for 3300-3670 MHz band.

2.282 Further, since 24.25-28.5 GHz band is likely to be used for 5G in India, to maintain level playing field, it will be appropriate that minimum roll-out obligations specified are made applicable for both the existing as well as the new operators.

2.283 In view of the above, **the Authority recommends that**

a. Band specific minimum roll out obligations for 24.25-28.5 GHz band for all TSPs i.e., existing as well as the new entrants should be specified as under:

(i) Metros LSAs

Time Period	**Roll Out Obligations**
By the end of 1st year	**Commercial launch of services anywhere in the LSA**
By the end of 3rd Year	**Cumulative number of sites to be deployed: 900**
By the end of 5th Year	**Cumulative number of sites to be deployed: 1500**

(ii) Non-Metro LSAs

Time Period	Roll Out Obligations
By the end of 1st year	**Commercial launch of services anywhere in the LSA**
By the end of 3rd Year	**Cumulative number of sites to be deployed:** **Category A LSAs: 2400** **Category B LSAs: 1500** **Category C LSAs: 800**
By the end of 5th Year	**Cumulative number of sites to be deployed** **Category A LSAs: 3300** **Category B LSAs: 2300** **Category C LSAs: 1500**

b. **To keep the customers informed, the TSPs should be mandated to publish the network deployment map on their website depicting the areas where the services have been launched using 24.25-28.5 GHz spectrum band.**

c. **Since the Minimum Roll Out Obligations will be equally applicable for all the TSPs i.e., existing as well as the new TSPs, the clause 8.1.4 of the NIA for spectrum auction held in March 2021 on 'Rollout obligation using any technology in any band' shall not be applicable for 24.25-28.5 GHz band.**

G. ACCOUNTING OF VNOS NETWORK FOR ROLL-OUT OBLIGATIONS

2.284 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."*

2.285 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."*

2.286 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.

2.287 With this background, stakeholders were asked while assessing fulfilment of roll out obligations of a network operator, whether the network elements (such BTS, BSC etc.) created by the attached VNO, be included and in case, to be considered. Stakeholders were also requested to suggest detailed mechanism for the same.

Comments received from the stakeholders

2.288 Majority of operators were of the opinion that the network elements created by attached VNOs be considered whereas a few of them were against the idea for including the networks elements created by the attached VNOs while assessing the fulfilment of rollout obligations.

2.289 The stakeholders who were in favour are of the opinion that since the VNO will be using the same spectrum resources as the network operator to augment or complement the coverage already established by its own network elements, they should be included while assessing the fulfilment of rollout obligations. Roaming arrangements (inter-circle and intra-circle) between operators shall also use the same principles, i.e., Rollout fulfilment of Host network shall also be passed on to the Tenant Network.

2.290 The stakeholders who were averse to the idea have submitted that the roll-out obligations of a licensee are part of the NIA and license conditions and need to be complied with by the successful bidder with or without permissible sharing of infrastructure. Therefore, the network elements installed by its VNO operator are irrelevant to the coverage requirements and should not be considered while assessing the compliance with MRO. Another stakeholder mentioned that since the VNOs are not associated with creation of Digital Infrastructure viz. Core or RAN Networks. They are into delivering services using the Core and RAN networks of the TSPs. Hence the network rollout obligations shall remain the exclusive preserve and obligation of the network operator only.

Analysis

2.291 As mentioned earlier, TRAI gave its Recommendations on 'Enabling Unbundling of Different Layers Through Differential Licensing' in August 2021, wherein it was, inter-alia, recommended that a separate authorization under UL for Access Network Provider to provide network services on wholesale basis. In the said recommendation, it was 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."*

2.292 To realize the envisaged benefit, it is important that while assessing fulfilment of roll out obligations of Access Network provider, the network elements (such BTS, BSC etc.), created by the attached VNO are also included.

2.293 In view of the above, **the Authority recommends that while assessing the fulfilment of roll out obligations of Access Network provider, the network elements (such BTS, BSC etc.), created by the attached VNO(s) should also be included.**

H. SPECTRUM CAP

2.294 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."

526-698 MHz band

2.295 It is clear that the above definition does not include the new bands (526-698 MHz, 3300-3670 MHz and 24.25-28.5 GHz bands), proposed to be included in the forthcoming auction.

2.296 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.

2.297 With this background, stakeholders were asked for their opinion whether there is a need to review the spectrum cap for sub-1 GHz bands, and if so, what should be the spectrum cap for sub-1 GHz bands.

Comments received from the stakeholders

2.298 Some of the stakeholders were of the opinion a combined cap in the Sub-GHz band should be prescribed as 35%.

2.299 One stakeholder suggested that there is no change required for 800 & 900 MHz bands however, for spectrum cap purposes, the spectrum of 600MHz and 700 MHz be clubbed and additionally capped at 2 x 20 MHz to enable rural 5G by at least 4 operators.

2.300 One of the stakeholders mentioned that there are no material changes to indicate any requirement for a change in the spectrum cap in sub-1 GHz bands and existing spectrum cap of 50% of all sub-1 GHz band be continued. It was further suggested that the spectrum in 526-698 MHz, being put to auction for the first time, should also be included in the total spectrum available for the calculation of spectrum cap for sub-1 GHz bands.

2.301 One of the stakeholders suggested that there should be three levels of spectrum caps (a) sub 1 GHz, (b) sub 4 GHz and (c) sub 30 GHz. For each sub-section let there be 35% cap, to prevent hoarding of spectrum by any one TSP.

2.302 One stakeholder mentioned that 50% spectrum cap has become irrelevant due to inclusion of new bands and suggested that an overall cap on all frequency bands in an LSA would be more appropriate. Amount or percentage of the overall spectrum cap be defined so that spectrum can be maximally utilized as well as marked competition is fostered.

2.303 Some stakeholders submitted that the role of spectrum cap is to ensure that spectrum is used optimally and efficiently whilst ensuring competition and choice for the consumers. One of the stakeholders suggested that the spectrum caps should be carefully determined/reviewed so that all operators can deploy networks in a technically and economically efficient manner.

Analysis

2.304 In the past, DoT through its letter dated 29th September 2017 informed the Authority that the Government had constituted an Inter-Ministerial Group (IMG) on “Stress in balance sheet in Select Sectors”. The IMG, among others, reviewed the spectrum cap applicable for Telecom Service Providers (TSPs). IMG, in its report, stated that the issue of spectrum cap merits detailed examination and variety inputs from sectoral regulators and hence, DoT may consider the issue separately. In light of IMG report, DoT requested TRAI to provide its views on whether existing applicable band-wise spectrum cap of 50% of the total spectrum assigned in a band for an LSA and the over-all cap of 25% of the total spectrum assigned in an LSA across all bands should continue or needs review. DoT also requested that in the latter case, TRAI may consider providing new band-wise and overall spectrum cap.

2.305 On 21st November 2017, the Authority finalized its response to DoT after consultation with telecom service providers. In this response, the Authority inter-alia stated that:

> *"the Authority is of the view that the overall spectrum cap should be revised from the current limit of 25% to 35%."*
>
> *"....the Authority is of the opinion that the current intra-band cap should be removed. Instead, there should be a cap of 50% on the combined spectrum holding in the sub-1 GHz bands (700 MHz, 800 MHz and 900 MHz bands)"*.

2.306 Agreeing with the Authority's opinion, DoT made the following amendments to the license provisions on 19th March 2018:

> *"Notwithstanding anything contained in NIA for auctions conducted for award of spectrum in the years 2012, 2013, 2014, 2015 and 2016, the limit of Cap for spectrum holding are hereby revised as detailed below:*
>
> *(a) The overall spectrum cap is revised from the current limit of 25% to 35%.*
> *(b) The current Intra-band cap is removed and a Cap of 50% on the combined spectrum holding in the sub-1 GHz bands (700 MHz, 800 MHz and 900 MHz bands) is applicable.*
> *(c) There shall be no Cap for individual or combined spectrum holding in above 1 GHz band.*
> *......................................"*

2.307 While the issue of spectrum cap was examined by the Authority in November 2017 and DoT has accepted it as recently as March 2018, introduction of new spectrum bands in sub-1 GHz bands triggered this question that whether the existing combined cap for sub-1 GHz bands needs any revision.

2.308 The Authority is of the view that a TSP should be allowed to acquire spectrum to meet its coverage and capacity requirement. Sub-1 GHz bands provide wider and deeper coverage, which could be very useful in enhancing terrestrial mobile coverage, particularly for in-building coverage and rural coverage.

2.309 Overall spectrum cap currently applicable in India is 35%. Therefore, one option is to reduce the spectrum cap for sub-1 GHz bands from 50% to 35%, which was also suggested by some of the stakeholders. In case, only the existing TSPs take part in the auction and spectrum cap of 35% is prescribed (as suggested by some of the stakeholders), auction may not result in a market clearing price for the spectrum. As regards the new bands proposed by DoT in its reference, in the earlier section, the Authority has recommended that in the forthcoming auction, 526-612 MHz band should not be included but 40 MHz (paired) spectrum in 600 MHz band should be included. Thus, 40 MHz (paired) additional spectrum will be getting added in the sub-1 GHz bands. Therefore, the Authority is of the view that the existing cap of 50% for combined spectrum holding in sub-1 GHz bands may be reduced to 40%. The Authority also noted that with the increased spectrum in sub-1 GHz bands due to inclusion of 600 MHz band, even with the reduced cap of 40%, a TSP, if desires, can acquire more than what it could have acquired earlier.

2.310 In view of the above, **the Authority recommends that a Cap of 40% be prescribed on the combined spectrum holding in the sub-1 GHz bands i.e., 600 MHz (APT 600 Option B1), 700 MHz, 800 MHz and 900 MHz bands.**

3300-3670 MHz and 24.25-28.5 GHz bands

2.311 Since 3300-3670 MHz and 24.25-28.5 GHz bands are also proposed to be auctioned, above provisions of spectrum cap needs to be reviewed.

However, 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."*

2.312 Further, DoT has informed that spectrum availability in 3.5 GHz band has gone up by 70 MHz (3300-3670 MHz) and in addition, 24.25 to 28.5 GHz frequency band has been decided to be used for IMT/5G. These 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.

2.313 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 facilitate competition in the 5G segment, deliberations were required on need of intra-band spectrum cap for these bands. 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 3.5 GHz band.

2.314 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[10], 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.

2.315 With this background and keeping in mind the importance of 3300-3670 MHz and 24.25-28.5 GHz bands for 5G, stakeholders were as asked to give their opinion, whether spectrum cap per operator specific to each of these bands be prescribed. If so, what should be the cap?

Comments received from the stakeholders

2.316 Majority of the stakeholders suggested for separate intra-band spectrum caps for these bands.

2.317 A few stakeholders suggested for separate spectrum cap of 35% and mentioned that such a spectrum cap will ensure fair competition and enable both the existing TSPs and any new entrant to have equal chance of obtaining the spectrum in these bands.

2.318 Another stakeholder suggested that keeping a cap of 100 MHz for a 370 MHz auction will lead to quasi-administrative allocation at reserve price. Therefore, a spectrum cap of 50% for these bands is suggested to promote competition. It is worthwhile to note that the quantity of spectrum put to auction, the cost of spectrum, competitive forces propelled by the move to upgrade to 5G will automatically ensure a multi-operator scenario in these bands.

2.319 The other group of stakeholders supporting to auction only 300 MHz spectrum from 3300 MHz to 3600 MHz, mentioned that to avoid a monopoly and create conditions for fair and good competition among available MNOs in India, 80 MHz of spectrum should be the spectrum

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

cap for the band 3300–3600 MHz to accommodate the different terrestrial mobile operators.

2.320 Some stakeholder suggested that in 3300-3670 MHz band, cap of 100 MHz should be prescribed, which will allow at least four TSPs to be competitive and work towards winning the customer through best quality 5G services. In the case of the mmWave band, it should be 30% of the total available spectrum in the band.

2.321 One of the stakeholders suggested a cap of 50 MHz for 3.5 GHz band. Another stakeholder suggested a cap of 150 MHz for 3.5 GHz band

2.322 For 26/28 GHz bands, cap of 800-1200 MHz spectrum cap has been suggested by some of the stakeholders. Two stakeholders suggested a cap of 400 MHz for 24.25-27.5 GHz band to ensure competition in this 5G segment.

2.323 One of the stakeholders suggested for at least 800-1000 MHz contiguous spectrum per operator that in mmWave spectrum It was further submitted that contiguous spectrum blocks should be allocated without splitting them into two bands i.e., n257 and n258.

Analysis

2.324 Spectrum availability in mid band is 370 MHz and in mmWave it is 4.25 GHz. Considering the global trend, these bands are likely to be used for 5G. In case, only the existing TSPs take part in the auction and spectrum cap of 35% is prescribed (as suggested by some of the stakeholders), auction may not result in a market clearing price for the spectrum. Therefore, the Authority is of the view that band-specific (intra-band) spectrum cap should be kept as 40% (rounded off considering the block size in each of these bands) of the total spectrum put to auction. Accordingly, if total spectrum available in these bands is put to auction, the spectrum cap for 3300-3670 MHz band comes to 150 MHz and for 24.25-28.5 GHz, it comes to 1700 MHz.

2.325 In view of the above, **the Authority recommends that for 3300-3670 MHz and 24.25-28.5 GHz bands, band-specific (intra-band) spectrum cap should be kept as 40% (rounded off considering the block size in each of these bands) of the total spectrum put to auction.**

2.326 In addition to the above, shareholders were also asked to give their opinion on (a) whether there should be separate spectrum cap for group of bands comprising of 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands together and if so, suggest the cap; (b) whether overall spectrum cap of 35% requires any change to be made (c) For computation of overall spectrum cap of 35%, whether spectrum in 3300-3670 MHz and 24.25-28.5 GHz bands be included.

Comments received from the stakeholders

Comments on separate cap for 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands

2.327 Some of the stakeholders opined that separate spectrum cap for group of bands comprising of 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands, stakeholders are of the opinion that separate cap is not required and the current overall cap of 35% be continued.

2.328 One of the stakeholders suggested that there is no point in grouping the FDD and TDD bands for spectrum caps, as their characteristic and usage are different altogether. Anyhow, the grouping can be done within the 1800 MHz and 2100 MHz FDD bands with maximum cap of 35% per operator. There is very low inventory left in 2300 MHz TDD band, hence there seems no justifications of grouping 2300 MHz and 2600 MHz band for the want for spectrum cap.

2.329 One stakeholder suggested that overall spectrum cap should be applicable till 2500 MHz band. Another stakeholder opined that there is no significant change in availability or technical and strategic importance of these bands to prompt any new thinking with respect to spectrum cap.

Change in overall spectrum cap of 35%

2.330 Many stakeholders were of the view that there is no need for any change in the overall cap of 35%. One stakeholder mentioned that the overall cap should be applicable till 2500 MHz band. One stakeholder suggested that the available spectrum be distributed equally among the 4 TSPs. If not, then the spectrum cap of 35% should continue separately for each band.

2.331 One of the stakeholders suggested that the telecom markets need fair and farsighted policies to prevent market to go for duopoly and there should be scope for accommodating more players in future.

2.332 One of the stakeholders mentioned that the overall spectrum cap of 35% in an effectively three operator/bidder scenario has become irrelevant. 35% cap is not suitable for promoting competition as this may lead to quasi-administrative allocation in some bands, therefore, it should be 50%.

2.333 Another group of stakeholders suggested that in addition to an overall spectrum cap across multiple bands, in-band spectrum caps be there to avoid a monopoly and create conditions for fair and good competition.

Comments on inclusion of 3300-3670 MHz and 24.25-28.5 GHz bands for computation of overall spectrum cap

2.334 Regarding inclusion of 3300-3670 MHz and 24.25-28.5 GHz bands for computation of overall spectrum cap of 35%, there are different opinions.

2.335 One stakeholder mentioned that for computation of overall spectrum cap of 35%, spectrum in 3300-3670 MHz and 24.25-28.5 GHz bands should not be included.

2.336 Another stakeholder suggested that 3300-3670MHz band can be included, however, 24.25-28.5GHz band should not be included in the cap calculation as it will skew the denominator.

2.337 One stakeholder opined that the spectrum in 3300-3670 MHz and 24.25-28.5 GHz bands should also be included for computation of overall spectrum cap of 35%.

2.338 One stakeholder was of the view that spectrum in 3300-3670 MHz and 24.25-28.5 GHz bands should be included in the overall spectrum cap of 50%.

Analysis

2.339 As regards inclusion of 3300-3670 MHz and 24.25-28.5 GHz bands while computing overall spectrum cap, it is noted that these high frequency bands come with a huge quantum of spectrum and in case these bands are also included for computation of overall spectrum cap, the denominator for computation of spectrum cap will increase to an extent that the overall spectrum cap may lose its relevance.

2.340 It is further noted that for sub-1 GHz bands, a separate combined cap of 40% has been recommended and separate band specific cap has been recommended for 3300-3670 MHz and 24-25-28.5 GHz bands. Therefore, the only bands which are not subjected to a cap by themselves, but are covered under overall cap are 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz. In case 3300-3670 MHz and 24.25-28.5 GHz bands are included for computation of the overall spectrum cap, the bands which are not subjected to a cap by themselves i.e., 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands may be left with no effective cap. Considering that separate combined cap for sub-1 GHz bands and band-specific cap in 3300-3670 MHz and 24.25-28.5 GHz have been recommended, the Authority is of the view that the overall cap is no longer relevant and therefore, may be removed. However, a separate cap for combined spectrum holding in 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands be introduced and the cap be kept same as recommended for 3300-3670 MHz and 24.25-28.5 GHz bands i.e., 40%, for the reasons already discussed.

2.341 In view of the above, **the Authority recommends that the overall cap is no longer relevant and therefore, should be removed. However, a separate Cap on the combined spectrum holding in 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands be introduced and the spectrum cap for this group of bands be kept as 40%.**

I. SURRENDER OF SPECTRUM

2.342 DoT through its letter dated 23rd September 2021 has, inter-alia, communicated the 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.

2.343 In this regard, it is noted that provision for surrender of spectrum has been decided by the Government as part of the Telecom Reforms. 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."*

2.344 Currently, to shed the excess spectrum (if any with the TSP), the only option available to TSP is to sell-out the spectrum through the prescribed spectrum trading process. 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.

2.345 The Government has decided to introduce 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 made in the spectrum surrender framework so that any possible misuse by the licensees, could be avoided.

2.346 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.

2.347 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 rights, some fee may be charged. Another view could be that if a TSP surrenders spectrum, the same spectrum can be put to auction 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.

2.348 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, a provision needs to be created for surrender of existing spectrum holdings obtained through erstwhile auctions, what should be the process and associated terms and conditions.

2.349 With this background, stakeholders were asked to give their opinion about (a) process and associated terms and conditions for permitting surrender of spectrum for future auctions, (b) provisions which may be created in the spectrum surrender framework to avoid any possible misuse by the licensees, (c) counting of eligibility period for surrender of spectrum in case spectrum acquired through trading, (d) provision for surrender of spectrum for the existing spectrum licensees, process and associated terms and conditions, and (e) spectrum surrender fee to be charged from TSPs for surrender of spectrum.

(a) Process and associated terms and conditions for permitting surrender of spectrum for future auctions

2.350 In respect of surrender of spectrum, many stakeholders were of the opinion that surrender of spectrum is a key element of the spectrum reforms announced by the Government and it should be allowed in line with the Cabinet decision and the terms and conditions associated with surrender of spectrum should be kept simple and easy to implement.

2.351 One of the stakeholders suggested that the process of surrendering spectrum be simplified for future auctions. Any TSP who intends to surrender spectrum should be permitted to give a prior notice to DoT along with a processing fee. Subsequently, DoT may process the case of surrendering and issue a confirmatory letter to this effect. While acknowledging the request of surrender of spectrum, DoT may ensure that that TSP has cleared the spectrum deferred payments related to that spectrum only.

2.352 Another stakeholder suggested that the TSPs should give 6 months' notice to surrender the spectrum. The provision of surrender should clearly reflect the amount to be charged for the pro-rata use of spectrum, any payment made by the operator prior to spectrum surrender should be adjusted from the pro-rata value and balance to be paid/ received from the operator. There should not be any liability towards such spectrum post surrender. In case of surrender, for all such spectrum, the pro-rated value of the balance validity of the spectrum on the date of surrender will have to be compared with the dues payable to the Government. If the net sum is negative i.e., the pro-rated value is less than the dues payable then the TSP will be required to pay the net sum to the Government at the time of the surrender. If the net sum is positive, i.e., the pro-rated value is more than the dues payable, then the TSP will have the option of either adjusting it against a) Quarterly License fees/SUCs payable b) Annual spectrum instalments payable on account of past auctions c) Payments for future auctions d) any other payments to be made to the Government.

2.353 Another stakeholder proposed that the surrender of spectrum be made a part of the future NIAs and be applicable only for spectrum acquired post issuance of the policy. The valuation of the surrendered spectrum, lower of the current market price and Net Present Value (NPV) of the price at which spectrum was obtained, will be the surrender value of the spectrum. In case the TSP had opted for upfront payment, it should be refunded the amount basis the surrender value of the spectrum. In case the TSP had opted for deferred payment option, then it should be required to settle balance deferred payment liability post deducting the surrender value of the spectrum.

2.354 Some stakeholders suggested that the spectrum purchase dues for post surrender period should not be levied and excess fee collected if any, should be returned. Another stakeholder suggested that the detailed terms and conditions for permitting surrender of spectrum should be in sync with the current processes and terms as given in the Spectrum Trading guidelines. Some stakeholders suggested that spectrum surrender conditions should be simple, surrender fee should be levied only to cover administrative costs.

2.355 Another stakeholder suggested that the provision of surrender should clearly reflect the amount to be charged for the pro-rata use of spectrum, any payment made by the operator prior to spectrum surrender should be adjusted from the pro-rata value and balance to be paid/ received from the operator. There should not be any liability towards such spectrum post surrender.

2.356 One of the stakeholders has submitted that TSP will surrender the spectrum when there is no ecosystem or further migration path or not able to roll out the network. Surrender of spectrum should be allowed after 2 years of spectrum allocation without any fee or penalty.

Analysis

2.357 The Authority noted that creation of provision for surrender of spectrum was announced as part of the Telecom Reforms in September 2021. DoT, in its reference, had mentioned the following:

"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".

2.358 Some of the stakeholders have submitted that in case spectrum acquisition charges for the post surrender period is paid by the TSPs, the same should be returned or adjusted. The Authority notes that the spirit of the decision is to ensure that unlike in the past auctions, TSPs (buyers) surrendering the spectrum are not liable for the payment of spectrum acquisition charges for the post surrender period if they opt to surrender the spectrum with due notice. At the same time, the Authority would advise the Government to legally examine and decide the issue with regard to the interest or principal paid for the post-surrender period. Therefore, **the Authority recommends that in respect of surrender of spectrum, DoT should take an appropriate decision with regard to the issue of interest or principal paid for the post surrender period and accordingly include the decision in the guidelines for surrender of spectrum so that the TSPs can take an informed decision.**

2.359 The Authority feels that to achieve the purpose of this provision, the spectrum surrender conditions should be simple and transparent. The process with defined timelines should be clearly prescribed and be implemented through an online portal-based system. Accordingly, DoT may come out with "Guidelines for Surrender of Spectrum" prescribing a simple, transparent and time bound online process.

2.360 As per the decision of the Government conveyed by DoT, a TSP is permitted to surrender its spectrum (fully or partially) after a minimum period of 10 year and one-year prior notice is required. Hence, it is apparent that a TSP should make a request for surrender of spectrum at least 12 months prior to the proposed date of surrender. As the TSP will make a request for surrender of spectrum at least 12 months prior to the proposed date of surrender, DoT should convey in-principle approval or otherwise within a period of sixty days from the date of application. Further, outstanding spectrum payment, if any, in respect of proposed quantity of spectrum being surrendered, till the proposed date of surrender, may also be communicated to the TSP along with the in-principle approval. Other payments/dues should not be linked to surrender of spectrum. Within a period of three months from date of demand raised by the DoT, the TSP has to clear the dues so communicated. Upon receipt of payment, the final approval to surrender of spectrum w.e.f. from proposed date of surrender may be communicated to the TSP within 15 days thereafter. On the proposed date of surrender of spectrum, the TSP should submit a letter to DoT certifying that the surrendered spectrum has been vacated and no longer in use.

2.361 DoT should put to auction the surrendered spectrum immediately, once the final approval to surrender of spectrum (upon receipt of outstanding dues payment up to the proposed date of surrender) is issued.

2.362 In view of above, **the Authority recommends the following for formulating 'Guidelines for Surrender of Spectrum':**

a. **DoT should come out with "Guidelines for Surrender of Spectrum". The spectrum surrender conditions should be simple and transparent. The process with defined timelines should be clearly specified and be implemented through an online portal-based system.**
b. **A Telecom Service Provider should be permitted to surrender spectrum after a minimum period of 10 (ten) years from the date of acquisition of spectrum by the TSP through the auctions conducted henceforth.**

c. **TSP should make a request for surrender of spectrum at least 12 months prior to the proposed date of surrender.**
d. **DoT should convey in-principle approval or otherwise within a period of sixty days from the date of application for surrender of spectrum.**
e. **Outstanding spectrum payment till the proposed date of surrender, if any, in respect of proposed quantity of spectrum being surrendered, should be communicated to the TSP along with the in-principle approval.**
f. **Other payments/dues should not be linked to surrender of the spectrum under consideration.**
g. **Within a period of three months from date of demand raised by DoT, the TSP shall clear the dues so communicated by DoT.**
h. **Upon clearance of dues, the final approval to the surrender of spectrum, effective from proposed date of surrender, should be communicated by DoT to the TSP within 15 days.**
i. **On the proposed date of surrender of spectrum, the TSP should submit a declaration to DoT that the surrendered spectrum has been vacated and is no longer in use.**
j. **DoT should put to auction the surrendered spectrum immediately, once the final approval to surrender of spectrum (upon clearance of dues up to the proposed date of surrender) is issued.**

(b) Provisions in spectrum surrender framework to avoid any possible misuse by the licensees

2.363 Regarding the provisions in spectrum framework to avoid any possible misuse by the licensees, one stakeholder mentioned that the spectrum can only be acquired by a licensee and the provision for minimum spectrum tenure of 10 years with one-year prior intimation seems to be enough to discourage any possible misuse. Therefore, no further provisions are required to be created to safeguard the spectrum surrender framework.

2.364 Another stakeholder mentioned that the valuation of the spectrum to be surrendered should be done basis the current market price of the said spectrum. As the Government has decided to hold annual auction of all available spectrum, the surrendered spectrum should be made part of the next upcoming auction. The valuation of the surrendered spectrum should be lower of the current market price and Net Present Value (NPV) of the price at which spectrum was obtained, to protect Government revenue as well as prevent speculative behavior. If there is excess demand for such spectrum, the TSP can opt for spectrum trading to get higher valuation.

2.365 One stakeholder mentioned that significant amount of the investments is made by the operator, specifically while rolling out the new technology in the initial years post spectrum acquisition, while the cash generation takes time. Considering the above factors, in case an operator is willing to surrender the spectrum after a period of 10 years, it would imply that such operator doesn't see any value generation from spectrum even after a period of 10 years.

Analysis

2.366 The Authority is of the view that there could be many reasons for a TSP to go for surrender of spectrum. One of the reasons due to which a TSP could go for surrender of spectrum (fully or partially) can be the scenario where the TSP is not in a position to utilize such spectrum effectively and efficiently. However, there may be a situation in future where the provision of surrender may provide an advantage or arbitrage due to price differential of the same spectrum in future auctions. There may be a possibility that the TSP who has just surrendered the spectrum can again go for the same spectrum in next auction. The Authority feels that such speculative behavior may be avoided through certain restrictions. One of the conditions may be that if a TSP surrenders partial or complete spectrum in a band, it may be barred to take part in the auction of spectrum in that band for a period of 2 years from date of surrender. Another condition may be that if a TSP has acquired some spectrum in a band, a lock-in period of 2 years may be applied, before surrendering the qualifying spectrum in that band acquired earlier.

2.367 In view of above, **the Authority recommends that the following conditions may be included in the 'Guidelines for Surrender of Spectrum':**

a. **In case, a TSP surrenders partial or complete spectrum in a band, it will be barred to take part in the auction of spectrum in that band for a period of 2 years from date of surrender of spectrum.**
b. **In case, a TSP has acquired some spectrum in a band, a lock-in period of 2 years will be applicable, before surrendering the qualifying spectrum in that band acquired earlier.**

(c) Counting of eligibility period for surrender of spectrum in case spectrum acquired through trading

2.368 Regarding counting of eligibility period for surrender of spectrum in case spectrum acquired through trading, many stakeholders suggested that it should be counted from date of assignment of spectrum to the TSP who was first assigned its right to use. In its support, couple of stakeholders have mentioned that in case of surrendering of traded spectrum, there is no loss to the exchequer in terms of revenue and also the validity period of the spectrum remains the same.

2.369 Another stakeholder suggested that the period should be counted from the date of acquisition of spectrum by the current lessee through the process of spectrum trading, as the spectrum allocation validity is also from the date of spectrum allocation.

2.370 One stakeholder proposed that the present 2 years lock-in from the date of acquisition through spectrum trading for further trading can be extended for surrender of spectrum in addition to this 10 year lock-in. Such lock-in will discourage the speculative behavior. Another stakeholder has suggested that the surrender of spectrum should be allowed after 5 years from the date of acquisition through trading.

Analysis

2.371 The Authority has examined the comments of the stakeholders. The Authority has also examined the decision of the Government to permit the surrender of spectrum after a minimum period of ten (10) years. The Authority feels that the TSPs have been given a time period of 10 years from date of acquisition to become eligible for surrendering the spectrum. Moreover, the spectrum purchase decisions are made by the TSPs after duly considering its long terms utilization and exploring other available options. Therefore, spectrum acquired through auction or trading should be treated at par in the hands of the acquirer and the period of ten years should be counted from the date of acquisition of spectrum, whether acquired directly through auction or through trading. Therefore, the Authority is of the view that TSP should be permitted to surrender the spectrum after a minimum period of 10 (ten) years from the date of acquisition of spectrum whether acquired through auction, trading or any other permitted means of acquisition.

2.372 In view of above, **the Authority recommends that a TSP should be permitted to surrender the spectrum after a minimum period of 10 (ten) years from the date of acquisition of spectrum by the TSP whether acquired through auction, trading or any other permitted means of acquisition.**

(d) Provision for surrender of spectrum for the existing spectrum licensees, process and associated terms and conditions

2.373 In their responses, a few stakeholders are of the view that provision for surrender of spectrum may be created for the existing spectrum holdings also, whereas couple of other stakeholders are against this idea.

2.374 The stakeholders who are in favour of the idea have submitted that TSPs should be allowed to surrender existing spectrum and the modalities of this surrender should be the same as those for the forthcoming auctions except that the time period should be 6 years, that is, 33% of 20 year period, in line with 33% of 30 year period for forthcoming auctions, from date of allotment of spectrum. Couple of other stakeholders in its support have mentioned that the same principle as applicable to forthcoming spectrum auction for surrender of spectrum should be applied on the existing spectrum holding of the TSPs. This would ensure level playing field for both old and new players as well as uniform spectrum policy for all spectrum holding through auction.

2.375 One of the stakeholders against the idea, submitted that spectrum surrender policy should not be extended to spectrum acquired by TSPs in the past, as this would be akin to changing conditions for the TSPs post spectrum acquisition. These conditions, if known earlier, would have influenced the strategy employed by the particular TSP. Hence, there should not be any policy to allow surrender of spectrum acquired in past auctions or existing spectrum held by TSPs. However, to ensure better utilization of existing spectrum, TSPs be allowed to exchange their existing spectrum with unsold spectrum in past auctions or new spectrum in upcoming auctions. For example, one TSP may like to switch some part of its 1800 MHz spectrum holdings with the 800/900 MHz spectrum band available with the Government based on its business requirements while being revenue neutral. This can be done by paying the difference in amount, which can be calculated based on the last auction determined price.

2.376 Another stakeholder against the idea, mentioned that the past spectrum should be kept out of the policy for surrender of spectrum so that the sanctity of past auction should be maintained. This is even more important as the Government is desirous of reducing the litigation burden on the sector and any such misstep would open a pandora box of new litigations.

Analysis

2.377 The Authority has examined the comments of the stakeholders. The Authority has also noted the decision of the Government that the provision for surrender of spectrum will be applicable for the auctions conducted henceforth. Two views are emerging on examination of the issue. One view could be to have level playing field and accordingly the provision for surrender of spectrum may also be made available for the existing spectrum holding of the TSPs acquired through past auctions. Another view could be that the NIA for the earlier auctions did not contain such provision and changing NIA conditions post auction may not stand scrutiny of the law. However, it is a matter to be explored whether such change in existing conditions will be adversely affecting one or more players or it will be having a positive effect on all players alike.

2.378 Therefore, the Authority is of the view that DoT may examine the possibility for creation of provision for surrender of spectrum for the existing liberalized spectrum holding of the TSPs acquired through past auctions.

2.379 In view of above, **the Authority recommends that DoT may appropriately examine the possibility for creation of provision for surrender of spectrum for the existing spectrum holding of the TSPs acquired through past auctions.**

(e) Spectrum surrender fee to be charged from TSPs for surrender of spectrum

2.380 Some stakeholders suggested that the spectrum surrender fee be charged only to the extent of recovering administrative costs. One stakeholder proposed that as for any license, an application processing fee of INR 50,000 is charged by DoT, the same amount could be charged as a spectrum surrender fee.

2.381 Another stakeholder submitted that the compensation for surrender of spectrum would be dependent on market value of the spectrum and would be always lower than the amount paid for the spectrum, there is no need of a deterrent surrender fee, however, the TSPs should be required to pay a processing fee of 1% of the balance spectrum value, as being done in case of spectrum trading.

2.382 Some stakeholders suggested that no surrender fee should be charged from the TSPs while surrendering spectrum. In its support, one stakeholder mentioned that the government has already received the pro rata payments for the utilization of the spectrum from the operator and charging any surrender fee may act as an inhibitor for the operator to surrender the spectrum. Some stakeholders mentioned that 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.

2.383 One stakeholder suggested that the spectrum surrender conditions should be simple, without penalty and TSP should have paid all outstanding dues until the time of surrender. Another stakeholder submitted that sometimes, surrender of spectrum become inevitable in case ecosystem in the particular band is not getting developed. In such a scenario, the fee to be charged from the TSP, if any, should be minimal.

Analysis

2.384 As noted earlier, there could be many reasons for a TSP to go for surrender of spectrum. One such reason, due to which a TSP could go for surrender of spectrum (fully or partially), can be the scenario where the TSP is not in a position to utilize such spectrum effectively and efficiently. If a TSP is not in a position to utilize and monetize the spectrum then only it will go for surrender of spectrum. It is a provision which the Government has decided to introduce in order to encourage better utilization of spectrum and to encourage business. The Government has also decided that the spectrum purchase dues for the remaining (post surrender) period will not be levied. Further, the Government can always put to auction the spectrum proposed to be surrendered in the notice period itself.

2.385 Therefore, the Authority is of the view that surrender fee should not be kept high to make the provision ineffective. It should be a kind of administrative fee for the purpose of processing of surrender application. An amount of Rs. 1 lakh (Rs. One lakh) per spectrum band per LSA may be kept as surrender fee.

2.386 In view of above, **the Authority recommends that surrender fee should not be kept high to make the provision ineffective. It should be a kind of administrative fee for the purpose of processing of surrender application. Surrender fee may be kept as Rs. 1,00,000 (Rupee One lakh) per spectrum band per LSA.**

J. OTHER RELATED ISSUES

2.387 During the consultation process, there are other issues which were either raised by the stakeholders or are required to be considered in view of comments made by them. These issues are discussed below:

a. Inclusion of 5G Technology in the Notice Inviting Applications (NIA)

2.388 The technology section under the NIA defines the technologies for which the spectrum can be used for. Technology section of the NIA (Section 2.3) for the auction of spectrum in different bands conduced in March 2021 is reproduced below:

"*Spectrum blocks in the liberalized spectrum or acquired through auction(s) may be combined if required by technology and there are no restrictions on the technology to be deployed for providing services within the scope of the service license, provided it is compatible with technology(ies) already deployed in the LSA. The successful bidder shall provide details of the technology proposed to be deployed for operation of its services using spectrum block assigned through this auction within one month of obtaining the license, if the technology happens to be GSM/WCDMA/LTE/CDMA. In case of switching over to a different technology (other than GSM/WCDMA/LTE/CDMA), while rolling out the networks for compliance of roll out obligations, information regarding the new technology should be given at least six months before any new technology Base Station site is offered for testing. The technology should be based on standards approved by ITU/TEC or any other International Standards Organization/ bodies/ Industry.*

Existing Licensees will be allowed to use the additional spectrum block(s) assigned through this auction to deploy any technology other than GSM/CDMA, by combining with their existing spectrum holding in the same band after converting their entire administratively *assigned spectrum into liberalised spectrum in the same band. Existing CMTS/ UASL/UL with access service authorisation licensees can liberalise their administratively assigned spectrum in 1800 MHz/900 MHz / 800 MHz bands for the balance validity period of spectrum assignment as per the Guidelines prescribed from time to time.*

In case of a change of technology, by the licensee following must be ensured:

g) *Continuity of coverage, provisioning, delivery, quality of services in the network deployed with earlier technology. For withdrawal of service, the conditions prescribed in the respective Service License are to be followed. Further, the quality of service (QoS) is governed by the respective TRAI regulations. In this regard, conditions mentioned in the Unified License including its amendment dated 24.01.19 has to be complied.*

h) *Licensee will be required to submit the test reports as per test schedule/ procedure to the licensor who may also carry out sample verification.*

i) *For use of technology other than GSM, CDMA, WCDMA and LTE, prior clearance will be required to ensure that harmful interference is not caused to the already operating technologies either in the same band or in the adjacent bands.*"

2.389 As can be seen from the above, the technologies mentioned in the NIA, for which the spectrum can be used, are GSM/WCDMA/LTE/CDMA technologies. For any other/new technology, is required to be given at least six months before any new technology Base Station site is offered for testing and the technology is required to be based on standards approved by ITU/TEC or any other International Standards Organization/ bodies/ Industry.

2.390 Further, in case of a change of technology, by the licensees for use of technology other than GSM, CDMA, WCDMA and LTE, prior clearance will be required to ensure that harmful interference is not caused to the already operating technologies either in the same band or in the adjacent bands.

2.391 5G technology is well tested and is already implemented in various countries, and 5G Technology trials are already undergoing in India after the issue of trial licenses in the spectrum bands which are under consideration for auction. Further, as communicated by DoT in its reference, the forthcoming auction is for International Mobile Telecommunications / 5G. Therefore, the Authority is of the view that 5G technology should also be included alongside the other technologies and suitable provisions need to be created.

2.392 Thus, in view of the above, **the Authority recommends that to enable an early launch of 5G services, Section 2.3 of the NIA of 2021, pertaining to the technology to be deployed, should be suitably modified to include IMT-2020 (5G technology) along with the other already mentioned technologies.**

b. Rationalization of SACFA Fee

2.393 The DoT issues Standing Advisory Committee on Radio Frequency Allocations (SACFA) clearances for fixed wireless stations. In the TRAI's Recommendations to the Department of Telecommunications on 'Ease of Doing Telecom Business', dated 30th November 2017[11], while recommending for Standing Advisory Committee on Frequency Allocation (SACFA) Clearance, it was recommended that '*the entire process of SACFA clearance as well as grant of all licences/approvals, that are issued by WPC, should be made paper-less and executed end-*

[11] https://www.trai.gov.in/sites/default/files/Recommendations_EDB_30112017.pdf

to-end through an online portal. Upon successful implementation of online portal, DoT may also review the SACFA fee being levied upon the TSPs.'

2.394 The process for SACFA clearance has been made online through 'SaralSanchar Portal'. However, it is observed that the processing fee of Rs.1000/- per sight is charged. Approximately 35,000 applications are received for SACFA clearance every month[12]. The technical evaluation is done primarily for Aviation hazards, Obstruction to the line of site of existing/planned networks, and Interference (Electro-Magnetic Interference/Electro Magnetic Compatibility) to existing and proposed networks.

2.395 Further, recently as announced in the new telecom reforms dated 15th September 2021, SACFA clearance for telecom towers will be eased, and DoT will accept data on a portal based on self-declaration basis. In this effect, DoT on 06th October issued procedure for simplification of SACFA clearance process of installing towers[13] through self-declaration / automated time bound approvals on SaralSanchar Portal of DoT. While this is a welcoming reform and is likely to fasten the 5G deployment process. It is equally important to review the need for SACFA fee and the amount of SACFA fee.

2.396 It is also to note that during the implementation of 5G, the number of sites/small cells that are likely to be deployed will be large in number.

2.397 In view of above, **the Authority reiterates its recommendation made in 'Ease of Doing Telecom Business', dated 30th November 2017, that Department of Telecommunications should review the SACFA fee being levied upon the TSPs / other agencies.**

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[12] https://www.trai.gov.in/sites/default/files/CP_08122021.pdf

[13] https://dot.gov.in/sites/default/files/Telecom%20Reforms%202021-booklet%20combined%20as%20on%2003112021_0.pdf

c. Rationalizing of prescribed fee for testing of roll-out obligations

2.398 Spectrum assignment comes with minimum roll-out obligations and the TSPs are required to fulfil the same within the prescribed timelines and offer the sites to Telecom Enforcement, Resource and Monitoring (TERM) Cells for testing of the same.

2.399 For the testing of Rollout obligations, DoT issued revised procedure on 8th August 2016[14]. According to this procedure, the licensee is required to register with the respective TERM Cell of DoT for confirming for the compliance to the prescribed rollout obligations by submitting the prescribed fee. While registering, the Licensee required to submit a self-certification for fulfilment of roll-out obligations in an LSA along with self-conducted test results as per prescribed Test Schedule test Procedure usage (TSTP) and prescribed fee. The details along with the proof of DHQ/BHQ/SDCA covered by use of any technology in any band by a licensee shall also be provided while registering with TERM Cell/LSA Units. The TERM Cells would then carry out sample testing of 10% of such self-certified DHQs/BHQs/SDCAs.

2.400 As seen from above, while the TERM Cells do a sample test of 10% of the self-certified sites, the fee is levied for all the sites offered for testing.

2.401 In this regard, TRAI in its earlier recommendations on 'Ease of Doing Telecom Business' of 2017, *inter-alia*, made recommendation that the TSPs should be charged for roll-out obligations test fee only for the DHQs/ BHQs/ SDCAs which are actually tested by TERM Cells. However, this recommendation is still pending with the DoT.

2.402 To facilitate competition and encourage new entrants in the telecom sector, the Authority is of the view that the above recommendation requires an early decision. Therefore, **the Authority reiterates its recommendation made in 'Ease of Doing Telecom Business', dated**

[14] https://dot.gov.in/sites/default/files/2016_08_22%20TERM-AS-IV.pdf?download=1

30th November 2017, that the testing fee should be charged only for the sites which are actually tested by LSA unit instead for all sites which are offered for testing.

d. Norms on Electromagnetic Field exposure by BTS (Base Stations)

2.403 During the Consultation Process, some of the stakeholders have made the following submissions in respect of EMF norms:

- The norms for exposure limit for the Radio Frequency Field (Base Station Emissions) were made stringent and reduced to 1/10th of the limits prescribed by ICNIRP at the time when most of the towers were of 2G and 3G technology. While prevailing stringent EMF norms might have been implementable for 2G and 3G technologies, the same will not be feasible with 5G and beyond technologies, as these technologies will be primarily deployed in higher spectrum frequencies of C-Band and mmWave band. There is need to align the emission norms with ICNIRP guidelines as 5G will be characterized using spectrum in higher bands with bigger channel bandwidth with consequent reduction in cell site coverage.
- This issue also has been acknowledged by the committee formed by DoT on “Regulatory Policy for 5G India 2020”. Thus, it is imperative that decisive actions are taken on this aspect prior to auction of spectrum so that the bidders can make an informed choice as the roll-out costs with current EMF norms may be very high and become a deciding factor in spectrum uptake. The human-exposure requirements in India be revised and aligned with the ICNIRP requirements to ensure smooth 5G rollout and make deployments practically feasible.

2.404 In view of the above, the Authority is of the view that DoT may appropriately examine the issues raised by the stakeholders.

e. Issues relating to Backhaul Spectrum

2.405 Mobile broadband services require a quantum increase in the capacity of mobile access as well as backhaul network. The access technologies have evolved over a period which has resulted in better use of access spectrum in terms of improved spectral efficiencies and increased capacity. Many additional access spectrum bands have been opened up for IMT. However, the higher data carrying capacity of access technologies can be effective in providing mobile broadband services to the customers only if these are complemented by an equally supportive and capable backhauls.

2.406 To achieve this, the increase in radio resources must be accompanied and supported by an equally strong backhaul. Without strengthening the backhaul the full potential of RAN cannot be exploited. Fiber is often considered the most suitable type of backhaul medium due to its longevity, high capacity, high reliability, and ability to support very high-capacity traffic. However, fibre backhaul at present is not up to the mark and as of May 2021, on an average about 35% BTSs were fiberized.

2.407 While availability of access service is very important, adequate backhaul capacity is equally important. Since, in India, fiberization is still on a lower side and microwave (wireless) backhauls are the solution and in 5G technology, backhauls with high bandwidth carrying capacities will be required.

2.408 TRAI made its recommendations on 'Allocation and Pricing of Microwave Access (MWA) and Microwave Backbone (MWB) RF carriers', dated 29th August 2014. These recommendations inter-alia, included recommendations on opening up of high capacity backhaul E-band (71-76 / 81-86 GHz) and V-band (57-64MHz). DoT in the reference-back to TRAI dated 14th October 2021 on "Reforming the Guidelines for Transfer/Merger of Telecom Licenses", has mentioned that TRAI's recommendations on 'Allocation and Pricing of Microwave Access (MWA) and Microwave Backbone (MWB) RF carriers', dated 29th August 2014 is under consideration.

2.409 During the consultation process, some of the stakeholders raised the issue of backhaul spectrum. One of the stakeholders mentioned that E&V bands can address the backhaul challenges which will get multiplied with the 5G services and have suggested that E&V bands to be sold as part of the coming auction. Two stakeholders proposed that the E&V bands should be auctioned, bundled with the access spectrum in mid-band. While another stakeholder suggested for auction of backhaul spectrum, especially in high-capacity bands for TSPs so that the industry can meet the demands of exponentially growing traffic and transition towards 5G.

2.410 One of the stakeholders further commented that spectrum in E-Band and V-Band can also play a very critical role in this aspect, owing to its use case of integrated Access Backhaul and wireless to home network. All spectrum identified for Access and/or microwave Backhaul and/or E&V bands for providing communication services, irrespective of the technology or medium i.e., terrestrial or satellite, be allocated only through the auction methodology.

2.411 In view of the above, the Authority is of the view that DoT may appropriately examine the issues raised by the stakeholders.

f. Decision on other TRAI's Recommendations by DoT

(i) Recommendation on Enhancement of Scope of Infrastructure Providers Category-I (IP-I) Registration:

2.412 Currently, the Infrastructure Providers are permitted to provide only passive infrastructure such as Dark fiber, duct space and tower to licensed service providers. To boost investment in sector and encourage sharing of active infrastructure, there was need to enhance the scope of Infrastructure Providers (IP) and allow them to own, establish, maintain, and work active infrastructure also.

2.413 To increase the sharing and efficient utilisation of active telecom infrastructure such as Radio Access Network, Wireline Access Network, and Transmission systems, TRAI had made Recommendations on 'Enhancement of Scope of Infrastructure Providers Category-I (IP-I) Registration' on 13^{th} March 2020.

2.414 The decision on these recommendations is required which will help in faster rollout of 5G networks and fixed line broadband services. It would also increase fiberisation, reduce the cost of telecom infrastructure, increase competition in provisioning of services, attract investment in the sector, and increase affordability of services in rural and remote areas.

2.415 In view of the above, **the Authority is of the view that the Department of Telecommunications should take the decision on the recommendations made in 'Enhancement of Scope of Infrastructure Providers Category-I (IP-I) Registration', dated 13^{th} March 2020 at the earliest.**

(ii) Recommendation on Roadmap to Promote Broadband Connectivity and Enhanced Broadband Speed

2.416 Broadband is a basic infrastructure essential for improving the socio-economic development. For developing countries, such as India, broadband is a key driver of economic growth. Proliferation of high-speed broadband across the country requires fiberisation and densification of networks. Investing in the expansion of broadband is becoming more and more vital just to make sure that everyone is connected. Accordingly, to achieve these objectives, TRAI made recommendation on 'Roadmap to Promote Broadband Connectivity and Enhanced Broadband Speed' on 31.08.2021 which inter-alia included recommendations related to a roadmap to the Government for infrastructure creation, fiberisation and densification of networks, and proliferation of high-speed broadband services in the country.

2.417 In these recommendations, to reflect the importance of broadband, minimum download speed of 2 Mbps was defined, and further categories of fixed broadband has been defined based on speed, which are 'Basic Broadband' (2-50 Mbps), 'Fast Broadband' (50-300 Mbps), and 'Superfast Broadband' (300 Mbps and above).

2.418 Regarding Right of Way (RoW) permissions which are required by all types of utility service providers, recommendations were made for National RoW Policy and for streamlining RoW permission framework. These recommendations are crucial for building robust telecom infrastructure.

2.419 Access to secure, reliable, and affordable high-speed broadband services is a clear and urgent priority for every Indian citizen. Proliferation of high-speed broadband across the country requires fiberization and densification of networks. Further, for the faster rollout of 5G networks and fixed line broadband services, fiberization is prerequisite. Faster RoW permissions at reasonable cost will reduce the cost of telecom infrastructure, increase competition in provisioning of services, attract investment in the sector, and increase affordability of services in rural and remote areas.

2.420 Therefore, finalization of recommendation is required for faster rollout of 5G networks and fixed line broadband services.

2.421 In view of the above, **the Authority is of the view that the Department of Telecommunications may take the decision on the recommendations made in 'Roadmap to Promote Broadband Connectivity and Enhanced Broadband Speed' dated on**

31.08.2021 at the earliest for faster rollout of 5G networks and fixed line broadband services.

CHAPTER-III: VALUATION AND RESERVE PRICE OF SPECTRUM

A. INTRODUCTION

3.1 The Authority has, over the years, been acutely conscious of the need for rational valuation and pricing of the precious spectrum resource to enable the orderly growth of the telecom sector. As has also been recognized in the Consultation Paper of 30.11.2021, 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.

3.2 The decisive turn to auction as the preferred mode of alienation of spectrum can be traced to the judgment of the Hon'ble Supreme Court of 02.02.2012 in *CPIL and Others* v. *UoI and Others* [(2012) 3 SCC][15] (often referred to as the *2G Case*), where the Apex Court had, *inter alia*, held that:

a. "…the doctrine of equality…regulates the rights and obligations of the State vis-à-vis its people and demands that the people be granted equitable access to natural resources and/or its products and that they are adequately compensated for the transfer of the resource to the private domain…";

b. "…the State is the legal owner of the natural resources as a trustee of the people, and although it is empowered to distribute the same, the process of distribution must be guided by the constitutional principles including the doctrine of equality and larger public good";

c. "…wherever a contract is to be awarded or a licence is to be given, the public authority must adopt a transparent and fair method

[15] It was further held in *Natural Resources Allocation In Re: Special Reference [(2012) 10 SCC]* that, *inter alia*, "…spectrum, which according to the law declared in the *2G case*, is to be alienated only by auction and no other method".

for making selections so that all eligible persons get a fair opportunity of competition";

d. "…In other words, while transferring or alienating the natural resources, the State is duty-bound to adopt the method of auction by giving wide publicity so that all eligible persons can participate in the process".

3.3 As early as in its *Recommendations on Auction of Spectrum* of 23.04.2012, the Authority had recognized that the key objectives for auction are (a) Government can augment its resources but the objective should be to serve public cause and public good by adopting fair and reasonable methods, (b) transfer of resource to private domain must be adequately compensated, and (c) efficient utilization of spectrum should be promoted.

3.4 In its later *Recommendations on Valuation and Reserve Price of Spectrum* of 09.09.2013, the Authority listed out the different factors that influence the valuation of spectrum, including its limited availability, rivalrousness and excludability, demand-side factors, the need for allocative efficiency, and the larger macro-economic factors at the country level. In these recommendations, the Authority also cautioned that the valuation of spectrum is difficult and not infallible, also since valuing spectrum and setting reserve prices is part science and part art.

3.5 The Authority continues to abide by the view that spectrum valuation should be based on clear and cogent reasoning, transparency, logic and scientific method. The importance of the present context has to be suitably factored in, such as the current status of spectrum demand and supply, and the structural and process reforms in the telecom sector unveiled by the Government in September, 2021, that are expected to protect and generate employment opportunities, promote healthy competition, protect interests of consumers, infuse liquidity, encourage investment and reduce the regulatory burden on telecom service providers. The Authority is cognizant that the value of spectrum changes over time based on a number of techno-economic factors.

3.6 The present Chapter deals with both the distinct stages of the exercise: spectrum valuation and the setting of the reserve prices for the different spectrum bands under consideration. It has been the practice of the Authority to conduct the valuation exercise to arrive at LSA-wise numbers for each spectrum band. In the present consultation process too, the methodologies and approaches used for spectrum valuation have been disclosed to facilitate feedback from stakeholders. The framework and related assumptions of the modelling techniques employed in the present valuation exercise, the process by which reserve prices are derived from the valuation, and the rationale for the associated conditions being recommended have also been elaborated in the later sections of this Chapter.

B. VALUATION OF SPECTRUM IN THE CONTEXT OF RECENT REFORMS

(1) Increase in duration of spectrum allocation

3.7 DoT, in its letter of 23.09.2021 (Annexure 1.2 of the Consultation Paper), indicated, *inter* alia, that:

> 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.

3.8 One of the other decisions conveyed in the above DoT letter, i.e., provisions for surrender of spectrum after a minimum period of 10 years, with a provision for a surrender fee and a further provision that "the spectrum purchase dues for the remaining (post surrender) period will not be levied" also has a bearing on the increase in duration of spectrum.

3.9 To elicit stakeholder feedback on the issue of increase in duration of spectrum allocation in future auctions, the following question was raised in the Consultation Paper (CP):

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.

3.10 In response, some stakeholders stated that since the reform package is one of the measures to infuse liquidity and encourage investment in the telecom sector, thereby providing financial relief to the sector, it should not be seen from the perspective of linear correlation with the spectrum valuation.

3.11 Another stakeholder said that since the spectrum for period of 30 years will be sold by auction, market forces will determine the correct spectrum valuation based solely on demand and supply constraints.

3.12 One other stakeholder stated that TSPs should be given both the options – either to opt for a 20 year or a 30 year duration, and accordingly the valuation should be extrapolated with appropriate indexing.

3.13 Another view that was brought out by a stakeholder in the consultation process is that in the event that net revenue realization is the same over the 30 years as was the case over the earlier 20 years, nevertheless to qualify as an operator friendly reforms package, the outgo on account of spectrum charges to be paid per annum would be at least two-thirds lower than if the spectrum charges were to be paid over 20 years.

3.14 The Authority has carefully considered the views of various stakeholders. Firstly, the Authority notes that a 30-year duration of allocation of spectrum is nowhere resorted to internationally, and therefore, very little guidance is available from other country experiences. Secondly, the

Authority is of the view that the increase in duration of spectrum allocation from 20 years to 30 years definitely affects the valuation of spectrum since (1) it extends the duration of the property rights (right to use spectrum) vested in the prospective buyer proportionately; (2) it thereby improves business certainty and mitigates the risk associated with future procurements; and (3) it allows the buyer to enjoy the benefits accruing from the spectrum over the longer duration and earn revenues from the utilization of spectrum.

3.15 The present value of spectrum allocated for 20 years can be considered to be equal to the present value of spectrum allocated for 30 years only if the sum of benefits accruing from each of the reckoned periods is the same. In other words, such a conclusion is tenable if and only if the net benefits accruing from the spectrum allocation in the last 10 years is equal to zero, i.e., if and only if

$$\sum_{21}^{30} Ci = 0$$

where 'C' is the net benefit accruing in year 'i', i varying from 21 to 30.

3.16 A very useful analogy of comparing the property rights in spectrum to property rights in real estate is available in the literature[16]. In comparing spectrum property rights to those in real estate, the following similarities have been noted: (1) the property rights for both spectrum and real estate are acquired at a price, arrived at using similar methods; (2) the property rights can be subject to certain restrictions in both cases (such as restrictions to avoid interference in the case of spectrum and building law restrictions in the case of real estate); and (3) the possibility of expropriation when needed for public purpose exists in both cases. In this context, the duration of tenure rights has been recognized as one of the attributes in their valuation, and it has been noted that "…long-term…interests are often more valuable than short ones"[17].

[16] See '*Box 4.3: To Allocate Spectrum, Study Real Estate'* in Varadharajan Sridhar (2012), *The Telecom Revolution in India: Technology, Regulation, and Policy* (New Delhi: Oxford University Press).

[17] *Governance of Tenure* Technical Guide No.11: *Valuing land tenure rights*, Food and Agricultural Organization of the United Nations (Rome, 2017)

3.17 The auction process in the case of spectrum is intended to vest a bundle of property rights in the buyer over the radio frequencies, subject to certain terms and conditions. If we consider the example of real estate, if the property rights are vested for 30 years instead of for 20 years, it cannot be anybody's case that the valuation of the real estate would remain the same: indeed, since the owner of the property would enjoy the fruits for a longer period, the value at which the alienation would be done for the longer period would be proportionately higher. Using the same analogy, the vesting of property rights in spectrum for a longer duration, which also has the effect of ensuring business certainty and continuity and risk mitigation for the buyer, would have to account for the proportionate increase in value derived by the buyer.

3.18 A related issue that has been considered by the Authority is whether it would be prudent and practical to incorporate the increased duration of 30 years into some of the modelling exercises used in the valuation.

3.19 Any techno-economic modelling exercise is, by definition, as robust as the assumptions used. The Authority has, over the years, developed some level of expertise in developing and employing the different models that are utilized in the valuation exercise. At the same time, the Authority has also been cognizant that it is no soothsayer: making projections far into the future, especially in the case of the rapidly evolving telecom sector, is fraught with uncertainty. To mitigate the risk of mis-valuation, the Authority, in its 20-year projections for some models, makes conservative estimates, fully recognizing that these may sometimes not come true in the real world. The effort has been to err on the side of caution, and not let mathematical formulae overwhelm the practical realities of the marketplace, while at the same time, arriving at reasonable estimates of valuation.

3.20 In sum, the Authority is of the opinion that the 30-year projections would be challenging and uncertain, especially in the telecom sector where the techno-economic conditions change and evolve at a rapid pace. Under the circumstances, the Authority has, as will be elaborated in the later part of this Chapter, decided that the present valuation exercise will be conducted using 20-year projections (as before), wherever projections are applicable in some of its models. Such projections are based on the learning and experience gained by the Authority in such modelling and valuation exercises over the previous years.

3.21 As noted in paragraph 3.8 above, one other decision conveyed by DoT in its letter of 23.09.2021 has a bearing on the decision to increase the duration from 20 to 30 years, and the consequent increase in valuation. The decision to allow the surrender (subject to conditions) recognizes that a buyer may wrongly estimate the value placed on the spectrum over the long run. The option of surrender (after a minimum holding period of 10 years), without liability for purchase dues for the post-surrender period attenuates this problem significantly. Even while the valuation of the spectrum goes up proportionately, the buyer has the option to surrender the spectrum when, in the opinion of the buyer, the costs of holding the spectrum at the given (bid) price outweigh the benefits, without being liable for spectrum purchase dues for the post-surrender period.

3.22 To conclude, the Authority is of the view that the valuation of spectrum for the increased allocation period of 30 years should be proportionately higher than the valuation of the same spectrum for an allocation period of 20 years. The Authority's valuation exercise will be conducted for an allocation period of 20 years as done in previous exercises and recommendations, using the appropriate techno-economic modelling exercises, and the reserve price arrived at. Thereafter, the reserve price should be proportionately increased to reckon for the increased allocation duration of 30 years.

3.23 **Therefore, the Authority recommends that the reserve price of spectrum allocation in case of 30 years should be equal to 1.5 times (one-and-a-half times) the reserve price of spectrum allocation for 20 years for the respective band.**

(2) Spectrum related reforms

3.24 The six decisions conveyed through DoT's letter of 23.09.2021, which are required to be considered/ factored in by the Authority while providing recommendations are:

(i) Rationalizing Bank Guarantees to securitize deferred annual spectrum payment instalments in future spectrum auctions;
(ii) Increase in duration of spectrum allocation;
(iii) Regular conduct of spectrum auction on annual basis;
(iv) Provision for surrender of spectrum;
(v) No spectrum usage charges (SUC) for spectrum acquired in future auctions;
(vi) Sharing of spectrum (Removal of additional 0.5% SUC).

3.25 The issue of increase in duration of spectrum allocation and regular conduct of spectrum auction have been dealt in the CP separately. To obtain comments of stakeholders on items (i), (iv), (v), and (vi) above, the following question was raised in the CP:

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.

3.26 Most of the stakeholders stated that these reforms were meant to help the telecom sector address its current liquidity challenges, other legacy issues and financial stress in the sector, and will help improve interest and participation in the auction; hence these decisions should not have any bearing on the valuation of spectrum.

3.27 The submissions made by the stakeholders have been examined by the Authority. The measures announced by the Government will have long term positive financial implications for the telecom sector. As has been acknowledged by most of the stakeholders, these measures will improve the liquidity position of the industry and have a beneficial impact on its growth.

3.28 The Authority notes that rationalization of bank guarantees will not only help in augmenting the funds position but will also improve the cash flow position of the TSPs. With no levy of SUC for spectrum acquired in future auctions, there will be a reduction in cash outgo of TSPs, since the weighted average SUC levels may reduce by up to 2-3% of Adjusted Gross Revenue (AGR), depending upon the quantum of spectrum acquired in future auctions. As such, the removal of SUC on spectrum acquired in future auctions is a welcome reduction in the regulatory burden of the TSPs. There is no gainsaying that this abolition of levy of SUC on spectrum acquired in future auctions is a long overdue reform, as SUC itself is a legacy levy that pre-dates spectrum auctions.

3.29 As will be clear in later sections of this Chapter, SUC is used as an input in one of the valuation approaches used in the spectrum valuation exercise, and the impact of this forward-looking decision has already been reckoned for in the valuation of spectrum.

3.30 The decision regarding provisions for surrender of spectrum has been examined in paragraph 3.21 above. This decision has the impact of mitigating not only the effects of proportional increase in valuation, but also any potential downside from the “winner’s curse”, in case the buyer devalues the spectrum acquired at a given price at a future date.

3.31 The Authority notes that the decisions of the Government put to consultation under this question have been widely welcomed, and would likely have a positive impact on the sector, going forward. However, the Authority, at this early stage of the reform process, is not inclined to speculate on the impact of the reforms on the valuation of spectrum. It could be argued that the decisions have improved the financial position of the TSPs and, therefore, they may be in a better position to place an enhanced value on the spectrum, which is a critical input into their future business activities. On the other hand, it could equally be argued that the reasons for which the Government took these decisions is a recognition of the structural and financial burdens faced by TSPs. The Authority would like to emphasize that the valuation exercise (and the setting of the reserve prices) is grounded in a techno-economic methodology that is time-tested. The valuation is intended to elicit spectrum prices that encourage buyers to procure radio frequencies in different bands, while at the same time ensuring that bidders are discouraged from collusive behaviour.

3.32 The aspects related to the decisions conveyed by DoT in the letter of 23.09.2021 (referred to in Q.36 of the CP) have been duly factored in into the valuation approaches, as necessary.

(3) Annual valuation exercise

3.33 As part of the procedural telecom reforms, DoT conveyed the decision of the Government for regular conduct of spectrum auction(s) on annual basis, normally in the last quarter of the financial year, but also, where necessary, at shorter intervals.

3.34 Accordingly, the following question was raised in the CP: -

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.

3.35 Some stakeholders agreed that the valuation exercise should be done afresh each year to take into account the current economic and business conditions which change from time to time with limited or no linkages with earlier conditions. On the other hand, some stakeholders see no justification to conduct a valuation exercise every year.

3.36 One stakeholder suggested that the extensiveness and comprehensiveness of this exercise can be curtailed by deciding certain fixed parameters like how much to discount the price in subsequent auctions on failure to find a buyer in auction. Availability of market determined price for all spectrum reduces the relevance of an extensive annual valuation exercise. Re-evaluation is required for unsold spectrum.

3.37 One stakeholder is of the view that one year is a very short period to warrant any change in the prices revealed during last conducted auctions.

3.38 Before considering the issues arising from the stakeholders' comments, the Authority would like to draw attention to one aspect of the auction process that can significantly improve the availability of information pertaining to each auction conducted by DoT. The Authority notes that spectrum auctions are conducted by DoT in accordance with NIA prepared and issued by DoT. As such, DoT is best placed to critically analyse the auction outcomes. The Authority further notes that DoT places on its website information such as provisional results, bidder activity, bid trail, etc., related to auctions conducted by it. However, it would be beneficial if a report, critically analysing the auction outcomes and lessons learnt, is prepared in addition by DoT after each auction is concluded. Accordingly, **the Authority recommends that DoT shall prepare a comprehensive report analysing critically the outcomes of each forthcoming auction to be shared with the Authority within 90 days of conclusion of the auction.**

3.39 Regarding the issues raised in Q.40 above, the Authority has carefully considered the views of various stakeholders. The Authority undertakes the spectrum valuation exercises using various models/ approaches that use different datasets of technical, market and economic data, updated periodically. These parameters do not change much in a short time span. At the same time, even though regular auctions may yield spectrum prices from time to time, there is a need to evaluate the techno-economic context at regular intervals to reckon for changes in the possible value attributed to the radio frequencies. Further, as has been the experience in past auctions, spectrum, even in the same band, is often sold only in some (and not all) LSAs, and there is every likelihood that auctions may yield auction determined prices only for some LSAs and for some spectrum bands. DoT has also expressed the view that "spectrum lying idle is a waste for the economy". As such, the Authority is of the view that while annual valuation exercises may not be necessary, there is an imperative need to revisit spectrum valuation at regular intervals. While the auction determined prices can be utilized for setting reserve prices (after indexation) since they explicitly reveal market preferences, spectrum in bands/ LSAs that remained unsold could be put to auction in subsequent auctions without the need for indexation, thereby indirectly providing for a discount equal to the interest rate.

3.40 **Accordingly, as there will be regular conduct of spectrum auctions on annual basis (or at shorter intervals), the Authority recommends that**

(I) For existing bands (including for the bands being put to auction for the first time in the forthcoming auction), a fresh spectrum valuation exercise be conducted once every three years; a suitable reference be made to the Authority by Government for this purpose.

(II) For auctions conducted in the interim period between periodic valuation exercises conducted once every three years,

(1) for LSAs where the spectrum put to auction in a previous auction is sold, the auction determined prices (duly indexed using applicable MCLR if more than one year has elapsed since the previous auction) should be used for arriving at the reserve prices for the next auction;

(2) for LSAs, where spectrum remains unsold in previous auctions, past recommended reserve price (without indexation) should be used.

(III) For new spectrum bands, to be put to auction for first time, a reference be sent to the Authority, as per established procedure as and when these bands are proposed to be put to auction.

(IV) However, if required, DoT may seek fresh reserve prices from the Authority for the existing bands, providing a full and reasoned justification for the same.

C. FACTORS AFFECTING VALUATION OF SPECTRUM

3.41 Spectrum is a valuable input in the provisioning of telecommunication services. Any policy decision affecting the prices of spectrum is reflected in the prices of telecommunication services. The interests of the public at large are linked with spectrum pricing. Thus, effective spectrum pricing based on a sound rationale is a prerequisite to ensure that spectrum is utilized in an optimal manner for the affordability of the services and the sustainability of the telecom sector. To arrive at the prices of the spectrum, the Authority has been following different approaches/ methodologies which are based on various technical, financial as well as economic factors. In order to obtain views of the stakeholders on the factors relevant for spectrum valuation and how these can be used in different valuation approaches, the following question was raised in the CP:

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.

3.42 In response, quite a few stakeholders have given a range of factors that influence spectrum valuation. These include revenue potential, consumer behaviour, spectrum as a key requirement for critical services and sustainable competition, availability of funds for the deployment of networks, affordability of services, past reserve prices, and duration of spectrum allocation. Some stakeholders have also stated that while calculating reserve price of the spectrum, factors such as per capita income, ARPU, GDP, inflation, global benchmarks etc., should also be taken into consideration. Other stakeholders' views consider demand and supply, objective of the auction, impact of proliferation on national economy, fostering sustainable and efficient competition, national policies on spectrum, balance between Government's expectation to generate revenue and growth of telecom sector in the country, and opportunity cost of spectrum remaining unsold as factors that need to be considered.

3.43 However, with regard to the question as to in what manner should these factors be reflected in the valuation of spectrum, no stakeholder has provided any alternative method for incorporating these factors in the valuation.

3.44 The Authority has carefully considered and examined the comments of the stakeholders. As stated by them, one of the key factors influencing spectrum valuation is revenue potential. Revenue potential itself depends upon variables like subscriber base, the pricing of the various telecom products, and customer uptake of services. These variables also change with time and are influenced by the business strategies of the individual firms. The Authority is of the view that the revenue generated from spectrum services is one of the important parameters that should be considered in spectrum valuation.

3.45 Economic and financial parameters like GDP, inflation, ARPU etc., that fluctuate with time and the state of the economy are also quite important to the valuation exercise. The use of international benchmarking of spectrum prices is also useful sometimes, specially when technical and commercial data required for modelling is not available for a spectrum band. However, the Authority notes that the use of international benchmarking is constrained by limitations arising from inter-country differences in geography, population, GDP, per capita incomes, ARPU, etc. It is often remarked that some of the LSAs in India are the size of some of the countries with which comparisons are sought to be made, whether on the basis of geography, population, or GSDP/ GDP. Further, it needs to be noted that spectrum usage rights are alienated using different methodologies globally. These may include (i) auctioning the rights for a specific time period with further auctions for renewal, as being done in India; (ii) administrative assignment; and (iii) auctioning the rights with a strong presumption of renewal with defined terms and conditions. Hence, given the differences in socio-economic conditions and regulatory regimes of the different jurisdictions, one must be careful in making simplistic inter-country comparisons of spectrum prices etc.

3.46 The macro- and micro-economic status of the country has a bearing on the paying capacity of subscribers, growth prospects of the industry etc. These aspects too need to be suitably incorporated in the valuation exercise.

3.47 Spectrum prices determined in previous auctions and the prices discovered in international auctions are also important indicators of the market’s willingness to pay for spectrum and also need to be appropriately included. The past auction prices can be indexed at a suitable rate to reflect inflation, time value of money etc.

3.48 The Authority is of the view that the parameters like subscriber base, revenue potential, traffic, return on investment, macro- and micro-economic parameters, past prices, and international prices, that have also been considered in past valuation exercises, should be used in the present valuation as well. The Authority maintains the view that the only way to take into account all the relevant factors is to make use of a diverse set of methods of valuation of spectrum in order to incorporate relevant micro- and macro-economic factors, which may influence the value of spectrum.

D. VALUATION AND RESERVE PRICE OF SPECTRUM IN 800 MHZ/900 MHZ/1800 MHZ/2100 MHZ/2300 MHZ/2500 MHz BANDS

(1) 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/2500 MHz bands

3.49 As discussed in the Consultation paper (CP), one of the possible approaches to value 800 MHz/900 MHz/1800 MHz/2100 MHz/2300 MHz bands is to consider auction determined prices of the last auction held in March, 2021, as the value of the spectrum in the respective bands and thereafter appropriately indexing (if required) between the time gap of the auction held in March 2021 and the next round of auction.

3.50 In this context, the following questions were raised in the CP:

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?

3.51 Many stakeholders are of the opinion that the auction determined prices of March 2021 auction should not be taken as the value of spectrum in the respective band for the forthcoming auction in the individual LSA citing that considerable amount of spectrum remained unsold in the last auctions and one of the prime reasons was high reserve price. Therefore, a fresh exercise is required.

3.52 One stakeholder has suggested that due to continuously evolving technology trends, present circumstances which the industry faces are completely different from the various auctions held in the past.

3.53 On the other hand, another stakeholder suggested that auction discovered prices are a relevant and important factor in a subsequent valuation exercise of already auctioned and sold spectrum bands. Indexation should be contemplated only if the valuation exercise is being done post one year of last auction. However, past auction prices are not a relevant consideration for 'new' spectrum bands. Even for considering the auction determined prices for spectrum bands auctioned and sold earlier, in years prior to the auction, other relevant factors such as competitive intensity and pressure for renewal, etc., be considered.

3.54 One other stakeholder has stated that due weightage may be given to past reserve prices also.

3.55 The Authority has carefully considered the comments of various stakeholders. Many stakeholders are not in the favour of using the March 2021 auction determined prices solely as the value of 800 MHz/900 MHz/1800 MHz/2100 MHz/2300 MHz spectrum bands. They have suggested a fresh approach for the valuation of the spectrum in the forthcoming auction taking into account the prevailing conditions. As stated in the CP, 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 (irrespective of whether it is a market clearing price or not).

3.56 The Authority finds merit in the view that directly adopting the March, 2021 auction prices as the value of spectrum in the respective bands for the forthcoming auction is not an appropriate valuation approach in the current exercise. Thus, the Authority has decided that instead of relying solely on the prices discovered in the spectrum auction of 2021, a fresh exercise for valuation of 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz spectrum bands should be undertaken.

(2) Valuation of Spectrum: Single Approach versus Multiple Approaches

3.57 It has been the Authority's position over the years that the various approaches used in the valuation of different spectrum bands have their respective merits and constraints. Rather than relying on one valuation approach, it is prudent and rational to rely on a number of approaches to arrive at the final valuation. It is not possible to claim deterministically that any one of these models/ approaches is absolutely the right approach to arrive at the valuation, since no single approach can completely and exactly capture every variable that influences the valuation of spectrum. It is well-nigh impossible to calculate the complete range of possible valuations. Therefore, the Authority has been consistently maintaining that rather than following a deterministic approach, it is best to work with a probabilistic average valuation (through simple mean) that captures the range of possible valuations. Accordingly, the following questions were raised in this regard in the CP for seeking the comments of the stakeholders:

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.

3.58 In response, some stakeholders stated that the present methodologies need correction, while another set of stakeholders stated that past valuation approaches are not relevant in present conditions.

3.59 Some other stakeholders supported TRAI's approach that every band should be evaluated separately and multiple valuation approaches can be adopted because it is not possible to deterministically ascertain if any one valuation is the 'right' valuation, since each model has certain strengths as well as limitations.

3.60 One stakeholder suggested that a single valuation approach for a particular spectrum band can be taken as the appropriate value of that band if it gives the optimum result.

3.61 The Authority has carefully considered the comments of the stakeholders. The Authority is inclined to continue with its consistent and considered view that it is not possible to say deterministically that any one methodology/ approach is the right method for determining the value of spectrum in various bands. Each method/ approach/ model has certain strengths as well as limitations. Some models capture intrinsic technical features better, whereas others are based on economic and market realities. No particular model completely captures every variable related to technical, economic, sectoral, geographic and regulatory realms that influence the valuation of spectrum. Equally, as stated earlier, it is not possible to model the complete range of possible valuations, as the non-availability of relevant data is a binding constraint.

3.62 Since September, 2013, the Authority has been conducting spectrum valuation by taking the simple mean of the valuations obtained from the various valuation approaches, on the assumption of equal probability of occurrence of each valuation approach.

3.63 This approach is justified since the attempt is to arrive at the 'Expected Value' of the valuation of spectrum from the set of available valuations, and the simple mean serves this purpose as a measure of central location. Accordingly, the Authority has decided to use various valuation approaches, wherever feasible for the different spectrum bands, and take the simple mean of the valuations obtained through the different approaches used for valuation of a particular spectrum band, as applicable, to arrive at the average valuation.

(3) Valuation approaches/methodologies

3.64 Given that the telecom industry is moving towards technology-neutral usage of spectrum, thereby increasing the difficulty associated with the technological segregation of financial and non-financial data, the following question was raised in the CP:

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.

3.65 Some stakeholders are of the view that the past valuation methodologies are not relevant in the present context and these methodologies may not yield the desired results and suggested that the valuation method must incorporate the revenue potential/ income, paying capacity of the service providers and global benchmarks adjusted for ARPU/ Return on Capital Employed (RoCE). The incremental rise in ARPU and the revenue potential from 5G services must be factored in, since it is observed that globally, launch of 5G services has not led to any significant rise in ARPU and revenues.

3.66 A few stakeholders stated that there is a need to strike a balance between the Government's requirement to generate revenue from the auction and the financial status of the industry. Spectrum pricing, which is both sustainable as well as affordable to the TSPs/ISPs, will in the long-term, lead to significant socio-economic gains, and result in the orderly growth of the sector. Some stakeholders also suggested the use of global benchmarking in arriving at spectrum pricing.

3.67 Some stakeholders have also given certain methodology-specific comments, which have been dealt with in the respective sections of this Chapter that follow.

3.68 The Authority has carefully considered the comments given by stakeholders. The Authority is of the view that using ARPU for normalization to incorporate the cross-country differences, will not be rational as ARPU is dependent upon the pricing and product strategies of the TSPs, that may be widely different across countries. Changes in tariffs cause fluctuations in ARPU and over time, significant variations have been observed in the way ARPUs have changed. Further, the tariff regime in India is of forbearance, and the ARPU is thereby an outcome of interplay of market forces. In view of the large tenure of 30 years for which spectrum is to be alienated, using a benchmark like ARPU for adjustment/ normalization is not advisable.

3.69 The Authority recognizes that nowadays the telecom industry is moving towards technology neutral usage of spectrum allowing 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.

3.70 Therefore, considering the changing dynamics of the telecom sector, the Authority has decided that the recent technological developments and the latest available data on market and economic parameters should also be taken into account in the methodologies adopted for spectrum valuation.

(4) Valuation of 1800 MHz Spectrum

3.71 The approaches for estimating the value of spectrum in 1800 MHz band, used by the Authority in the present exercise, are outlined below:

a. Multiple Regression Model

3.72 By using Multiple Regression model, the LSA-wise prices for the spectrum in the 1800 MHz band realized in the previous auctions may be correlated with the relevant explanatory variables (such as GSDP per capita, population density, subscriber base) to estimate the LSA-wise value of spectrum in 1800 MHz band.

3.73 The Authority used the Multiple Regression model for deriving one of the possible valuations of spectrum in 1800 MHz band in its recommendations of September 2013 and August 2018. In the instant consultation process, none of the stakeholders has offered any comment on this model.

3.74 In the present exercise, the Authority has decided to make use of the Multiple Regression model for arriving at one of the possible valuations of spectrum in 1800 MHz band. For this purpose, the LSA-wise auction determined prices of spectrum in 1800 MHz band (the independent variable) since the 2012 auction have been regressed with LSA-wise mobile subscriber base, GSDP per capita and population density (the explanatory variables) for forecasting the price of spectrum in the 1800 MHz band in the forthcoming auction.

3.75 The details of the Multiple Regression model are at **Annexure 3.1**.

b. Producer Surplus Approach

3.76 As there is an inverse relationship between the quantum of spectrum allocated to a telecom service provider (TSP) and the expenditure of the TSP on the radio access network (RAN) required for serving a particular level of demand, the allocation of additional spectrum to an existing TSP creates a producer surplus, on account of savings in its expenditure on network. The Producer Surplus model estimates the opportunity of cost saving to an average TSP upon expenditure in the RAN and the spectrum usage charge (SUC) upon getting additional spectrum. The opportunity of the net saving in expenditure to the TSP has been termed as producer surplus. The producer surplus, estimated using this model, is a possible valuation of spectrum.

3.77 The Authority used the Producer Surplus model for estimating one of the possible valuations of spectrum in 1800 MHz band in its recommendations of September 2013, October 2014, January 2016 and August 2018. In the present consultation process, one stakeholder has stated that this approach ignores the starting point of spectrum holdings, changes in technology and data usage growing exponentially.

3.78 The Authority has carefully considered the comments of the stakeholders and is of the view that any model for valuation of spectrum will have a set of assumptions based on the current trends and data. The Authority considers the Producer Surplus model as a feasible approach for estimating the value of spectrum in 1800 MHz band from the perspective of an average TSP willing to invest in the expectation of a targeted/ projected revenue and profitability. Further, the Authority is of the view that the Producer Surplus model will be well-served by suitably updating it for the 4^{th} Generation (4G) mobile network in view of the fact that, at present, the 4G mobile networks caters to most of the mobile traffic in the country.

3.79 Accordingly, the Authority has decided to use the results of the Producer Surplus model as one of the possible valuations of spectrum in 1800 MHz band. The detailed methodology of the Producer Surplus model is at **Annexure 3.2**.

c. Production Function Model

3.80 The Production Function model estimates the value of spectrum through the Cobb-Douglas production function with spectrum and base stations as two factor inputs to produce mobile traffic. The Cobb-Douglas production function is a commonly used functional form for estimating the relationship between the inputs and output.

3.81 This model has been adopted by the Authority for deriving the valuation of spectrum in 1800 MHz band in its September 2013, October 2014, January 2016 and August 2018 recommendations. In the present consultation, no specific input has been received from the stakeholders in respect of this model.

3.82 In view of the fact that the Production Function model provides a reasonable approximation of the value per MHz of spectrum to a TSP, the Authority has used the Production Function model to obtain one possible valuation of the spectrum in the 1800 MHz band. The detailed methodology of the Production Function model is given in **Annexure 3.3**.

d. Revenue Surplus Approach

3.83 The Revenue Surplus model for valuation of spectrum in 1800 MHz band is premised on the assumption that the net present value (NPV) of the projected revenue surplus over the next 20 years could potentially represent the maximum amount which a TSP would be willing to pay for additional spectrum in 1800 MHz band.

3.84 The Revenue Surplus model was previously adopted by the Authority for the valuation of spectrum in 1800 MHz band in its recommendations of October 2014, January 2016 and August 2018. In the present consultation, while some stakeholders have supported this approach, the others did not provide any specific inputs.

3.85 In view of the fact that using this approach, the value of spectrum may be reasonably estimated from the perspective of a wireless access service provider willing to invest in spectrum to realize the net revenue potential/ revenue surplus over the period for which the spectrum in 1800 MHz band is granted to it, the Authority, in the present exercise, has decided to use the results of the Revenue Surplus model as one of the possible valuations of spectrum in 1800 MHz band. The detailed methodology of the Revenue Surplus model is given at **Annexure 3.4.**

e. Trend-line Approach

3.86 The Authority has been considering auction determined prices as one of the best indicators for spectrum valuation. Using the available information, 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 the coefficient of time 't'.

3.87 In this context, the following question was raised in the CP:

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?

3.88 Some stakeholders have responded that the earlier auctioned spectrum prices are not sustainable in the present circumstances due to significant changes in the state of the telecom sector. Hence, the ADP approach based on a time-series analysis is not relevant for the valuation of spectrum. Further, it is not necessary that the value of spectrum will always increase with the passage of time.

3.89 A few stakeholders are of the view that new/ unsold bands do not have any reference price for ADP and no trend-line can be determined for the same. Other bands have also remained largely unsold in the past auctions, and hence the entire exercise should be done afresh for every spectrum band.

3.90 Another stakeholder suggested that the application of a linear relationship-based time-series analysis may not be optimum in all scenarios and other relevant factors need to be given due weightage. For instance, in the 1800 MHz band, the auctions in 2012, 2014, 2015 and 2016 had an issue of survival by continuation of license or license renewal.

3.91 After carefully examining the comments received from various stakeholders, the Authority notes that auction determined prices are now available for the different spectrum bands, from multiple auctions held in India since the year 2010. These auctions have enabled sufficient data points to yield statistically significant results for these bands.

3.92 Further, the Authority is of the view that each model has its own strengths and constraints. While some models estimate the valuation of spectrum in a band by way of comparing its technical efficiency with another spectrum band, the others arrive at a valuation using the principle of opportunity cost and economic factors. As the Trend-line model provides a possible valuation of spectrum in the forthcoming auction using auction determined prices which are one indicator of the value placed by the market on the concerned radio frequency, it offers the possibility of enriching the data analysis. Therefore, the Authority has decided to use the results of the Trend-line model as one possible valuation of the spectrum in the 1800 MHz band.

3.93 The details of the Trend-line model are given at **Annexure 3.5.**

f. Use of last auction determined prices

3.94 The Authority in its 2018 recommendations 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.

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.

3.95 In response, a few stakeholders have stated that the past method followed by the Authority in the 2018 recommendations of considering auction determined prices of the auctions held in the previous two years be continued. However, some other stakeholders are of the view that past valuation approaches are not relevant in the present circumstances and the entire valuation exercise for each band should be conducted afresh in view of legacy issues and substantial changes in factors like technology, consolidation, shift towards OTTs etc., since then.

3.96 The comments given by the stakeholders have been examined by the Authority with reference to the recent auction held in March, 2021. It can be seen that during the said auction, all the spectrum sold in the LSAs was sold at the reserve price. Nevertheless, in the absence of a more reliable indicator of market preference, the Authority maintains the view that auction determined prices, as an outcome of an auction, is a reasonably good indicator of the value of spectrum and cannot be ignored. The Authority considers it proper that the spectrum prices discovered in the auctions conducted up to two years should be used as one of the methods of valuation of spectrum. The Authority considers ADP as a robust indicator of market preference and does not propose to underutilise the valuable ADP data in the valuation exercise. At the same time, the Authority has, in the current exercise, taken care to ensure that ADP does not also over-determine the valuations and reserve prices of different bands. Accordingly, the Authority is of the view that the prices revealed in the last auction held in March, 2021 be taken as one of the values of the spectrum in the respective band for the forthcoming auction, duly indexed.

3.97 In the previous 2018 recommendations, the Authority used the 'Marginal Cost of Funds based Lending Rates (MCLR) system' for indexing the last auction determined prices.

3.98 Accordingly, the Authority is of the view that auction determined prices revealed in the auction(s) held in the previous two years, duly indexed with MCLR, be taken as one of the possible valuations in the respective spectrum bands in the present spectrum valuation exercise**.**

3.99 To sum up, the Authority has used the following approaches for the valuation of the 1800 MHz spectrum in the present exercise: (1) Multiple Regression model; (2) Producer Surplus model; (3) Production Function model; (4) Revenue Surplus model; (5) Trend-line approach; and (6) duly indexed auction determined price discovered in the March, 2021 auction. The valuations arrived at using these models are given at **Annexure 3.6.**

(5) Valuation of the 900 MHz Spectrum

3.100 The 900 MHz spectrum band was put to auction in 2021 in 19 LSAs. Out of a total of 98.80 MHz of spectrum put to auction in these 19 LSAs, a total of 38.4 MHz of spectrum was sold across 9 LSAs. The following methods have been used as the possible approaches to arrive at valuation for the 900 MHz band in the present exercise: (1) the available last auction determined price (duly indexed); (2) factor of technical efficiency of 2 for the spectrum in the 900 MHz band with respect to the spectrum in the 1800 MHz band; (3) factor of technical efficiency of 1.5 for the spectrum in the 900 MHz band with respect to the spectrum in the 1800 MHz band; (4) factor of technical efficiency of 1 for the spectrum in the 900 MHz band with respect to the spectrum in the 800 MHz band; and (5) economic premium of spectrum in 900 MHz band over the spectrum in 1800 MHz band. The methodology of the economic premium approach is given at **Annexure 3.7**. The valuation of the spectrum in the 900 MHz band arrived at using the afore-mentioned methods is given at **Annexure 3.8**.

(6) Valuation of the 800 MHz Spectrum

3.101 The spectrum in 800 MHz band was put to auction in 22 LSAs in the last auction held in March 2021. Out of a total of 230 MHz of spectrum put to auction (across 22 LSAs), 150 MHz of spectrum was sold (across 19 LSAs). In the present exercise the following methods have been used as the possible approaches for the valuation of spectrum in 800 MHz band: (1) the available last auction determined price (duly indexed); (2) factor of technical efficiency of 2 for the spectrum in the 800 MHz band with respect to the spectrum in the 1800 MHz band; (3) factor of technical efficiency of 1.5 for the spectrum in the 800 MHz band with respect to the spectrum in the 1800 MHz band; and (4) multiple regression model. For the methodology of the multiple regression approach, the Annexure 3.1 may be referred to. The valuation of the spectrum in the 800 MHz band arrived at using the afore-mentioned methods is given at **Annexure 3.9**.

(7) Valuation of the 2100 MHz Spectrum

3.102 In the previous auction, the spectrum in 2100 MHz band was put to auction in 19 LSAs. Out of a total of 175 MHz of spectrum across 22 LSAs put to auction, 15 MHz was sold across 3 LSAs. In the present exercise, the following methods have been used as the possible approaches for the valuation of spectrum in 2100 MHz band: (1) last auction determined price (duly indexed), and (2) the factor of technical efficiency of 0.83 for the spectrum in the 2100 MHz band with respect to the spectrum in the 1800 MHz band. The valuation of the spectrum in the 2100 MHz band arrived at using the afore-mentioned methods is given at **Annexure 3.10**.

(8) Valuation of spectrum in the 2300 MHz and 2500 MHz bands

3.103 The following questions were put for consultation with respect to the 2300 MHz and 2500 MHz spectrum bands:

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.

3.104 Many stakeholders attributed the relative lack of interest in 2500 MHz band to different factors such as lack of harmonization, non-availability of device ecosystem, and high reserve prices.

3.105 With respect to the use of auction determined prices for the 2300 MHz band, some stakeholders have favoured the same but without indexation, while others have suggested not to use this approach due to the changing market and economic conditions.

3.106 The spectrum in the 2500 MHz band was put to auction in 12 LSAs in March, 2021 but remained entirely unsold. In this background, comments were sought from the stakeholders as to whether the auction determined prices of previous auction i.e. October, 2016 should be used as one possible valuation of spectrum in 2500 MHz band. None of the stakeholders supported this approach.

3.107 On the issue of valuing the spectrum in the 2300 MHz/ 2500 MHz bands by relating it to the value of spectrum in any other band using technical efficiency factor, a stakeholder has suggested linking the price of 2500 MHz band to the price of the 2300 MHz band and using the last ADP for valuation of both these bands.

3.108 With respect to the 2300 MHz band, it emerges from the comments of some stakeholders that they are agreeable to the use of the price realized in the previous auction held in March, 2021 for arriving at the value of this band, but also that they are not in favour of indexation of the auction determined prices of the March 2021 auction. A few stakeholders have suggested linking of 2300 MHz and 2500 MHz bands and using the ADP of 2300 MHz band for both the spectrum bands.

3.109 The Authority is of the view that since spectrum in the 2300 MHz band was sold in the last spectrum auction, it would be appropriate to use the market revealed prices of the auction held in March, 2021 for the valuation of this band. In this band, the auction determined prices of March, 2021 in respect of all the 22 LSAs are available. This price duly indexed (with MCLR) can be used as one of the approaches for valuation, in addition to Multiple Regression model and Trend-line model. Another approach to value the spectrum in the 2300 MHz band adopted by the Authority in the current exercise, is on the basis of technical efficiency of the spectrum in 2300 MHz band with respect to the spectrum in the 1800 MHz band. The Authority notes that according to the Technical Note (2018) of M/s Nokia[18] on 5G spectrum and Coverage Consideration Aspects, the coverage of the 2300 MHz (and the 2500 MHz) spectrum bands in TDD, is around 50% of the 1800 MHz band FDD coverage. Therefore, a technical efficiency factor of 0.5 has been adopted for the spectrum in the 2300 MHz (and the 2500 MHz) band with respect to the spectrum in the 1800 MHz band. At the same time, as the spectrum in the 2300 MHz (and 2500 MHz) band is unpaired, the valuation has been calculated accordingly.

3.110 Accordingly, the Authority has decided to use the following approaches for valuation of spectrum in 2300 MHz band: (1) technical efficiency of the spectrum in 2300 MHz band with respect to the spectrum in 1800 MHz band; (2) duly indexed Auction Determined Prices of the March, 2021 auction; (3) Multiple Regression model; and (4) Trend-line model.

3.111 For the methodologies of the multiple regression model and the Trend-line approach, Annexure 3.1 and Annexure 3.5 respectively may be referred to. For the valuation arrived at for 2300 MHz spectrum band using the aforementioned approaches, see **Annexure 3.11**.

3.112 With respect to the 2500 MHz band, none of the stakeholders is in favour of using the auction determined prices of the October, 2016 auction as

[18] 5G Spectrum and Coverage Consideration Aspects – Technical Note, 2018

one possible valuation for this band. A few stakeholders are in favour of valuing the 2500 MHz band as being equal to the auction determined prices of the 2300 MHz band.

3.113 The Authority notes that in the year 2010, DoT had assigned the 2500 MHz spectrum band to the PSUs viz., BSNL and MTNL at the May, 2010 auction determined prices of 2300 MHz band.

3.114 Earlier also, in the 2016 recommendations, the Authority recommended that the reserve price of 2500 MHz spectrum band be equal to recommended reserve price of 2300 MHz band.

3.115 The Authority is of the view that being adjacent to each other and technically of similar coverage relative to the 1800 MHz band, the propagation characteristics of 2500 MHz are comparable with those of the 2300 MHz band. As such, this can be used as one of the approaches for the valuation of the 2500 MHz band. Further, in view of the Technical Note (2018) referred to above, the technical efficiency of the 2500 MHz band (TDD) with respect to the 1800 MHz band (FDD) as discussed in paragraph 3.109 above, can also be used for arriving at one possible valuation of the 2500 MHz band in different LSAs. Hence, the Authority is of the view that it is reasonable to use the two approaches – (1) assuming the valuation of 2500 MHz as equivalent to 2300 MHz spectrum band, and (2) using the technical efficiency factor with respect to the 1800 MHz (FDD) band – be used in the valuation of the 2500 MHz band.

3.116 For the valuations arrived at for 2500 MHz spectrum band, **Annexure 3.12** may be referred to.

(9) Arriving at the Average Valuation of the 800 MHz, 900MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz spectrum bands

3.117 In view of various valuation approaches adopted for different spectrum bands and discussions at preceding paragraphs, the Authority has arrived at an expected average valuation of 800 MHz, 900MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz spectrum bands as the simple mean of the various valuations that have been adopted and given at **Annexure 3.9**, **Annexure 3.8**, **Annexure 3.6**, **Annexure 3.10**, **Annexure 3.11** and **Annexure 3.12** respectively of this Chapter.

3.118 Consistent with the approach followed in previous recommendations, the Authority is of the view that the expected value of spectrum can be estimated using different valuation approaches. From these estimates of valuation, it is possible to calculate an average valuation as the simple mean of the estimates at hand. Therefore, the Authority has decided that the average expected valuation of 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz spectrum bands in an LSA should be based on the simple mean of the various valuation approaches in that particular band.

3.119 Accordingly, the LSA-wise average expected value of the 800MHz, 900MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz spectrum bands is tabulated below :

TABLE 3.1: AVERAGE VALUE PER MHz (20 years)

(Rs. in crore)

LSA	Category	Average Value per MHz of 800 MHz Band	Average Value per MHz of 900 MHz Band	Average Value per MHz of 1800 MHz Band	Average Value per MHz of 2100 MHz Band	Average Value per MHz of 2300 MHz Band	Average Value per MHz of 2500 MHz Band
		PAIRED				UNPAIRED	
Delhi	Metro	683.99	622.88	385.14	319.67	149.06	122.67
Kolkata	Metro	218.01	218.27	138.14	114.66	45.96	40.25
Mumbai	Metro	668.15	555.92	337.37	280.02	147.24	115.79
Andhra Pradesh	A	417.32	411.67	245.10	203.43	83.68	72.48
Gujarat	A	374.53	366.08	214.91	178.37	72.35	63.04
Karnataka	A	283.49	290.84	172.67	143.32	90.78	66.97
Maharashtra	A	482.47	453.24	271.90	225.67	84.58	76.28
Tamilnadu	A	321.10	316.83	200.84	NA	115.80	83.00
Haryana	B	87.96	96.70	57.97	48.11	NA	NA
Kerala	B	147.36	157.26	83.00	68.89	NA	NA
Madhya Pradesh	B	194.33	222.37	125.63	104.27	NA	NA
Punjab	B	144.90	148.71	87.37	72.52	18.02	19.93
Rajasthan	B	202.74	192.28	106.97	NA	NA	NA
U. P. (East)	B	229.01	237.30	130.09	NA	NA	NA
U.P. (West)	B	190.36	216.85	124.11	103.01	NA	NA
West Bengal	B	127.02	141.14	82.25	52.86	NA	NA
Assam	C	71.67	79.97	45.37	34.88	NA	NA
Bihar	C	180.47	210.22	116.80	96.94	13.86	21.53
Himachal Pradesh	C	31.81	36.90	20.64	17.13	2.41	3.79
Jammu & Kashmir	C	39.49	46.80	26.02	21.59	2.75	4.63
North East	C	38.24	39.44	24.25	13.27	NA	NA
Orissa	C	76.60	91.75	50.17	41.64	NA	NA

(10) Estimation of Reserve Price of the 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300MHz, and 2500 MHz spectrum bands

3.120 A reserve price refers to the lower bound on the bid below which the item up for sale cannot be acquired through an auction. During previous 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 the final reserve price. In this regard, the following questions were raised in the CP:

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?

3.121 Some stakeholders suggested that the reserve price of all the spectrum bands be fixed at 50% of the valuation to enable competitive bidding and allow market conditions determine the actual price through auction. The reserve price should be decided in such a manner that there is greater participation in the auction. A high reserve price barrier may discourage TSPs from participation in the auction, resulting in spectrum remaining unsold.

3.122 One stakeholder has supported the use of the prices discovered in the March, 2021 auction be adopted as the reserve prices in the forthcoming auction. However, other stakeholders are not in favour of directly adopting the auction determined price of March, 2021 as the reserve price in the respective spectrum bands for the forthcoming spectrum auction. According to them, the reserve price has been increasing significantly through the years since it was linked to the previous auction prices. Spectrum was acquired by the operators at the previous prices under duress, due to various factors such as impending renewals, urgent capacity requirements, etc. However, these purchases at reserve prices in no way signify that reserve prices are an ideal benchmark for determining reserve prices for forthcoming auction.

3.123 The Authority notes that a reserve price is the starting point for an ascending price auction and bidding is the means to true price discovery. A reserve price ensures a minimum guaranteed amount for the owner/ seller of goods. It prevents excessive bargaining in the auction process. The 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 realization of the underlying value of the asset being auctioned and deterring collusive behaviour among bidders. 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. The level at which reserve prices are set has implications for each of the objectives normally set for spectrum auctions: efficiency, competition, transparency, market development, and Government revenue[19].

3.124 The Authority notes that setting reserve prices is a distinct second stage that follows the valuation exercise. To set an optimal reserve price, information about the complete range of possible valuations and the probability of occurrence of each possible valuation would be required. However, due to the near impossibility of the availability of such information, we proceed with the simple mean (average) of all available valuations in each spectrum band. The reserve price could be set at the level of the average valuation itself; however, the danger in such an

[19] Malisuwan, Settapong, *et al* (2016), *Mobile Spectrum Value and Reserve Price by using Benchmarking Approaches*, International Journal of Scientific Engineering and Technology, 5:1 (pp. 81-4)

approach is that the reserve price may be set at too high a level, specially since the theoretical optimum valuation is not known or available.

3.125 The Authority has been conscious of the limitations of the theoretical models. As has been stated in the literature, "[g]ood auction design is *not* 'one size fits all'" [20] . Indeed, "…auction design…entails practical judgments guided by theory and all available evidence, but it also uses *ad hoc* methods to resolve issues about which theory is silent"[21].

3.126 The Authority has, in this context, carefully considered the different views regarding the level at which the reserve price should be set, vis-à-vis the average valuations arrived at. The Authority has been traditionally setting the reserve price at the level of 80% of the average valuation. At the time of settling for this level in the 2013 recommendations, the Authority had noted *inter alia* that (1) reserve prices in spectrum auctions around the world are around 45-55% of the final prices realised in the auction; (2) the reserve price is <u>not</u> the final auction price; and (3) that Brown and Morgan[22] find from results of field experiments of auctions of collectible coins that positive reserve prices set at the level of 70% of the purchase price of the coins lead to higher revenues and lower number of bidders relative to zero reserve prices.

3.127 Malisuwan *et al* (see footnote above) note that the ratio of reserve price to auction price "…possibly varies greatly across the historical database -from less than 0.1 to 1", and that in many cases, regulators determine to multiply estimates of spectrum value by 70%-80% to derive the reserve prices. The Authority also notes that Plum Consulting, as part of the ITU team which advised the National Broadcasting and Telecommunications Commission (Thailand) ahead of the 2015 spectrum auctions in the 900

[20] Klemperer, Paul (2002), *What Really Matters in Auction Design*, The Journal of Economic Perspectives, 16:1 (pp. 169-89).
[21] Milgrom, Paul (1999), *Putting Auction Theory to Work: the Simultaneous Ascending Auction*, World Bank, Policy Research Working Papers Series.
[22] Brown, Jennifer and John Morgan (2009), *How much is a Dollar Worth? Tipping versus equilibrium co-existence on competing online auction sites*, The Journal of Political Economy

MHz and 1800 MHz bands, had recommended reserve prices that are at a level of around 70% of their estimate of value for each band[23].

3.128 DoT's views, conveyed to the Authority in its letter of 02.11.2021, in response to TRAI's letter of 27.09.2021, also need to be considered in this context. In this letter, DoT has, *inter alia*, indicated its view that:

a. "there is a need to strike a balance between the generating revenue from the auction on the one hand, and long term growth/ sustainability of the telecom sector, introduction of new services/ technologies, on the other";
b. For transitioning to 5G technology, etc., the TSPs need to be in good health with sufficient capacities to make regular and substantial capital expenditure;
c. In the 2021 auction, only 37.1% of the spectrum put to auction was acquired by TSPs.
d. Spectrum lying idle is a waste for the economy.

3.129 To gain better insight into the historical context in which the forthcoming auction will be held, the Authority took note of the bidding activity during the previous auctions, indicated in the Table below:

TABLE 3.2: BIDDING ACTIVITY IN PREVIOUS AUCTIONS

Year of Auction	Spectrum Band	Quantum of spectrum put to auction (MHz)	Quantum of spectrum sold (MHz)	% Quantum of spectrum unsold	No. of LSAs that remained unsold	Number of bidders who acquired spectrum
2015	800MHz	108.75 (20 LSAs)	86.25 (18 LSAs)	20.69%	2	3
	900MHz	177.8 (17 LSAs)	168 (17 LSAs)	5.51%	-	4
	1800 MHz	99.2 (15 LSAs)	93.8 (14 LSAs)	5.44%	1	7
	2100 MHz	85 (17 LSAs)	70 (14 LSAs)	17.65%	3	3
2016	700 MHz	770 (22 LSAs)	-	100%	22	-

[23] Chan, Yi Shen and Sarongrat Wongsaroj (2016), *Valuing Spectrum in Thailand: what can we learn?*, Plum Insight, available at plumconsulting.co.uk.

	800MHz	73.75 (19 LSAs)	15 (4 LSAs)	79.66%	15	1
	900MHz	9.4 (4 LSAs)	-	100.00%	22	-
	1800 MHz	221.6 (21 LSAs)	174.8 (19 LSAs)	21.12%	2	7
	2100 MHz	360 (22 LSAs)	85 (12 LSAs)	76.39%	10	3
	2300 MHz	320 (16 LSAs)	320 (16 LSAs)	-	-	3
	2500 MHz	600 (22 LSAs)	370 (20 LSAs)	38.33%	2	2
2021	700 MHz	660 (22 LSAs)	-	100%	22	-
	800MHz	230 (22 LSAs)	150 (19 LSAs)	34.78%	3	2
	900MHz	98.8 (19 LSAs)	38.4 (9 LSAs)	61.13%	10	2
	1800 MHz	355 (22 LSAs)	152.2 (21 LSAs)	57.13%	1	3
	2100 MHz	175 (19 LSAs)	15 (3LSAs)	91.43%	16	1
	2300 MHz	560 (22 LSAs)	500 (22 LSAs)	10.71%	-	2
	2500 MHz	230 (12 LSAs)	-	100.00%	22	-

3.130 The above table indicates that the number of bidders/ players has decreased and a considerable quantity of spectrum remained unsold.

3.131 Further, while arriving at the reserve price, the Authority has considered the market prices revealed in the auctions held in recent past and has adequately factored in the same for arriving at the respective valuation of different bands. Given that the Auction Discovered Prices in the recent past have not been market-clearing prices in many cases, the reliance placed on them for setting the reserve prices for the forthcoming auction need closer scrutiny. As has been mentioned earlier, while there is no doubt that ADP is the best available indicator of spectrum value, the time has come to reconsider its utility as the sole determinant of reserve price at the last stage of the valuation and reserve-price-setting exercises of the Authority. Such an approach has the effect of holding the reserve prices, and consequently the outcomes of the auction, captive to the past – a past that may not have delivered optimal results in all cases. As we have noted already and has been brought to the attention of the Authority by the stakeholders, past auction sales were shaped by many factors, including spectrum renewals and other legacy issues. Further, as is brought out above, the auction prices in most cases have stopped being the market clearing prices in the last few auctions.

3.132 The Authority has analysed the details of spectrum prices in various bands for the previous auctions and these are given below:

TABLE 3.3: SPECTRUM PRICES IN PREVIOUS AUCTIONS

Year of Auction	Spectrum Band	No. of LSAs where spectrum was put to auction	No. of LSAs where spectrum was sold	No. of LSAs where ADP>RP
2015	800MHz	20	18	14
	900MHz	17	17	17
	1800 MHz	15	14	9
	2100 MHz	17	14	10
2016	700 MHz	22	-	No bid received
	800MHz	19	4	3
	900MHz	4	-	No bid received
	1800 MHz	21	19	6
	2100 MHz	22	12	Nil
	2300 MHz	16	16	6
	2500 MHz	22	20	1
2021	700 MHz	22	-	No bid received
	800MHz	22	19	Nil
	900MHz	19	9	Nil
	1800 MHz	22	21	Nil
	2100 MHz	19	3	Nil
	2300 MHz	22	22	Nil
	2500 MHz	12	-	No bid received

3.133 It is noted by the Authority that, in the auction of 2021, even in bands where spectrum has been sold, it has been sold at the reserve price, whether completely or partially. Therefore, the Authority is not inclined to place an over-reliance on the Auction Determined Prices for the purpose of arriving at reserve prices at the final stage. In any case, besides using the ADP itself as one of the valuations in the respective bands, it has also been factored into three of the six methodologies used for the baseline 1800 MHz band.

3.134 The context in which the auction is held plays an important role while deciding upon the level of the reserve prices. For example, in its 2013 recommendations, the Authority had recommended the reserve price of the 1800 MHz spectrum band as the lower of the two figures – 80% of the average valuation or the price realised in the November, 2012 auction in each LSA, after noting that the realised price (in November, 2012) was not a market clearing price. At the same time, in the October, 2014 recommendations, the Authority recommended a different criterion for setting the reserve price, noting the "changed context as well as circumstances surrounding the forthcoming auction".

3.135 As discussed above, the context of the forthcoming auction this time has been articulated by DoT in its letter of 02.11.2021. DoT has emphasized the need to strike a balance between generating revenue and the sustainability of the telecom sector in a way that TSPs are in good health with sufficient capacities to make regular and substantial capital expenditure for transitioning to 5G technology. DoT has also adverted to the Government's intent, *inter alia*, to infuse liquidity and encourage investment in the sector, and has highlighted that only 37.1% of the spectrum put to auction (in the previous auction) was acquired by TSPs and that spectrum lying idle is a waste for the economy. The inputs received by the Authority during the consultation process also point to the need for further rationalization of the reserve price.

3.136 As such, the Authority is inclined to consider that a reserve price set at 70% of the average valuation of spectrum band would go a long way in helping discover the market clearing price of the spectrum. As has been stated earlier, a reserve price is a means of achieving price discovery, and the Authority is of the view that a reserve price set at the level of 70% of average valuation in view of the context of the forthcoming auction, will ensure healthy competition, leading to the discovery of the true market price. However, in the LSAs where spectrum in a band was completely sold in the auction(s) held in the past two years (i.e., where market clearing prices have been achieved), the reserve price will be the higher of the two prices – (1) 70% of the average valuation; and (2) ADP (duly indexed) of the previous auction.

3.137 At the same time, the Authority recognizes the importance of a competitive auction process. The past few years have seen a sharp reduction in the number of TSPs offering wireless access services across LSAs. It is also a fact that simultaneously, the quantum of spectrum becoming available for auction is increasing, and new bands have been made available by the Government for telecom services. It is therefore imperative that the Government give serious thought to competition issues, and actively encourage the entry of new players into the telecom sector. The Authority accordingly, as mentioned in Chapter II, urges the Government to consider and decide upon the Authority's recommendations of 19.08.2021 on *Enabling Unbundling of Different Layers through Differential Licensing***.**

3.138 To accelerate the pace of investment in telecom infrastructure in the North East and Jammu & Kashmir LSAs and consistent with previous recommendations, **the Authority recommends that the reserve price for North East and Jammu & Kashmir LSAs in 800 MHz, 900MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz bands should be fixed at a discount of 50% on the reserve price. This discount for the North East and Jammu & Kashmir LSAs will also be applicable while arriving at reserve prices of other spectrum bands as well.**

3.139 The Authority, in light of the above discussion and having given careful consideration to the various aspects involved, is inclined to set the reserve price at a level of 70% of the average valuation arrived at for each band. Accordingly, **the Authority recommends that the reserve price for the 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz bands should be set as follows:**

- **a) At 70% of the average valuation;**
- **b) In the LSAs where spectrum in a band was completely sold in the March, 2021 auction, the reserve price shall be the higher of the two figures – (1) 70% of the average valuation; and (2)**

auction determined price of the March, 2021 auction, duly indexed.

3.140 **Accordingly, the recommended reserve price of 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz spectrum bands for each LSA is tabulated below**:

TABLE 3.4: RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN 800 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	478.79	479
Kolkata	Metro	152.61	153
Mumbai	Metro	467.70	468
Andhra Pradesh	A	292.12	292
Gujarat	A	262.17	262
Karnataka	A	198.44	198
Maharashtra	A	337.73	338
Tamilnadu	A	224.77	225
Haryana	B	61.57	62
Kerala	B	103.16	103
Madhya Pradesh	B	136.03	136
Punjab	B	101.43	101
Rajasthan	B	141.91	142
U. P. (East)	B	160.30	160
U.P. (West)	B	133.25	133
West Bengal	B	88.91	89
Assam	C	50.17	50
Bihar	C	126.33	126
Himachal Pradesh	C	22.27	22
Jammu & Kashmir	C	13.82	14
North East	C	13.38	13
Orissa	C	53.62	54

TABLE 3.5: RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN 900 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	436.02	436
Kolkata	Metro	152.79	153
Mumbai	Metro	389.15	389
Andhra Pradesh	A	288.17	288
Gujarat	A	399.11	399
Karnataka	A	203.59	204
Maharashtra	A	317.27	317
Tamilnadu	A	221.78	222
Haryana	B	67.69	68
Kerala	B	212.93	213
Madhya Pradesh	B	155.66	156
Punjab	B	104.10	104
Rajasthan	B	134.59	135
U. P. (East)	B	166.11	166
U.P. (West)	B	151.79	152
West Bengal	B	98.80	99
Assam	C	55.98	56
Bihar	C	147.16	147
Himachal Pradesh	C	25.83	26
Jammu & Kashmir	C	16.38	16
North East	C	13.80	14
Orissa	C	64.22	64

TABLE 3.6: RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN 1800 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	269.60	270
Kolkata	Metro	96.70	97
Mumbai	Metro	236.16	236
Andhra Pradesh	A	171.57	172

Gujarat	A	150.43	150
Karnataka	A	120.87	121
Maharashtra	A	190.33	190
Tamilnadu	A	140.59	141
Haryana	B	40.58	41
Kerala	B	58.10	58
Madhya Pradesh	B	87.94	88
Punjab	B	61.16	61
Rajasthan	B	74.88	75
U. P. (East)	B	91.06	91
U.P. (West)	B	86.88	87
West Bengal	B	57.57	58
Assam	C	31.76	32
Bihar	C	81.76	82
Himachal Pradesh	C	14.45	14
Jammu & Kashmir	C	9.11	9
North East	C	8.49	8
Orissa	C	35.12	35

TABLE 3.7: RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN 2100 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	223.77	224
Kolkata	Metro	80.26	80
Mumbai	Metro	196.01	196
Andhra Pradesh	A	142.40	142
Gujarat	A	124.86	125
Karnataka	A	100.32	100
Maharashtra	A	157.97	158
Haryana	B	33.68	34
Kerala	B	48.22	48
Madhya Pradesh	B	72.99	73
Punjab	B	50.76	51
U.P. (West)	B	72.11	72
West Bengal	B	37.00	37

Assam	C	24.41	24
Bihar	C	67.86	68
Himachal Pradesh	C	11.99	12
Jammu & Kashmir	C	7.56	8
North East	C	4.65	5
Orissa	C	29.15	29

TABLE 3.8: RECOMMENDED RESERVE PRICE PER MHz (UNPAIRED) IN 2300 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	104.34	104
Kolkata	Metro	32.17	32
Mumbai	Metro	103.07	103
Andhra Pradesh	A	58.57	59
Karnataka	A	63.54	64
Tamilnadu	A	81.06	81

TABLE 3.9: RECOMMENDED RESERVE PRICE PER MHz (UNPAIRED) IN 2500 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	85.87	86
Kolkata	Metro	28.17	28
Mumbai	Metro	81.05	81
Andhra Pradesh	A	50.73	51
Gujarat	A	44.13	44
Karnataka	A	46.88	47
Maharashtra	A	53.39	53
Tamilnadu	A	58.10	58
Punjab	B	13.95	14
Bihar	C	15.07	15
Himachal Pradesh	C	2.65	3
Jammu & Kashmir	C	1.62	2

E. VALUATION OF SUB-1 GHZ BANDS

3.141 Under the technical/ spectral efficiency approach, the coverage/ propagation characteristics of a particular band are compared with the coverage of another spectrum band and a technical efficiency factor is derived as a ratio. This method has been used in the past recommendations by the Authority for valuation of various bands.

3.142 Given the similarity in the technical characteristics of sub-1 GHz bands, applying a methodology of a uniform technical factor, with reference to a similar band, can also be considered. Accordingly, the following question was raised in the CP:

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.

3.143 Some stakeholders have supported using a single methodology for valuation of all sub-1GHz bands by benchmarking the valuation where eco-system and past auction determined prices are available, whereas some others disagreed with this approach. A few stakeholders suggested that for newer bands, reserve prices may be set in line with international experience.

3.144 The Authority notes that the sub-1 GHz bands provide benefits of enhanced coverage and penetration thereby enabling the TSPs to serve a customer base spread over a large area. These lower bands are capable of covering wide areas with better propagation inside buildings as well. A GSMA report[24] indicates that mobile spectrum capacity below 1 GHz can lower the digital divide between urban and rural areas and help create digital equality. The characteristics of low-band spectrum give a consistent user experience across urban and rural areas at less cost.

[24] https://www.gsma.com/spectrum/wp-content/uploads/2021/04/WRC-23-Low-Band-Capacity.pdf

3.145 In previous valuation exercises for the 800 MHz and 900 MHz bands, the Authority noted that in comparison to 1800 MHz, technical efficiency of the 800 MHz band is similar to that of the 900 MHz band. Further, the 800 MHz and 900 MHz bands have been identified as IMT bands by ITU. Therefore, the Authority has, in the present exercise, decided to make use of the average valuation of the spectrum in the 800 MHz band as one of the possible valuations of spectrum in the 900 MHz band.

(1) Valuation of spectrum in 700 MHz band

3.146 The 700 MHz band, being a lower frequency band, provides better indoor and outdoor coverage compared to higher frequencies where additional cell sites/ towers would be required to be deployed to gain equivalent levels of coverage.

3.147 The Authority had earlier used internationally available market prices or the relative technical efficiency factor with another spectrum band to determine the value of 700 MHz spectrum band. The band was put to auction two times in India, first in October, 2016 and next in March, 2021. However, no bids were received for this band in both the auctions. Hence, there is no historical auction determined price data available to arrive at the valuation of this band. Accordingly, the following questions were asked in the CP:

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.

3.148 Many stakeholders are of the view that the relative lack of interest for this spectrum band is due to high/ over valuation of spectrum, slow development of the overall 5G ecosystem in the past, and the requirement of high capital investment for rolling out 5G services using this band.

3.149 Some of the stakeholders are of the view that it is imperative to revise the valuation approach and instead of linking to 1800 MHz band, this band should be linked to a band similar in propagation characteristics. The sub-1GHz bands are technically quite similar and the technical parameters of the 800 MHz band are much closer to those of the 700 MHz band, rather than those of the 1800 MHz band.

3.150 One stakeholder is of the view that the Government should consider allocating the spectrum in the 700MHz band to TSPs at a cost which may only allow the recovery of administrative costs (or nominal costs) *via* auction.

3.151 A few stakeholders have suggested that the valuation of this band needs to be aligned with international benchmarks.

3.152 The Authority has carefully examined the comments of the stakeholders. As is evident, there is little consensus among the views of different stakeholders.

3.153 As per a GSA report[25] on “Low Band Spectrum for LTE and 5G: May 2021”, a total of 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

[25] GSA - Low Band Spectrum for LTE and 5G (May 2021)

launched commercial LTE or 5G services in the band. Three operators have launched both, 55 have launched LTE and eight have launched 5G. As regards the device ecosystem for APT 700 (n28) band, as per the report published by GSA[26], 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. Thus, it can be inferred that LTE/5G ecosystem is developing fast in 700 MHz spectrum band. Global telecom players are already using the 700 MHz band to roll out 5G services.

3.154 In a whitepaper[27] released by Huawei in December, 2016 on LTE APT 700 deployment, the propagation characteristics of different bands have been compared. The higher frequency bands (>1GHz) have larger propagation loss and the low frequency bands such as 700 MHz and 800 MHz bands have lower propagation losses. Huawei has compared the APT 700 band with several other LTE bands adopting Hata model, which is divided into Okumura-Hata model and Cost231-Hata model to calculate the propagation loss. It has been stated that a single site coverage area using 700MHz band is almost 2 times larger than 1800 MHz band.

3.155 In the Nokia Technical Note referred to earlier, it has been indicated that the technical efficiency factor of 700MHz is proposed to be taken as comparable to the 800 MHz band.

3.156 The Authority notes that the 700 MHz band was put to auction twice earlier in 2016 and 2021. With a reduced reserve price in the second auction, it still remained unsold. The Authority is therefore of the view that, given its potential for improving network efficiency and to mitigate the risk of this band lying idle for longer, the valuation of the 700 MHz band merits a closer look in light of the discussions above, vis-à-vis the

[26] GSA - Low Band Spectrum for LTE and 5G (May 2021)

[27] APT 700 LTE whitepaper)Q4-2016 (Issue, https//:gsacom.com/paper/apt700-white-paper-huawei /

technical efficiency with respect to the 800 MHz band, in addition to the 1800 MHz band.

3.157 Accordingly, the valuation of this band has been conducted using the technical efficiency approach whereby the 700MHz band is valued in two ways: (1) at two times that of the 1800 MHz band; and (2) equal to that of the 800 MHz band.

3.158 Based on the above, the valuations arrived at for the 700 MHz spectrum band are at **Annexure 3.13.**

(2) Valuation of spectrum in 600 MHz band

3.159 With respect to the auctioning of frequencies in the range 526-698 MHz and its valuation, the following questions were raised in the CP:

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.

3.160 With regard to whether the entire spectrum in the range 526-698 MHz should be put to auction, the discussion and the Authority's recommendations at paragraphs 2.3 to 2.22 of Chapter-II may be referred to. Hence, the valuation exercise has been conducted for the 600 MHz (APT 600 MHz Option B1) band only.

3.161 Regarding the valuation of the spectrum in this band using technical efficiency approach or some other valuation approach, certain stakeholders who are of the view that this band must be put to auction have suggested linking this band with the other sub-GHz bands. A few stakeholders have suggested that this band must be priced equal to the 700 MHz band. Another stakeholder suggested that the valuation of this band must be equal to that of the 800 MHz band due to technical similarities with other sub-1 GHz bands. Some stakeholders suggested that international benchmarking in this or the 700 MHz band with normalization may be used for arriving at a valuation.

3.162 The Authority is conscious that the 600 MHz band are being put to auction for the first time in India. Internationally 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 data in this spectrum band.

3.163 Based on the comments received, there seems to be a consensus amongst stakeholders that this band provides enhanced coverage. Accordingly, the Authority is of the view that the technical efficiency approach can be used to link this band with other sub-1 GHz bands. Considering that the technical characteristics of the 600 MHz band are comparable to that of the 700 MHz band, and considering further that the ecosystem in the 600 MHz band is relatively less developed than that in the 700 MHz band[28], the Authority has decided to approach the valuation of the 600 MHz band by treating it as equal to the valuation of the 700 MHz band. Using this approach, the valuations arrived at for the 600 MHz band are at **Annexure 3.14.**

[28] GSA - Low Band Spectrum for LTE and 5G (May 2021)

3.164 The valuations of 600 MHz band is given below:

TABLE 3.10: VALUE PER MHZ OF 600 MHZ BAND (PAIRED) (20 years)

(Rs in crore)

LSA	Category	Value per MHz of 600 MHz
Delhi	Metro	727.14
Kolkata	Metro	247.15
Mumbai	Metro	671.44
Andhra Pradesh	A	453.76
Gujarat	A	402.17
Karnataka	A	314.42
Maharashtra	A	513.13
Tamilnadu	A	361.39
Haryana	B	101.95
Kerala	B	156.68
Madhya Pradesh	B	222.80
Punjab	B	159.82
Rajasthan	B	208.34
U. P. (East)	B	244.59
U.P. (West)	B	219.29
West Bengal	B	145.76
Assam	C	81.20
Bihar	C	207.03
Himachal Pradesh	C	36.54
Jammu & Kashmir	C	45.76
North East	C	43.37
Orissa	C	88.47

(3) Arriving at the average valuation of the 700 MHz band

3.165 As detailed at paragraph 3.63 above of this Chapter, the Authority has decided that the average expected valuation of 700 MHz spectrum band in a LSA should be based on simple mean of the various valuation approaches in this band.

3.166 Accordingly, the LSA-wise average expected value of 700 MHz spectrum band is tabulated below :

TABLE 3.11: AVERAGE VALUE PER MHZ OF 700 MHZ BAND (PAIRED) (20 years)

(Rs in crore)

LSA	Category	Average Value per MHz of 700 MHz
Delhi	Metro	727.14
Kolkata	Metro	247.15
Mumbai	Metro	671.44
Andhra Pradesh	A	453.76
Gujarat	A	402.17
Karnataka	A	314.42
Maharashtra	A	513.13
Tamilnadu	A	361.39
Haryana	B	101.95
Kerala	B	156.68
Madhya Pradesh	B	222.80
Punjab	B	159.82
Rajasthan	B	208.34
U. P. (East)	B	244.59
U.P. (West)	B	219.29
West Bengal	B	145.76
Assam	C	81.20
Bihar	C	207.03
Himachal Pradesh	C	36.54
Jammu & Kashmir	C	45.76
North East	C	43.37
Orissa	C	88.47

(4) Estimation of Reserve Price of the 700 MHz and 600 MHz bands

3.167 After carefully considering the comments given by the stakeholders and in light of the discussions above, **the Authority recommends that the reserve price of spectrum in the 700 MHz band should be set at 70% of the valuation arrived at. The reserve price of the spectrum in the 600 MHz band should be equal to the reserve price of 700 MHz spectrum band.**

3.168 **Thus, the recommended reserve price of the 600 MHz and 700 MHz spectrum bands for each LSA are:**

TABLE 3.12: RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN THE 600 MHz AND 700 MHz BANDS (20 years)

(Rs. in crore)

(1) LSA	(2) Category	(3) Reserve Price (as calculated)	(4) Recommended Reserve Price (Rounded off)
Delhi	Metro	509.00	509
Kolkata	Metro	173.00	173
Mumbai	Metro	470.01	470
Andhra Pradesh	A	317.63	318
Gujarat	A	281.52	282
Karnataka	A	220.09	220
Maharashtra	A	359.19	359
Tamilnadu	A	252.97	253
Haryana	B	71.36	71
Kerala	B	109.68	110
Madhya Pradesh	B	155.96	156
Punjab	B	111.87	112
Rajasthan	B	145.84	146
U. P. (East)	B	171.21	171
U.P. (West)	B	153.50	154
West Bengal	B	102.03	102
Assam	C	56.84	57
Bihar	C	144.92	145
Himachal Pradesh	C	25.58	26
Jammu & Kashmir	C	16.02	16
North East	C	15.18	15
Orissa	C	61.93	62

F. VALUATION AND RESERVE PRICE OF SPECTRUM IN THE 3300-3670 MHZ (MID-BAND)

(1) Valuation of the 3300-3670 MHz band

3.169 The Authority in its Recommendations of 01.08.2018 on 'Auction of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz, 3400-3600 MHz Bands' recommended the reserve price of the 3300-3600 MHz band equal to 30% of the reserve price of the 1800 MHz FDD band keeping in view of the Nokia Technical Note coverage analysis according to which the 3300-3600 MHz spectrum band TDD coverage will be around 30% of the 1800 MHz FDD coverage. In the spectrum auction held in March, 2021, spectrum in the 3300-3600 MHz band was not put to auction by DoT. In its letter of 02.11.2021, DoT stated that the TRAI recommended reserve price of spectrum in the 3300-3600 MHz band of the TRAI recommendations dated 01.08.2018 was accepted by the Digital Communications Commission (DCC) in its meeting held in December, 2019. However, the auction of spectrum in the 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 now become available. DoT stated that the Authority may like to consider issues such as the changes in the context and timing of the auction, increase in tenure of spectrum assigned through auction, etc., while making recommendations regarding this band.

3.170 The following question was raised in the CP in this context:

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.

3.171 A few stakeholders have supported the use of technical efficiency factor in the valuation of the 3300-3670Mhz band with respect to the 1800 MHz band, while another set of stakeholders suggested that the technical efficiency factor must be based on the total cost of ownership (TCO) of the band. Some stakeholders even favored technically linking this band to other mid-band spectrum such as in the 2300 and 2500 MHz bands. Some stakeholders have favoured the use of international benchmarking after normalization, using parameters such as ARPU, revenue, per capita income, license duration, and RoCE.

3.172 One stakeholder suggested an alternative approach by analyzing the marginal revenue contribution of 5G technology with a focus on CAPEX and OPEX of that technology. Some stakeholders have suggested that the past recommended reserve price in the 2018 recommendation must be scaled down by at least 90-95%.

3.173 The Authority has carefully examined the views of the stakeholders. Undoubtedly, spectrum in this band is very important for launching 5G services in India, and getting the price right is critical not only for the success of the forthcoming auction, but also to ensure early rollout of 5G services. The Authority, in its 2018 recommendations, used this approach wherein the reserve price was estimated based on the coverage characteristics of this band relative to the 1800 MHz band. The Authority has been following this approach consistently for arriving at the technical efficiency factor of other bands too, such as the 2100 MHz and the sub-1 GHz bands.

3.174 The Authority also analyzed the experience gained in international auctions in this band. Earlier, this kind of approach was used by the Authority for recommending reserve prices for the 700MHz, 2100 MHz, and 2300 MHz bands. As has also been argued earlier (in the discussion under Q.41), the Authority is of the view that using ARPU for adjustment/ normalization will not be a rational exercise. Parameters such as population and GSDP per capita offer greater promise, since they would be good proxies for market potential.

3.175 In its 2018 recommendations, the Authority recommended the reserve price of the 3300-3600 MHz TDD band at 30% of the 1800 MHz FDD band price based on coverage characteristics. Since the band was not put to auction so far, there is no data regarding the revealed market preference for this band. A period of nearly 4 years has passed since the earlier recommendations of the Authority. Also, DoT has, in its letter dated 02.11.2021, indicated that “[t]here are apparently changes in the context and timing of auction, and may be changes in various factors that may have a bearing on reserve prices etc."

3.176 In this background, the Authority has decided to conduct a fresh valuation exercise for this band. At the same time, in the absence of market data/ auction prices for this band, the Authority is inclined to continue with the same approach as before of valuing the 3300-3670 MHz (TDD) band on the basis of its technical efficiency with reference to of the 1800 MHz (FDD) band. The Authority notes that the changes made to the valuation and reserve price setting exercise for the baseline band (1800 MHz FDD) are likely to reflect the changes that have occurred in the context and timing of the forthcoming auction for the 3300-3670 MHz (TDD) band as well.

3.177 The technical note prepared by Nokia on "5G Spectrum and Coverage Consideration Aspects", 2018, mentions that the 3.5 GHz band is expected to operate on TDD mode. Coverage from 5G using this band will be limited as it will suffer both due to high propagation loss and TDD mode penalty. As per coverage analysis by Nokia, the 3.5 GHz band TDD coverage will be around 70% lower than the 1800 MHz band FDD coverage. Taking the 1800 MHz band FDD coverage as reference, the 3300-3670 MHz band TDD coverage has been estimated to be around 30% of the 1800 MHz FDD coverage.

3.178 After examining the comments of the stakeholders, open house discussions, industry reports, and considering the evolution of 5G and related ecosystem in this band, the Authority is of the view that the spectrum band 3300-3670 MHz should be treated as a single band of 370 MHz which is expected to operate in TDD Mode. The Authority, therefore, in light of the foregoing discussions, has decided a valuation for the 3300-3670 MHz TDD band equivalent to 30% of the average valuation of the 1800 MHz FDD band**.** As the 3300-3670 MHz band is unpaired, the valuation of the 3300-3670 MHz band has been calculated accordingly. Using this approach, the valuations arrived at for this band are at **Annexure 3.15.**

3.179 The LSA-wise valuation of the 3300-3670 MHz band is given below:

TABLE 3.13: VALUE PER MHz

IN THE 3300-3670 MHz BAND (UNPAIRED) (20 years)

(Rs. in crore)

LSA	Category	Value per MHz of 3300-3670 MHz
Delhi	Metro	57.77
Kolkata	Metro	20.72
Mumbai	Metro	50.61
Andhra Pradesh	A	36.77
Gujarat	A	32.24
Karnataka	A	25.90
Maharashtra	A	40.78
Tamilnadu	A	30.13
Haryana	B	8.70
Kerala	B	12.45
Madhya Pradesh	B	18.84
Punjab	B	13.11
Rajasthan	B	16.05
U. P. (East)	B	19.51
U.P. (West)	B	18.62
West Bengal	B	12.34
Assam	C	6.80
Bihar	C	17.52
Himachal Pradesh	C	3.10
Jammu & Kashmir	C	3.90
North East	C	3.64
Orissa	C	7.53

(2) Reserve Price of the 3300-3670 MHz band

3.180 In light of the discussions above, **the Authority recommends that the reserve price of spectrum in the 3300-3670 MHz band should be set at 70% of the valuation arrived at.**

3.181 **Thus, the recommended reserve price of the 3300-3670 MHz spectrum band for each LSA is tabulated below:**

TABLE 3.14: RECOMMENDED RESERVE PRICE PER MHz IN 3300-3670 MHz BAND (UNPAIRED) (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	40.44	40
Kolkata	Metro	14.50	15
Mumbai	Metro	35.42	35
Andhra Pradesh	A	25.74	26
Gujarat	A	22.57	23
Karnataka	A	18.13	18
Maharashtra	A	28.55	29
Tamilnadu	A	21.09	21
Haryana	B	6.09	6
Kerala	B	8.71	9
Madhya Pradesh	B	13.19	13
Punjab	B	9.17	9
Rajasthan	B	11.23	11
U. P. (East)	B	13.66	14
U.P. (West)	B	13.03	13
West Bengal	B	8.64	9
Assam	C	4.76	5
Bihar	C	12.26	12
Himachal Pradesh	C	2.17	2
Jammu & Kashmir	C	1.37	1
North East	C	1.27	1
Orissa	C	5.27	5

G. VALUATION AND RESERVE PRICE OF SPECTRUM IN THE 24.25 GHZ – 28.5 GHZ BAND (MMWAVE)

(1) Valuation of the 24.25-28.5 GHz band

3.182 The 24.25 – 28.5 GHz spectrum band is being contemplated for auction in India for the first time. There is neither any historical auction data nor financial/ non-financial information pertaining to this band with the

Authority. Thus, alternative approaches for valuation of this band could be based on relative technical efficiency factor of some other spectrum bands or the possibility of using international benchmarking.

3.183 Accordingly, the following questions were raised in the CP:

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.

3.184 One stakeholder has favoured the use of technical efficiency factor linking mmWave band with the mid-band based on their bandwidth ratios. Some stakeholders have rejected the use of technical efficiency method, as these radio frequencies have low propagation and support limited use cases as compared to other frequencies. Many stakeholders stated that international price ratios between the mmWave band and the mid-band be used for fixing reserve price for this band. Some stakeholders suggested that the price of the 24.25 - 28.5 GHz band should not be more than 1-2% of the price of the 3300-3670 MHz spectrum.

3.185 Regarding the valuation of new bands using international benchmarking by comparing the auction revealed prices where auctions have taken place, the following questions were raised in the CP:

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.

3.186 Many stakeholders favoured the use of international benchmarking for the valuation of new bands. Their preference is for using international auction prices discovered in concluded auctions, along with some form of normalization for country-specific parameters, such as ARPU, revenue potential, and RoCE, while avoiding population as a parameter. The stakeholders are also of the view that as per global standards Indian prices in some spectrum bands are quite high and significant reduction is required.

3.187 One stakeholder suggested that along with using auction prices, the incremental revenue potential of 5G bands in other countries must be factored in. Some stakeholders suggested using international price ratios between the 26 GHz band and the 3.5 GHz band for fixing reserve prices of mmWave band.

3.188 It is not feasible to set reserve prices on the basis of incremental revenue accruing from 5G internationally, as most of the auctions for the new 5G bands have been concluded in the previous 3 years, and the services have not yet attained critical mass. However, the Authority notes that wherever auctions for both the mmWave and mid band spectrum have taken place, these can be utilised to arrive at the valuation of the mmWave by using relative price analysis. Such an approach would also make redundant the use of normalization factors, since the comparison of prices is between the prices of the two bands for the same country in each case.

3.189 The international auction revealed prices per MHz in some countries where auctions of mid band and mmWave bands have taken place, is given below:

TABLE 3.15: INTERNATIONAL AUCTION PRICES IN THE MMWAVE BAND

Country	Mid Band	Auction Price per MHz per pop (in US $)	mmwave Band	Auction Price per MHz per pop (in US $)
USA	3.45 GHz	0.67	24GHz	0.009
USA	3.7 GHz	0.88	28GHz	0.003
Greece	3.4-3.8GHz	0.03	26 GHz	0.002
Taiwan	3.3-3.5 GHz	0.74	28 GHz	0.001
Australia	3.6GHz	0.21	26 GHz	0.009
Italy	3.4-3.8GHz	0.43	26 GHz	0.003
Republic of Korea	3.5GHz	0.20	28 GHz	0.005
Finland	3.4-3.8GHz	0.04	26GHz	0.002
Singapore	3.5 GHz	0.07	26 GHz	0.0001
Source : Global Mobile Suppliers Association, Regulators websites, S&P Global				

3.190 Based on the above prices, after adjusting the per MHz per pop prices for the differences in spectrum assignment duration for mid-band and mmwave band, if any, the country wise ratio of auction prices per MHz per pop per year for mmwave bands vis-à-vis mid-band has been calculated and is tabulated, as below:

TABLE 3.16: RATIO OF INTERNATIONAL AUCTION PRICES

Ratio of Auction Price Per MHz per Pop per year	
Country	**Mm-wave band/ Mid band**
USA (24/3.4)	0.020
USA(28/3.4)	0.006
USA (24/3.7)	0.015
USA(28/3.7)	0.004
South Korea	0.048
Italy	0.008
Australia	0.031
Taiwan	0.002
Greece	0.064
Finland	0.042
Singapore	0.001
Mean	**0.022**

3.191 As per the international auction price ratio analysis conducted, the average auction price ratio between the two bands viz. mmWave band and mid-band is about 2.20%. Since the ratio is between auction prices of the two bands in the same country, it avoids the problem of cross-country divergences, and thereby no further normalization would be required.

3.192 In view of the above, the Authority, therefore, has decided that valuation for the 24.25 – 28.5 GHz band shall be 2.20% of the valuation of the 3300-3670 MHz band. Using this approach, the valuations arrived at for the 24.25 – 28.5 GHz band are at **Annexure 3.16.**

3.193 The LSA-wise valuation of the 24.25 – 28.5 GHz band is given below:

TABLE 3.17: VALUE PER MHz

IN 24.25 – 28.5 GHz BAND (UNPAIRED) (20 years)

(in Rs.)

LSA	Category	Value per MHz of 24.25 – 28.5 GHz
Delhi	Metro	127.10 lakh
Kolkata	Metro	45.59 lakh
Mumbai	Metro	111.33 lakh
Andhra Pradesh	A	80.88 lakh
Gujarat	A	70.92 lakh
Karnataka	A	56.98 lakh
Maharashtra	A	89.73 lakh
Tamilnadu	A	66.28 lakh
Haryana	B	19.13 lakh
Kerala	B	27.39 lakh
Madhya Pradesh	B	41.46 lakh
Punjab	B	28.83 lakh
Rajasthan	B	35.30 lakh
U. P. (East)	B	42.93 lakh
U.P. (West)	B	40.96 lakh
West Bengal	B	27.14 lakh
Assam	C	14.97 lakh
Bihar	C	38.54 lakh
Himachal Pradesh	C	6.81 lakh
Jammu & Kashmir	C	8.58 lakh
North East	C	8.00 lakh
Orissa	C	16.56 lakh

(2) Reserve Price of the 24.25 – 28.5 GHz band

3.194 In light of the discussions above, **the Authority recommends that the reserve price of the spectrum in the 24.25 GHz – 28.5 GHz band should be set at 70% of the valuation arrived at.**

3.195 **Accordingly, the recommended reserve price of 24.25 – 28.5 GHz band for each LSA, is tabulated below:**

TABLE 3.18: RECOMMENDED RESERVE PRICE PER MHz

IN 24.25 – 28.5 GHz BAND (UNPAIRED)
(20 years)

(in Rs.)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	88.97 lakh	89 lakh
Kolkata	Metro	31.91 lakh	32 lakh
Mumbai	Metro	77.93 lakh	78 lakh
Andhra Pradesh	A	56.62 lakh	57 lakh
Gujarat	A	49.64 lakh	50 lakh
Karnataka	A	39.89 lakh	40 lakh
Maharashtra	A	62.81 lakh	63 lakh
Tamilnadu	A	46.39 lakh	46 lakh
Haryana	B	13.39 lakh	13 lakh
Kerala	B	19.17 lakh	19 lakh
Madhya Pradesh	B	29.02 lakh	29 lakh
Punjab	B	20.18 lakh	20 lakh
Rajasthan	B	24.71 lakh	25 lakh
U. P. (East)	B	30.05 lakh	30 lakh
U.P. (West)	B	28.67 lakh	29 lakh
West Bengal	B	19.00 lakh	19 lakh
Assam	C	10.48 lakh	10 lakh
Bihar	C	26.98 lakh	27 lakh
Himachal Pradesh	C	4.77 lakh	5 lakh
Jammu & Kashmir	C	3.00 lakh	3 lakh
North East	C	2.80 lakh	3 lakh
Orissa	C	11.59 lakh	12 lakh

H. ASSOCIATED CONDITIONS

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

3.196 The Notice Inviting Applications (NIA) for 'Auction of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz & 2500 MHz Bands' dated 6th January, 2021, *inter alia* contains 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."*

3.197 In this regard, the following question was raised in the CP:

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.

3.198 Almost all the stakeholders suggested that DoT may follow the method followed in the previous auctions in respect of collecting bid amount from the successful bidder in case spectrum is not available in a part of the

LSA. Only one stakeholder has stated that the balance pro-rated amount should not be indexed at the time of collection as it is the licensors' inability to make the spectrum available in some areas that is the source of the problem and, therefore, the licensees should not be forced to bear that burden. The Authority notes that there is a broad consensus among stakeholders regarding the methodology being adopted by DoT, with a few minor differences. The Authority is of the view that this methodology is well-known to the stakeholders and need not be tinkered with.

3.199 Therefore, **the Authority recommends that for collecting the bid amount from the successful bidder in case spectrum is not available in a part of the LSA, the existing methodology, as followed by DoT in the NIA for the March, 2021 auction, be followed in the forthcoming auction as well**.

(2) Payment Terms

3.200 The NIA dated 6th January, 2021 prescribes upfront payment of 50% in the case of 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands and 25% in the case of sub-1 GHz bands viz., 700 MHz, 800 MHz and 900 MHz, with some stipulations regarding spectrum becoming available at a later date. A moratorium period of two years for payment of balance amount of one-time charges for the spectrum has been prescribed and for deferred payments, the NIA states that the outstanding amount subsequent to the upfront payments shall be recovered in 16 equal annual instalments, duly protecting the net present value.

3.201 Further, DoT, in its letter of 23.9.2021 stated that in future auctions, access spectrum will be assigned for a period of 30 years. However, since in the 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. DoT has sought recommendations for associated conditions like upfront payment requirements, applicable moratorium period after upfront payments, number of deferred payment instalments and other related modalities, while undertaking auction for spectrum with validity for 30 years.

3.202 In this regard, the following questions were raised in the CP:

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?

3.203 In the Consultation Paper, stakeholders were invited to suggest the percentage of upfront payment, applicable moratorium period, number of instalments and the rate of discount for calculating amount of pre-payment/ deferred payment.

3.204 Many stakeholders suggested no upfront payment for the spectrum acquired in the upcoming auctions stating that such a measure would support investments as well as network deployment in the initial years and address the concerns of financial stress faced by the industry. On the other hand, any big upfront payment will effectively negate the relief package provided by the Government in September, 2021.

3.205 A few stakeholders have suggested uniform upfront payment of 10% of the bid amount irrespective of the spectrum band citing that there is a need to considerably relax the payment terms to provide initial impetus to the emerging technologies and give sufficient time for laying networks and monetize the spectrum.

3.206 Further, many stakeholders favoured moratorium for a period of 6 years and suggested that the outstanding amount subsequent to the upfront payments to be spread over the remaining validity period of spectrum. Also, some stakeholders (favouring a moratorium period of 5 years) also suggested the same method for recovering the deferred payment. However, a few other stakeholders suggested a distinct number of equated instalments, say 10/18, for recovering the deferred payment.

3.207 Regarding the rate of discount that should be used while exercising pre-payment/deferred payment option to ensure that the net present value of payment/ bid amount is protected, different stakeholders have expressed different views. The responses suggested include using the RBI repo rate, the SBI PLR, market rate of interest at 8-10%, G-Sec yield, and even that no interest rate be applied.

3.208 As can be seen from the comments above, many stakeholders are in favour of no or limited upfront payment, extension in the applicable moratorium period and number of equated yearly installments covering the license validity period.

3.209 The Authority has carefully considered the comments of the various stakeholders. The Authority notes that the recent reform package announced by the Government has, *inter alia*, increased the duration of assignment of spectrum from 20 years to 30 years. Further, the telecom service providers have been permitted to surrender spectrum acquired in the future auctions after a minimum period of 10 years, with due notice. To address the liquidity requirements of TSPs, the Government has also announced the extension of moratorium/ deferment of due payments of spectrum purchased in past auctions (excluding the auction of 2021) for up to four years, with NPV protected at the interest rate stipulated in the respective auction. The Government has also dispensed with the requirement for the successful bidder to submit a Financial Bank Guarantee of an amount equal to one annual instalment and Performance Bank Guarantee for roll-out obligations etc.

3.210 The Authority is also cognizant of the need for the long-term growth and sustainability of the telecom sector, infusing liquidity and encouraging investment, and the need for TSPs to be in good health so as to make regular and substantial capital expenditure for transitioning to 5G technology.

3.211 In light of above, the Authority is of the opinion that the TSPs be allowed the following flexible payment options:

Option I: Full or part upfront payment of the bid amount within 10 days of declaration of final price;

Where part upfront payment has been made, the buyer shall have the option of availing moratorium for the proportionate number of years for which the upfront payment has been made, and the balance amount shall be payable in equal annual instalments over the remaining period in advance at the beginning of the year, after the period of moratorium if any (duly protecting the net present value of the bid amount at the applicable rate of interest); the annual instalments shall become due and payable on the same date of each year.

Option II: Payment of 30 equal annual instalments of the bid amount (duly protecting the net present value of the bid amount at the applicable rate of interest) in advance at the beginning of the year, the first instalment becoming payable within 10 days of declaration of final price. The balance 29 instalments shall become due and payable on the same date of each following year.

3.212 Accordingly, **the Authority recommends that the following options be allowed to the buyers for making payments:**

(a) Option I: Full or part upfront payment of the bid amount within 10 days of declaration of final price;
Where part upfront payment has been made, the buyer shall have the option of availing moratorium for the proportionate

number of years for which the upfront payment has been made, and the balance amount shall be payable in equal annual instalments over the remaining period in advance at the beginning of the year, after the period of moratorium if any (duly protecting the net present value of the bid amount at the applicable rate of interest); the annual instalments shall become due and payable on the same date of each year.

(b) Option II: Payment of 30 equal annual instalments of the bid amount (duly protecting the net present value of the bid amount at the applicable rate of interest) in advance at the beginning of the year, the first instalment becoming payable within 10 days of declaration of final price. The balance 29 instalments shall become due and payable on the same date of each following year.

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 in 3GPP TS 22.261 as a Non-Public Network (NPN) and has been defined as "*a network that is intended for non-public use*".

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 public and uses spectrum defined in 3GPP[29].

4.4 The private cellular networks are suitable for different groups of applications, with specific architectures applicable to building various types of private networks[30]. They can be used by industries to 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. Enterprises use the private network to improve productivity, efficiency, flexibility, quality, security, and competitiveness.

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[29] GSA: https://gsacom.com/press-release/gsa-catalogues-370-private-mobile-networks/
[30] 5G Americas: Whitepaper on 5G Technologies in Private Networks (October 2020)

4.5 The newer cellular technologies such as LTE and 5G have enabled private networks to go wireless which give 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[31], the demand for private mobile networks based on LTE (and increasingly 5G) technologies is being driven by the spiraling 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 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.

B. Technologies for Private Network:

4.7 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.

4.8 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 economies of scale and interoperability benefits of global 3GPP technologies also apply to sector-specific equipment, and well-

[31] GSA: Private Mobile Networks (September 2021)

developed supply chains and established best practices are now in place in many sectors.

4.9 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[32].

4.10 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, 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[33].

4.11 There are some key features in the 5G system that make it very appealing for private network deployments. 3GPP Release 16 aims to enable 5G to substitute for private wired Ethernet, Wi-Fi, and LTE networks, and includes multiple capabilities designed specifically for industrial environments[34].

C. Benefits of private LTE and 5G networks for enterprises[35]

4.12 Private LTE and 5G networks for enterprises bring distinct benefits over use of public network especially for business critical and security critical applications:

- Superior service security through SIM-based authentication

[32] 5G Americas: Whitepaper on 5G Technologies in Private Networks (October 2020)
[33] https://stlpartners.com/telco_cloud/private-5g-vs-wi-fi-vs-private-lte/
[34] Deloitte: Technology, Media, and Telecommunications Predictions 2020
[35] https://zeetta.com/solutions/private-cellular-networks-for-enterprises/

- 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 optimized for the needs of specific user groups, devices or applications over the same infrastructure.

D. International Scenario on deployment of Private Cellular Networks

4.13 GSA in one of its report[36] 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/5G 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.

4.14 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

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

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

4.15 DoT, through its reference vide letter dated 13th September 2021 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.

4.16 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

4.17 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.

4.18 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.

4.19 As discussed, the demand of entities/enterprises/industries for private cellular network can be met by various means. The main ways, using which, the demand for private networks can be met are:

(i) Meeting the demand for private network through TSPs using a Network Slice from TSP's PLMN network.

(ii) Enterprise may request TSPs to establish an independent isolated private network in enterprise's premises using the TSP's spectrum.

(iii) Enterprise may obtain the spectrum on lease from TSPs and establish their own isolated Captive Wireless Private Network.

(iv) Enterprise may obtain the spectrum directly from the Government and establish their own isolated Captive Wireless Private Network.

a) Meeting the demand for private network through TSPs

4.20 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.

4.21 One way is a TSP could provide private network as a service to an enterprise, 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.

4.22 Another way is 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 be preferred in cases where security and control are the key concerns of the enterprise.

4.23 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.

4.24 With this background, stakeholders were asked whether any change(s) are required to be made in the licensing / policy framework to facilitate TSPs to meet the demand for Private Cellular Networks.

Comments received from the stakeholders

4.25 In their response, many stakeholders supported TSP-driven model by giving reasons such as - partnering with TSPs allows verticals to benefit from telecom operators' more extensive networks, more substantial spectrum assets, expertise, experience to run efficient networks for various use cases and solutions, and lower cost base. Other stakeholders mentioned that TSPs have alternate technological means available to support vertical use cases, such as, through network slicing, spectrum trading, sharing, leasing etc. One of the stakeholders submitted that TSPs can offer a wide range of managed solutions to industrial customers including 5G capabilities like 5G virtual networking for point-to-point connections, 5G private networks that cover a certain area, 5G+cloud, where vertical industry applications are deployed on the public cloud and connected through the 5G network and 5G edge computing for ultra-low latency processing.

4.26 Some stakeholders submitted that TSP-provided 5G services will not fully address India's private sector wireless needs. Thus, consider direct assignment of spectrum for Private Cellular Networks to the end users (viz. enterprise) at a nominal cost, allowing them the flexibility to partner with other stakeholders, including TSPs, OEMs, Application Service Providers, etc. Additionally, TSPs could purchase the spectrum and lease it to the enterprise at an affordable cost, and offer services based on 5G "network slicing".

4.27 Some of stakeholders mentioned that amendments may be required in the licensing framework and necessary changes in the licenses be enacted through a separate consultation that allows spectrum leasing, slicing. Another stakeholder suggested to modify the existing licensing framework to address the need for small, localized, independent, private broadband networks for specialized users including critical infrastructure, industrial, utilities and enterprises. One stakeholder suggested that in order to facilitate quick availability of technology and open the diverse ecosystem, private cellular networks should be kept out of the TSP's ambit.

4.28 One of the stakeholders mentioned that while some enterprises may be looking to partner with telecom service providers, some verticals may continue to operate their private networks and may desire access to spectrum. Consider this option carefully and consult stakeholders to ensure they most efficiently support the needs of verticals without undermining other spectrum users.

4.29 Couple of stakeholders proposed that an enabling framework be created to support alternate technological means and there is a need to facilitate and have policies that enable TSP to reuse the infrastructure deployed for public network to also provide private cellular network services through technologies like network slicing in 5G.

4.30 Another stakeholder mentioned that the auction-based allocation of spectrum is sufficient for meeting the demands of private networks. It has been suggested to further liberalize regime for spectrum trading, sharing and recommend guidelines for spectrum leasing.

4.31 Some stakeholders suggested for consideration of allocation of suitable frequencies for nominal fees to Enterprises directly, instead of creating dependency on cellular networks of Mobile operators. However, if at all, any leasing of spectrum is allowed by TSPs to the Industry, then framework for the same including prescription of formula for ceiling price at which such spectrum can be leased out to the Industry / Other ISPs by the TSPs be prescribed.

Analysis

4.32 As wide range of spectrum is available with mobile operators in different spectrum bands, it could enable them to address the industry needs in the best possible ways. As already discussed, the demand for Private Cellular Networks can be met by the TSPs in the following ways:

- A TSP could provide private network as a service to an enterprise by using network slicing over its public network. This is known as Public Network Integrated NPN. A Public Network Integrated NPN (PNI-NPN) can be made available by PLMNs e.g., using one (or more) network slice instance(s).
- A TSP could also provide private network service by establishing a separate isolated private network, including core and radio access network, for an enterprise/industry using its own existing IMT spectrum holding.

4.33 5G technology comes with a new feature of network slicing, which was not available with earlier cellular technologies. Network slicing allows running multiple logical customized networks on a shared common infrastructure complying with agreed SLAs for different vertical industry customers and requested functionalities.

4.34 While network slicing enabled network as a service will be using a slice of the public network deployed by the TSP, for the second option, TSP will set-up a private network for an enterprise/industry which will be isolated from the public network, using the IMT spectrum assigned to it for establishing Public Land Mobile Network (PLMN).

4.35 As the spectrum is assigned to the Access Service Licensee for establishing a Public Land Mobile Network (PLMN), the Authority is of the view that there should be clear enabling provisions in the License/Notice Inviting Applications (NIA) for Auction of Spectrum to permit the Access Service Licensee to set-up private network also known as Non-Public Network (isolated from public network), using the spectrum assigned for establishing PLMN.

4.36 However, while creating such a provision, it may be clearly mentioned that it will be the responsibility of the TSP to ensure that the prescribed QoS to their customers through public network is maintained.

4.37 In view of above, **the Authority recommends that**

(i) Access Service providers can provide private network as a service to an enterprise by using network resources (such as through network slicing) over its PLMN public network. For the sake of clarity, specific provisions should be made in the License.

(ii) Enabling provisions should be incorporated in the License/ Notice Inviting Applications (NIA) for Auction of Spectrum to

permit the Access Service Licensee to set-up private network, also known as Non-Public Network (which is isolated from public network), using the IMT spectrum assigned to it for establishing PLMN.

(iii) While creating the above provisions, it should be clearly mentioned that it will be the responsibility of the TSP to ensure that the prescribed QoS to their customers through public network is maintained.

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

4.38 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 three ways, i.e., 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

4.39 Unlicensed spectrum can be used by an organization to operate private network, subject to regulatory conditions. Though unlicensed spectrum is 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.

4.40 2.4 GHz and 5 GHz bands have globally been unlicensed for WiFi use. Some countries have also opened up 6 GHz and and V-band for WiFi use. Currently, in India 2.4 GHz and 5 GHz bands have been unlicensed for Wi-Fi use.

4.41 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[37].

4.42 In Europe, the European Commission approved regulations to allow the deployment of the lower 6 GHz band (5945-6425 MHz)[38] for Wi-Fi use, releasing 480 MHz spectrum for the same[39].

4.43 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

4.44 In spectrum leasing option, a TSP having exclusive spectrum usage rights, leases its partial 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.

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

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

4.46 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 may arise due to usage of spectrum by the enterprise for captive networks in a specified geography.

4.47 With this background, stakeholders were asked for their comments on whether the TSPs be permitted to give access spectrum on lease to an enterprise (for localized captive use), for a specific duration and geographic location to meet the demand for spectrum in globally harmonized IMT bands for private captive networks.

Comments received from the stakeholders

4.48 In response to the above question, many stakeholders supported the idea of granting permission for spectrum leasing by TSPs.

4.49 In its support, many stakeholders submitted that TSPs should be able to offer access spectrum on lease to an enterprise on commercially negotiated duration and price to enable vertical use cases. Another stakeholder opined that if there is a justified demand from parties to deploy private 3GPP networks within limited geographic areas, market-led intra-service spectrum sharing should be preferably achieved through leasing of spectrum from the licensees.

4.50 Another stakeholder highlighted the advantage of spectrum leasing approach such as coordinated use of spectrum avoids interference issues, effective and efficient use of spectrum as it does not require reserving spectrum exclusively for Private Networks, revenue to the Government as leasing of licensed spectrum to enterprises will be duly factored by TSPs while bidding for the spectrum, enforcement of regulatory requirements through TSPs who will be leasing their licensed spectrum to these entities.

4.51 Another stakeholder mentioned that the leasing conditions must involve clear geographical boundaries which ensure protection and coordination between the public network and the localized captive use.

4.52 Another stakeholder submitted that spectrum leasing be issued as a liberalizing and facilitating measure for TSPs and guidelines should also cover leasing of spectrum in smaller geographical units, locations, for smaller durations. Spectrum leasing policy be holistic and not be based on one use case of captive networks.

4.53 On the contrary to the stakeholders who supported the idea, there were many stakeholders who are against the idea of leasing of spectrum by TSPs for private captive use.

4.54 Some stakeholders submitted that spectrum leasing may not be a viable option for Private 5G networks and should not be considered as a way for allocation of spectrum for private networks as it may be difficult for industries to get spectrum from TSPs due to unavailability of network in their geographical area.

4.55 Some stakeholders were of the view that TSPs are generally reluctant to lease spectrum to others unless the TSP's use of the frequency band is non-existent. Further, there could be difficulty for the TSPs to balance between public network roll-out and private network demands. The price charged by the TSPs may work as a deterrent as TSPs can form a monopoly in specific regions based on their licenses and also certainty of continuity of operations could become an issue if spectrum sub-leasing is not monitored and regulated.

4.56 Another stakeholder opined that globally spectrum leasing has not worked out as a solution to enterprise networking needs, except in a few narrow and highly exceptional cases and even where it has been applied, the leases took years to negotiate. One of the stakeholders submitted that Spectrum leasing may result in inefficient utilization and hoarding of the spectrum.

Analysis

4.57 The Authority has considered this option for the entities to establish their own isolated captive wireless private network after leasing the IMT spectrum from the TSPs. In such standalone Non-Public Network, all network functions are located inside the logical perimeter of the defined premises (e.g., a factory) and it is separate from the public network. These Standalone Non-Public Networks can be desirable for several reasons. Some of them are:

- High Quality-of-Service requirements
- High security requirements, met by dedicated security credentials
- Isolation from other networks, as a form of protection against malfunctions in the public mobile network. Also, isolation may be desirable for reasons of performance, security, privacy, and safety
- Accountability: A non-public network makes it easier to identify responsibility for availability, maintenance, and operation

4.58 TSPs are assigned access spectrum in globally harmonized IMT bands through Auctions. Permitting TSPs to lease such spectrum to enterprises for localized captive use will be a win-win situation – TSPs will be able to efficiently utilize and monetize their spectrum resources and enterprises' spectrum need for private captive network will also be met, leading to economic growth of the country.

4.59 Some stakeholders are of the opinion that it might be difficult for entities to get spectrum for private network from TSPs at reasonable price and further continuity of services could also be any issue. However, the Authority feels that in case all the options viz. private network through Network Slicing, TSPs deploying captive wireless private network using its own IMT spectrum, spectrum leasing by TSPs and earmarking some spectrum for local use are opened up, enough options will be available to the enterprises/industry. TSPs leasing a chunk of spectrum for private captive network might turn out to be a very attractive and preferred solution.

4.60 In view of above, **the Authority recommends that the Licensees having Access Spectrum be permitted to lease their access spectrum to enterprises having Captive Wireless Private Network Permission/License for localized Captive wireless private network.**

4.61 Before discussing the modalities for leasing of spectrum, it may be appropriate to discuss the eligibility for taking spectrum on lease from the TSPs.

4.62 For establishing wireless private captive network using IMT spectrum, the entity/enterprise should have a permission/license under Section 4 of the Indian Telegraph Act, 1885 to do so. Subsequently, the entities holding such permission/license under section 4 of the Indian Telegraph Act, 1885 may obtain IMT spectrum either on lease from Access Service Providers or directly from DoT, as the case may be, for establishing Captive wireless private network. The examples of similar type of captive licenses are Captive Mobile Radio Trunking Service (CMRTS) license and Captive VSAT CUG Service license. Therefore, prior to assignment of spectrum to any private entity, the entity must have requisite permission/license under section 4 of the Indian Telegraph Act, 1885, whether the assignment of spectrum is through the process of leasing from Access Service Providers or through direct assignment by DoT.

4.63 One of the stakeholders in its comments submitted that only Unified Licensees with appropriate authorization should be permitted to obtain spectrum on lease from TSPs. The stakeholder has further added that in order to facilitate the enterprises, managed service providers and system aggregators for building their own captive communication networks, a new authorization under Unified Licensee can be introduced.

In this regard, the Authority is of the view that to promote ease of doing business, the applicant companies for deploying captive wireless private networks should not be burdened with any elaborate licensing regime. The permission/license for deployment of captive wireless private networks should be very light touch regime. The permission/license may be named as 'Captive Wireless Private Network (CWPN) Permission/License'. Permission/license for CWPN should be kept outside the purview of Unified License.

Guidelines for grant of captive license for 'Captive Wireless Private Network'

4.64 DoT should come out with the guidelines for grant of Permission/License for 'Captive Wireless Private Network' for entities (Enterprises) desirous of establishing captive wireless private network using IMT spectrum. The application process along with terms and conditions for establishing captive wireless private network should be clearly defined in the guidelines. These guidelines should be available on DoT website. Application submission and processing should be done through online portal in a time bound manner.

4.65 The key elements to be included in the guidelines are:

- A company registered under the Companies Act, 2013, will be eligible to apply for the Captive Wireless Private Network permission/license to establish indoor/within premise captive wireless private network using IMT spectrum in localized basis (specified geographic area to be governed through spectrum leasing agreement of the licensed enterprise with the Licensed TSPs and/or spectrum assignment by DoT).
- The process of filing application and processing of application for grant of permission/license should be through online portal based system.

- The permission/license will be granted for a period of 10 years; however, there will be provision for renewal of the same through the online portal.
- The guidelines should clearly specify the required documents and the same should be submitted through online portal only. The portal should accept the application only if all the necessary documents have been uploaded by the applicant. Entire process should be paperless.
- Applicable Processing fee may be specified as Rs. 50,000/-
- No entry fee or permission/license fee will be charged from the permission holder/licensee. However, the spectrum charges will be levied as per policy of the DoT, in case the spectrum is assigned by DoT. As the spectrum assignment by DoT also have eligibility conditions based on net worth of the CWPN permission holder/licensee, the applicant should be asked to submit the net worth certificate while applying and net worth of the permission holder/licensee should be mentioned in the permission/license so granted.
- Timelines for grant of permission/license should be specified and it should not be more than a period of 30 days from the filing of application, if the information/documents submitted by the applicant are found fit.
- Permission /License number should be issued by DoT, which will be used while applying for leasing of spectrum and/or seeking the spectrum earmarked for private captive networks from DoT.
- Any change in the details (such as name of the enterprise, ownership, address, contact details, etc.) provided during obtaining the permission/license, are required to be intimated through the online portal within 15 days of such change.
- For an enterprise operating at more than one location in the country, only one permission/license would be required. Therefore, grant of permission/license will be one time activity and the permission/license will be valid throughout the territory

of India. There will be no need to specify the specific geographic area of operation while applying for permission/license. However, while applying for spectrum, the specific details regarding area of operation along with coordinates need to be provided as per specified format. Spectrum is to be obtained separately for each individual geographic unit/ location.

- SACFA clearance requirements and applicable charges should be clearly specified.
- EIRP limits and EMF compliances should be specified.
- The area of operation, that is, the spectrum usage area of the licensee will be the area inside the logical perimeter of the defined premises with clearly specified geo coordinates. The World Geodetic System (WGS84) is a reference coordinate system providing accuracy of 2 centimeter and is used by the Global Positioning System. WGS84 format of geographic coordinate system or any other suitable geographic coordinate system may be used for mapping geographic coordinates.
- The permission holder /licensee of CWPN shall not offer any commercial telecom service. The permission/license as well as spectrum will be used only for its own captive usage as per the usage declared while applying for spectrum, and the permission holder /licensee will not use it for any commercial purpose.
- Permission holder/licensee of CWPN will deploy network elements as per TEC standards, wherever made mandatory, else as per relevant standards set by International Standardization bodies.
- Relevant network security conditions and instructions regarding procurement of telecom equipment from trusted sources may be specified.
- CWPN should not be connected to public network in any manner. The public network includes PSTN, PLMN, GMPCS and public internet. However, in case the licensee enterprise wants to have connectivity between its own multiple locations, the same may be

permitted through leased line obtained through licensed telecom service providers.

- The Licensor will be having a right to inspect the established CWPN and its bonafide use.

4.66 **The Authority recommends that for establishing isolated captive wireless private network using IMT spectrum, the entity/enterprise should be provided a Permission/license under Section 4 of the Indian Telegraph Act, 1885. The permission/license may be named as 'Captive Wireless Private Network (CWPN) permission/License'.**

4.67 **The Authority recommends that DoT should come out with the guidelines for grant of permission/License for 'Captive Wireless Private Network' for entities desirous of establishing captive wireless private network using IMT spectrum. The following key elements should be included in the guidelines:**

- **A company registered under the Companies Act, 2013, will be eligible to apply for the Captive Wireless Private Network permission/license to establish indoor/within premise captive wireless private network using IMT spectrum in localized basis (specified geographic area to be governed through spectrum leasing agreement of the licensed enterprise with the Licensed TSPs and/or spectrum assignment by DoT).**
- **The process of filing application and processing of application for grant of permission/license should be through online portal based system.**
- **The permission/license should be granted for a period of 10 years; however, there should be provision for renewal of the same through the online portal.**
- **The guidelines should clearly specify the required documents and the same should be submitted through online portal only. The portal should accept the application only if all the**

necessary documents have been uploaded by the applicant. Entire process should be paperless.

- **Applicable Processing fee may be specified as Rs. 50,000/-**
- **No entry fee or permission/license fee should be charged from the permission holder/licensee. However, the spectrum charges will be levied as per policy of the DoT, in case the spectrum is assigned by DoT. As the spectrum assignment by DoT also have eligibility conditions based on networth of the CWPN permission holder/licensee, the applicant should be asked to submit the networth certificate while applying and networth of the permission holder/licensee should be mentioned in the permission/license so granted.**
- **Timelines for grant of permission/license should be specified and it should not be more than a period of 30 days from the filing of application, if the information/documents submitted by the applicant are found fit.**
- **Permission /License number should be issued by DoT, which will be used while applying for leasing of spectrum and/or seeking the spectrum earmarked for private captive networks from DoT.**
- **Any change in the details (such as name of the enterprise, ownership, address, contact details, etc.) provided during obtaining the permission/license, are required to be intimated through the online portal within 15 days of such change.**
- **For an enterprise operating at more than one location in the country, only one permission/license should be required. Therefore, grant of permission/license should be one time activity and the permission/license should be valid throughout the territory of India. There should be no need to specify the specific geographic area of operation while applying for permission/license. However, while applying for spectrum, the specific details regarding area of operation**

along with coordinates need to be provided as per specified format. Spectrum is to be obtained separately for each individual geographic unit/ location.

- **SACFA clearance requirements and applicable charges should be clearly specified.**
- **EIRP limits and EMF compliances should be specified.**
- **The area of operation, that is, the spectrum usage area of the licensee will be the area inside the logical perimeter of the defined premises with clearly specified geo coordinates. World Geodetic System (WGS84) format of geographic coordinate system or any other suitable geographic coordinate system may be used for mapping geographic coordinates.**
- **The permission holder /licensee of CWPN shall not offer any commercial telecom service. The permission/license as well as spectrum will be used only for its own captive usage as per the usage declared while applying for spectrum, and the permission holder /licensee shall not use it for any commercial purpose.**
- **Permission holder/licensee of CWPN will deploy network elements as per TEC standards, wherever made mandatory, else as per relevant standards set by International Standardization bodies.**
- **Relevant network security conditions and instructions regarding procurement of telecom equipment from trusted sources may be specified.**
- **CWPN should not be connected to public network in any manner. The public network includes PSTN, PLMN, GMPCS and public internet. However, in case the licensee enterprise wants to have connectivity between its own multiple locations, the same may be permitted through leased line obtained through licensed telecom service providers.**

- **The Licensor should be having a right to inspect the established CWPN and its bonafide use.**

4.68 **The Authority recommends that Entities holding 'Captive Wireless Private Network Permission/License' should be permitted to obtain IMT spectrum either on lease from Access Service Providers or directly from DoT, as the case may be, for establishing Captive wireless private network.**

4.69 In addition to opinion on leasing of spectrum, stakeholders were also asked to give their opinion that in case spectrum leasing is permitted then, (a) whether the enterprise be permitted to take spectrum on lease from more than one TSPs, (b) mechanism that may be prescribed to keep the Government informed about such spectrum leasing i.e., prior approval or prior intimation, (c) timeline that 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, (d) whether the spectrum leasing guidelines should prescribe duration of lease, charges for leasing, adherence of spectrum cap provisions, roll out obligations, compliance obligations and if so, then the terms and conditions for it, (e) other associated terms and conditions, (f) any other suggestion relevant to leasing of spectrum.

Comments received from the stakeholders

(a) Spectrum on lease by an enterprise from more than one TSP

4.70 In regard to spectrum on lease by an enterprise from more than one TSPs, some of the stakeholders mentioned that they do not foresee any requirement by the enterprises to lease spectrum from more than one TSP; therefore, one enterprise may be allowed to take spectrum on lease from only one TSP in one LSA. It was also submitted that simplified framework for the leasing of spectrum be recommended and any complexities that may arise due to the enterprise accessing and using spectrum from multiple operators be avoided.

4.71 One stakeholder was of the opinion that the bandwidth provided by one TSP will effectively meet the requirement of an enterprise. While another stakeholder submitted that allowing enterprises to lease spectrum assets from different TSPs would unnecessarily increase the complication for network deployment, add to their costs, and consequentially act as an additional barrier to network deployment.

4.72 However, one stakeholder mentioned that the enterprises that are national in scope may have a need to lease spectrum from multiple TSPs, in which they will find difficulty and therefore, the enterprises should be the licensee of the spectrum.

(b) Mechanism for keeping the Government informed about spectrum leasing, and

(c) Timeline for approval / intimation from / to the Government

4.73 Regarding mechanism to keep the Government informed about spectrum leasing, that is, prior approval or prior intimation, majority of stakeholders have suggested for prior intimation.

4.74 In support of intimation, it has been submitted that since this model will be coordinated through TSPs, there should not be any issues of interference etc. which obviates the need for prior approval. However, to keep Authorities (DoT/TRAI) informed about such arrangements, an intimation period may be prescribed to each TSP, e.g., within 15 days of operationalization of such a Captive Network.

4.75 Another stakeholder submitted that only Unified Licensees with appropriate authorization should be permitted to obtain spectrum on lease from TSPs. However, to facilitate the enterprises, managed service providers and system aggregators in building their own captive communication networks, a new authorization under Unified Licensee can be introduced. The licensees under this authorization should be permitted to obtain spectrum through auction or lease, as per their business case. The interested parties may be required to inform the Government only 45 days prior to effective date of leasing.

4.76 Some stakeholders mentioned that both the parties (Enterprise and TSP), should provide a joint spectrum sub-leasing request/intimation at least 30 days prior to leasing the spectrum. This will give adequate time to government to analyze and put objection, if any. In case of no objection in those 30 days, the sub-leasing intimation/request should be considered as approved.

4.77 Another stakeholder proposed that parties to a sub-leasing agreement may be required to intimate the Government within 30 - 60 days of executing the sub-leasing arrangement and/or at the time of commencement of NPN operations.

(d) Spectrum leasing guidelines: duration of lease, charges for leasing, adherence of spectrum cap provisions, roll out obligations, compliance obligations etc., and terms and conditions

(e) Associated terms and conditions

(f) Any other suggestion relevant to leasing of spectrum.

4.78 Stakeholders submitted that an overall liberal policy be formulated for the leasing of spectrum by TSPs to enterprises as these enterprises will be just like other users/customers of TSPs. Any heavy touch regulatory requirement, without any evidence of harm, may adversely affect the wide uptake of such a framework. It was suggested that separate guideline be released on technical and management compliance and both the parties should be mandated to comply those norms. It was further suggested to allow TSPs to offer access spectrum on lease to an enterprise on mutual commercially negotiated duration and price.

4.79 Another stakeholder suggested that the leasing should be done on a voluntary and mutually negotiable basis. The framework of leasing spectrum to enterprises should allow market forces to drive it, as it happens even today in enterprise segment driven by mutually agreed SLAs.

4.80 Another stakeholder suggested that in the spirit of ease of doing business, the spectrum leasing regime should not be over-regulated by specifying the duration, charges etc. These finer business details should be left to mutually agreed commercial terms between parties.

4.81 Some of the stakeholders were of the view that given the diversity of use-cases and enterprise requirements, a one-size fits all approach to regulating spectrum is undesirable. Prescribing granular requirements to govern negotiations of sub-leasing arrangements between TSPs and enterprises be avoided, as that is likely to reduce the scope for negotiations and make the option of sub-leasing unviable for most enterprises.

4.82 Some of the stakeholders also opined that a decision by the government to prescribe lease terms would make the spectrum leasing option even less friendly to enterprises than it otherwise would be. Therefore, the spectrum leasing arrangements between TSP and enterprise be decided based on voluntary mutually negotiable agreement between the particular TSP and Enterprise and that can be up to the period of expiry of the tenure of the TSP's spectrum.

4.83 Regarding roll-out obligations, some of the stakeholders submitted that there should not be any conditions or roll out obligation as this spectrum is not being used exclusively for Private Networks. Some stakeholders have suggested that for effective utilization of spectrum, there must be rollout obligation of 12 months after leasing the spectrum at the enterprise premises.

4.84 For charges payable to Government, stakeholders submitted that since the leasing arrangement is being done only under an intimation which does not involve any administrative overheads to DoT, there should not be any charges payable to the government for leasing of spectrum.

4.85 Stakeholders have opined that the Government should release a separate guideline on technical and management compliance and both the parties should be mandated to comply those norms.

4.86 Another stakeholder submitted that spectrum leasing is not the only way to make available spectrum for private IMT networks. However, if leasing is used, there should be strong mechanism to monitor and enforce SLAs between TSP and private network customer.

Analysis

4.87 As already recommended, the CWPN permission holder/Licensee may obtain IMT spectrum either on lease from Access Service Providers or directly from DoT for establishing Captive wireless private network.

4.88 In case the licensee, having 'Captive Wireless Private Network Permission/License', obtains the IMT spectrum on lease from an Access Service Provider, it will be the responsibility of the Access Service Provider for proper and bonafide use of the spectrum. The Access Service provider, while leasing the spectrum, has to ensure that the private network is not causing any interference to other wireless networks. It may be a point that permitting Captive Wireless Private Network permission holders/licensees to lease-in IMT spectrum from more than one TSP, in an LSA, may create complications relating to compliances and interference. However, since the Access Service providers will be leasing the IMT spectrum out of their own assignment block, the Access Service Providers shall be capable of ensuring the compliances and interference issues in respect of spectrum leased out by them. Moreover, it may be possible that spectrum leased by one TSP may not be sufficient for the enterprise, in such a case if the enterprise is permitted to take spectrum on lease from more than one TSP, it can fulfil its spectrum requirement. Therefore, the Authority is of the view that there should not be any restriction on CWPN permission holders/licensees for obtaining IMT spectrum from more than one Access Service provider.

4.89 In order to have transparency in the process of IMT spectrum leasing by TSPs to the Captive Wireless Private Network Permission holders/Licensees, DoT should prescribe suitable guidelines on Spectrum Leasing. It may be noted here that spectrum leasing guidelines being discussed here pertain to spectrum leasing by TSPs to Captive Wireless Private Network permission holders/Licensees only. The following paragraphs discuss various issues on spectrum leasing for the purpose of formulation of guidelines.

4.90 In respect of mechanism of intimation to keep the Government informed about such spectrum leasing by TSPs to the Captive Wireless Private Network Permission holders/Licensees, most of the stakeholders are of the view of prior intimation of 15 to 45 days. Some of the stakeholders have also suggested for post leasing intimation to the licensor.

4.91 Considering that the detailed guidelines for leasing of spectrum will be put in place, the TSPs and the CWPN permission holder/Licensee will be knowing in advance about the provisions, obligations and other applicable terms & conditions. Further, it is expected that the TSPs will take all necessary measures to ensure that such spectrum leasing does not adversely affect the services to its own customers. Therefore, the Authority is of the view that regulatory interventions may not be required in spectrum leasing arrangement between the TSP and the CWPN permission holder/Licensee, as long as the prescribed guidelines are followed. Moreover, if it is found that the spectrum leasing guidelines have not been followed or for any other security related reasons, DoT will anyways have a right to terminate /cancel the CWPN permission/license even at a future date. Another point that needs to be kept in mind is that such spectrum leasing agreement falls under the category of B2B service and before such an agreement is materialized, such information could be commercially sensitive. Therefore, the Authority is of the view that the TSP and the Captive Wireless Private Network permission holder/Licensee may be asked to give a joint intimation within 15 days of the effective date of leasing of spectrum. The joint intimation should include details of spectrum band(s), quantum of spectrum in each band, period of lease, geographic area of lease and use of spectrum.

4.92 Regarding the question related to duration of lease, charges for leasing, adherence of spectrum cap provisions, roll out obligations, compliance obligations etc., the stakeholders have submitted that spectrum leasing arrangements between TSP and enterprise should be decided on the basis of voluntary mutually negotiable agreement between the particular TSP and Enterprise and can be up to the period of expiry of the tenure of the TSP's spectrum. The Authority also noted that many stakeholders were of the view that the spectrum leasing regime should not be over-regulated by specifying the duration, charges etc. These finer business details should be left to mutually agreed commercial terms between parties.

4.93 The Authority agrees to the views of stakeholders that the duration of lease, charges for leasing, adherence of spectrum cap provisions, roll out obligations, compliance obligations etc. should be left to the mutual commercial arrangements between the TSPs and Captive Wireless Private Network Permission holders/Licensees. However, the leasing guidelines should prescribe terms to ensure interference free operation, adoption of network synchronized frame structure and conformance to QoS norms for the telecom consumers through public network.

4.94 In view of above, **the Authority recommends that necessary guidelines for leasing of access spectrum by Telecom Service Providers to the Captive Wireless Private Network Permission holder/Licensees should be put in place specifying the terms and**

conditions and also providing the online process for submission of intimation regarding leasing of spectrum. The key elements to be included in the Access Spectrum leasing guidelines are:

- **TSPs will be permitted to lease their spectrum acquired through auction or liberalized spectrum holding to entities having Captive Wireless Private Network Permission/License.**
- **The 'Captive Wireless Private Network Permission holder/Licensee' should be permitted to take IMT spectrum on lease from one or more than one TSP in an LSA.**
- **TSP and the Captive Wireless Private Network permission holder/Licensee should give a joint intimation to DoT within 15 days of the effective date of leasing of spectrum. The joint intimation should include details of spectrum band(s), quantum of spectrum in each band, period of lease, geographic area of lease and use of spectrum.**
- **Use of leased spectrum by the CWPN permission holder/licensee should not cause interference to any public network. Any condition(s) imposed on the TSPs such as network synchronization, frame structure, DL:UL ratio etc. will also be applicable to the CWPN permission holder/licensee.**
- **It will be the responsibility of the TSP to ensure that prescribed QoS to the customers through public network is maintained, while leasing out the spectrum.**
- **The spectrum leasing charges shall form part of the AGR of the TSP.**
- **The leasing agreement should be mutually negotiated between the TSP and the enterprise.**

iii) Earmarking spectrum for private captive networks

4.95 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.

4.96 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 earmarked spectrum (in different spectrum bands including C-band and mmWave band) for local use, are Germany, Finland, UK, France, Sweden, South Korea, Hong Kong, Malaysia, Australia, Czech Republic, Japan, Taiwan, etc.

4.97 The method of allocation of spectrum for captive use is administrative in these 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.

4.98 With this background, stakeholders were asked for their opinion whether spectrum be earmarked for localized private captive networks.

Comments received from the stakeholders

4.99 Many stakeholders opposed the idea of earmarking of spectrum for private networks. Stakeholders have argued that dedicated set-asides for verticals leads to spectrum underutilization, fragmentation of spectrum, insufficient spectrum to operators, inflated prices paid for spectrum, loss to exchequer, reduced network investment, slower 5G rollouts, deteriorated network quality, reduced coverage, and coexistence challenges. These stakeholders also opined that it would disturb the level playing field and concerns on Law enforcement / Lawful Interception requirements. Besides, the level of investment and availability of relevant experts necessary to design, implement or operate the private network may be daunting for most enterprises.

4.100 Some stakeholders suggested that earmarking via administrative allocation of spectrum is based on the legally untenable grounds of first come first serve and substantial revenue opportunity loss to TSPs. Another stakeholder submitted that earmarking of spectrum for private networks should not be considered in frequency bands where demand is high.

4.101 Some of the stakeholders submitted that spectrum earmarking, especially in parts of 3670-4200 MHz and 28.5-29.5 GHz bands, comes at the cost of less spectrum for productive satellite services. Spectrum may be hoarded, underutilized, or traded by private local users back to 5G/IMT operators, resulting in losses to the Government. Instead, frequencies for IMT/5G could be reused for the localized private captive networks in specific geographic locations, whether through spectrum leasing or through 'network slicing'.

4.102 Some stakeholders opined that any use of the 28 GHz band for private networks should be on a non-protected, non-interference basis to ensure that satellite services in this band can continue to be deployed without constraints. It has been submitted that review and identify harmonized IMT spectrum bands that are not yet been licensed and utilized in the country and these could be made available for private captive network deployments.

4.103 Another stakeholder submitted that in any private/captive deployment, where there is very little accountability, earmarking can potentially cause interference to incumbent services (satellite). The receivers on the LEO/MEO/GEO High Throughput Satellites are extremely sensitive and can pick-up any transmission in this band by 5G.

4.104 Many stakeholders supported the idea of earmarking of spectrum for private networks. In their support, couple of stakeholders submitted that 5G spectrum should be easily available to meet the spectrum needs of dedicated/captive private broadband LTE/5G networks. Following the global scenarios, Indian industry is quite poised to enter into this new era of building their private network and managing it as per their choices. Thus, there is a need to back them by designating an IMT spectrum so that benefits of economies of scale can be availed. Other stakeholders submitted that direct allocation of spectrum at a reasonable price would provide multiple benefits to the enterprise /industry verticals such as control, innovation, flexibility, secured network, and assured QoS.

4.105 One of the stakeholders stated that as private network deployments typically cater to highly specialized use cases, end-user/industrial participation in rollouts is now manifesting globally. Innovative applications emerging from early NPN deployments could see many ICT products/services from India. This would also give an impetus to the start-ups and could help create a leading position for India on the Internet and knowledge/service sector.

4.106 Another stakeholder submitted that earmarking would ensure that enterprises themselves can be licensed for spectrum use and that the licenses are tailored to their needs, including exclusive use in a geographic footprint that corresponds to their business premises and tailored for their industry use-cases. Moreover, a license provides certainty that enterprises have spectrum access for the duration of the license.

4.107 One of the stakeholders submitted that Private captive networks would offer significant benefits to Indian providers, businesses, and consumers, primarily through increased innovation and development nationwide. Another stakeholder expressed that earmarked spectrum for localized private captive networks will help enterprises and industry automation and ensure co-existence of other services as well.

Analysis

4.108 It is observed that all the telecom service providers and many other stakeholders are not in favour of earmarking spectrum for localized private captive network. To justify the submissions, stakeholders have stated that dedicated set-asides for verticals lead to spectrum underutilization, fragmentation of spectrum, insufficient spectrum to operators, inflated prices paid for spectrum etc. It has also been stated that enterprise business contributes substantial revenue to TSPs and any truncation in the addressable market adversely affects viability of TSPs. On the other hand, many stakeholders have supported the idea of earmarking of spectrum for private networks. To justify their demand, the stakeholders have mentioned that following the global scenarios, Indian industry is quite poised to enter into this new era of building their private network and managing it as per their choices and thus there is a need to back them by designating an IMT spectrum so that benefits of economies of scale can be availed. These stakeholders have also submitted that direct allocation of spectrum at a reasonable price would provide multiple benefits to the enterprise /industry verticals such as control, innovation, flexibility, secured network, and assured QoS.

4.109 As already discussed, earmarking spectrum for localized private captive network will allow enterprises to fulfil affordability, reliability, continuity, flexibility, criticality and security requirements of the business. The economic growth likely to be achieved by implementation of Industry 4.0 could be much higher and could work as a catalyst for the overall growth of the country, creation of new job opportunities, remote operation of sites which could be risky for humans, to name a few. While Industry 4.0 can be served by using network slicing; however, it requires presence of TSP's network in the given area. One could argue that in case an enterprise wants to set up private captive network in a remote area where TSP's networks may not be available, option of spectrum leasing is available. However, it will be a situation where all the enterprises interested in setting up captive wireless private network, would be completely dependent on the TSPs. Therefore, the Authority is of the view that earmarking some spectrum for localized Captive wireless private networks, is a key requirement for some of the industries, particularly in cases of manufacturing and other verticals where the connectivity is highly critical. This will aid in development of collective ecosystem and overall development of the country.

4.110 In view of above, **the Authority recommends that certain spectrum be earmarked for Captive Wireless Private Networks to be assigned directly by DoT to Captive Wireless Private Network Permission holders/Licensees.**

4.111 Once it is decided that some spectrum should be earmarked for captive wireless private networks, next issues that need to be decided are (i) which spectrum band(s) should be earmarked for CWPNs, (ii) how much spectrum should be earmarked and (iii) other related issues. These issues have been dealt in the subsequent paras.

(iv) Spectrum bands (or frequency ranges), quantum of spectrum, block sizes and spectrum cap for earmarked spectrum

4.112 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.

4.113 Considering the economic benefits from next industrial revolution, there is a need to explore how best the private cellular networks be implemented and promoted in India. 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.

4.114 With this background, stakeholders were asked that if 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). Stakeholders were also asked to give their opinion about spectrum band(s) (or frequency range), quantum of spectrum, block size and spectrum cap for different suggested spectrum band(s).

Comments received from the stakeholders

Comments on IMT/non-IMT bands

4.115 While some of the stakeholders who were not in favor of earmarking any spectrum for CWPNs did not submit any response on these issues, many other stakeholders supported for those frequencies in which IMT ecosystem is available, but the same are being used for non-IMT services in India. One of the stakeholders submitted that there are a number of IMT bands in which 3GPP mobile technology is available but are not used by TSPs in India and these can be used for Private 5G/LTE networks, and some of these are 3.7-4.2 GHz, 4.889-4.999 GHz, 5950-6450 MHz.

4.116 Some stakeholders opined that private network can coexist with FSS due to their low power emission and confined geographic operations. This makes a win-win situation for all. These stakeholders suggested for flexible norms where some spectrum bands for private networks will be shared with incumbents based on the geographical location and some will be dedicated only for private network usage. One of the stakeholders stated that the spectrum allocated for satellite applications can be used for private captive indoor uses as this will not create interference for satellite systems.

4.117 Some stakeholders submitted that spectrum earmarking for private network be within frequencies designated for IMT. It is also submitted that there are technical risks in allowing private use of spectrum which is assigned for non-IMT services such as satellite services.

<u>Comments on spectrum band(s), quantum of spectrum, block size, spectrum cap</u>

4.118 Some of the stakeholders suggested that the spectrum reservation be made in unsold bands to ensure maximum utilization and to create more value proposition for various entities. They suggested shared spectrum usage for private networks by using already allocated spectrum to MNOs / TSPs which has not been used in specific areas on a fixed period basis with extremely light commercials. It has also been proposed that provision for unlicensed bands in 5-6 GHz be made liberal to use it for both LTE as well NR for private network setups and should be made technology agnostic. It was also suggested that dedicated spectrum be made available across sub-6 GHz, at least 100 MHz and in mmWave bands, minimum 400 MHz spectrum.

4.119 Regarding mid-band, one of the stakeholders suggested for spectrum within the 3670-4200 MHz, whereas couple of other stakeholders suggested for n77 (3300-4200 MHz), n78 (3300-3800 MHz), and n79 (4400-5000/4990 MHz) spectrum bands for private network. Some stakeholders have mentioned that for private captive network in 3670 - 4200 MHz, a minimum of 100 MHz be earmarked where private network can coexist with FSS due to their low power emission and confined geographic operations.

4.120 One stakeholder has suggested that 80 MHz of spectrum in C-band in the chunks of 20 MHz is suitable for most private networks. However, it has also suggested that block size of 10MHz with maximum 4 blocks per applicant can be allocated to Private Cellular Network.

4.121 Another stakeholder mentioned that there are number of bands which are not used by TSPs in India but can be used for Private 5G/LTE networks. Some of the examples cited are 3.7-4.2 GHz, 4.889 – 4.999 GHz, 5.950-6.450 GHz and further suggested for spectrum in 4890-4990 MHz range for earmarking for Private LTE/5G networks. One of the stakeholders has suggested for 3600-3700 MHz spectrum band whereas another stakeholder suggested 3550-3700 MHz band for private captive networks.

4.122 In regard to mmWave, many stakeholders mentioned that in 24.25 - 27.5 GHz and 27.5 - 29.5 GHz bands private captive network can co-exist with incumbent services. Further, it was suggested that around 400 - 800 MHz be earmarked without compromising capacity and other requirements of MNOs and coexistence can be made possible with FSS in 28.5-29.5 GHz. Another stakeholder suggested for n261 (27.50 - 28.35 GHz) with available spectrum of 850 MHz.

4.123 Some of the stakeholders suggested for spectrum within 28.5-29.5 GHz range for local/private networks. However, some other stakeholders suggested that the 27.5-28.5 GHz rather than the 28.5-29.5 GHz band could be earmarked for localized captive networks in India on a non-interference, non-protection basis in relation to satellite systems.

4.124 One of the stakeholders mentioned that earmarking of spectrum for the deployment of private captive networks should not come at the expense of spectrum being used for productive satellite services and suggested that spectrum for private captive networks be found in other bands already identified for IMT. Some stakeholders opposed the suggestion of 3670-4200 MHz and 28.5-29.5 GHz bands currently being used for satellite communications for local private cellular networks.

4.125 Regarding Block sizes, there are various suggestions. For mid-band (sub-6 GHz), suggested block size includes 10 MHz with 4 blocks of 10 MHz, 20-40 MHz and 50 MHz. For mmWave, suggested block sizes include 50 MHz and 100 MHz.

4.126 Regarding spectrum cap, suggestion includes 100 MHz in the Sub-6 GHz band and 400 MHz in the mmWave band. However, one stakeholder mentioned that no cap is required as this is area/location specific.

Analysis

4.127 Many stakeholders favoured the earmarking of spectrum for private network in bands where the IMT ecosystem exists, but frequencies are earmarked for non-IMT services in India. One of the stakeholders has stated that there are a number of bands in which 3GPP mobile technology is available but are not being used in India for IMT purpose. These bands can be used for Private 5G networks.

4.128 In this regard, it is noted that for the mission 'Connect India' identified under NDCP 2018, one of the strategies envisaged, for making adequate spectrum available, is *'promoting the co-use/secondary use of spectrum'* (Para 1.2(b)(viii)) and for efficient spectrum utilization and management, one of the strategies envisaged is *'deploying dynamic database systems for allocation/ interference management'* (Para 1.2(c)(ii) of NDCP-2018).

4.129 The Authority has observed the views of some of the stakeholders who have stated that private networks can coexist with Fixed Satellite Service (FSS) due to their low power emission and confined geographic operations. This makes a win-win situation for all and is also as per the strategies envisaged in NDCP 2018. The spectrum allocated for satellite applications can be used for private captive indoor uses as this will not create interference for satellite systems. 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[40] 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.

4.130 Considering the availability of spectrum for IMT services in different bands, it may be difficult to earmark some quantum of spectrum for private captive networks at present, 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 improve substantially.

4.131 Therefore, the Authority is of the view that earmarking spectrum for private network in those bands where the IMT ecosystem exists, but frequencies are earmarked for non-IMT services in India, will be a better option in the present scenario. It will not impact the spectrum availability for TSPs in IMT bands. Further, the private network can

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

coexist with other services on shared basis without interfering with other services.

4.132 As regards the spectrum band in which some spectrum could be earmarked for private networks, the Authority observed the submission made by one of the stakeholders that some limited portion of spectrum within the 3800-4200 MHz, 4500-4990 MHz (n79) mid-band range and within the 28.5-29.5 GHz mm-wave range may be considered for local/private networks. Another stakeholder suggested that there are a number of bands which are not used by TSPs in India but can be used for Private 5G networks. Some examples of these are: (i) 3.7-4.2 GHz, (ii) 4.889 – 4.999 GHz, (iii) 5.950-6.450 GHz. The stakeholder further suggested that spectrum in mid band and particularly 4890-4990 MHz should be earmarked for Private LTE/5G.

4.133 One of the stakeholders has stated that should the Government decide to earmark exclusive spectrum for the deployment of private captive networks, it should not come at the expense of even more spectrum being lost from productive satellite services. Instead, spectrum for private captive networks should be found in other bands already identified for IMT.

4.134 Many countries have earmarked spectrum in C-band and/or in mmWave bands for private networks. Germany, Finland, UK, France, Sweden, South Korea, Hong Kong, Malaysia, Australia, Czech Republic, Japan, Taiwan, France, etc. have earmarked spectrum for private network. Details of the spectrum earmarked by these countries for private networks in mid-band and mmWave bands is given below:

Table 4.1

Details of the spectrum earmarked for private networks in mid-band and mmWave bands - International Scenario

Country	Mid-band		mmWave-band	
	Frequency Band (Mid-band)	Quantum	Frequency Band (mmWave-band)	Quantum
France[41]	2.575-2.615 GHz	40 MHz	-	-
Hong Kong[42]	-	-	27.95 – 28.35 GHz	400 MHz
Malaysia[43]	-	-	26.5 - 28.1 GHz	1600 MHz
Germany	3.7-3.8 GHz[44]	100 MHz	24.25-27.50 GHz[45]	3.25 GHz
Finland[46]	2.30-2.32 GHz	20 MHz	24.25–25.1 GHz	850 MHz
UK[47]	3.8-4.2 GHz	390 MHz	24.25-26.5 GHz	2.25 GHz
Sweden[48]	3.72-3.80 GHz	80 MHz (Initially 40 MHz)	24.25–25.10 GHz	850 MHz
South Korea[49]	4.72-4.82 GHz	100 MHz	28.9-29.5GHz	600 MHz
Japan[50]	4.6-4.9 GHz	300 MHz	28.2-29.1 GHz	900 MHz
Czech Republic[51]	3.40-3.44 GHz	40 MHz		
Taiwan[52]	4.8-4.9 GHz	100 MHz		

4.135 As can be seen from the above table, many countries have earmarked spectrum in the range 3.7-4.2 GHz. Since this spectrum range is not dedicatedly earmarked for local use but will be shared with FSS working in this range, the countries have earmarked as high as 390 MHz i.e., the entire range from 3.7-4.2 GHz. However, some countries have earmarked 100 MHz from 3.7-3.8 GHz. Czech Republic has earmarked 40 MHz in C-band from 3.4-3.44 GHz for private networks. Some countries have earmarked 20-40 MHz spectrum in 2300/2500 MHz

[41] Terms of Allocation of 2.6 GHz TDD Frequencies

[42] Guidelines for Assignment of Shared Spectrum in 26 and 28 GHz Bands under the Localised Wireless Broadband System (Private) Licence

[43] Allocation of spectrum bands for mobile broadband service in Malaysia (Dec 2019)

[44] Administrative rules for spectrum assignments for local spectrum usages (3.7-3.8 GHz) (Dec 2021)

[45] Germany - Administrative rules for spectrum assignments for local broadband spectrum usages (24.25-27.5 GHz) (Dec 2021)

[46] https://www.traficom.fi/en/communications/communications-networks/local-4g5g-networks

[47] Shared Access Licence - Guidance (Jul 2019)

[48] https://www.pts.se/globalassets/startpage/dokument/icke-legala-dokument/remisser/2021/radio/remissbemotande-lokala-tillstand.pdf

[49] https://www.netmanias.com/en/?m=view&id=blog&no=15139

[50] https://www.tele.soumu.go.jp/resource/e/search/myuse/use0303/batch.pdf

[51] http://5gobservatory.eu/wp-content/uploads/2021/04/90013-5G-Observatory-Quarterly-report-11-2.pdf

[52] https://www.ecct.com.tw/storage/2020/08/Taiwans-5G-Action-Plan-2019-2022.pdf

band. In mmWave band, the spectrum earmarked for private networks range between 400 MHz to 3.25 GHz.

4.136 As already discussed, in India, Government has decided to use 3300-3670 MHz spectrum for IMT purpose. Earmarking spectrum within this range for private network will reduce the availability of IMT spectrum for Telecom Service Providers. However, the possibility may be explored for earmarking some spectrum in 3700-3800 MHz range for low power indoor use for private network. As the frequency range 3700-4200 MHz is being used for Satellite C-band broadcasting receive antenna, using part of the same frequency range for private network may lead to direct in-band interference to receive antenna. The co-existence of private network and satellite C-band receive stations can be explored by creating an effective exclusion zone around the satellite C-band receive stations. For this purpose, a digital map of all the existing satellite C-band receive stations should be created having database of their geo-coordinates with automated software system. Whether the location of private network proposed by an applicant can be accommodated on co-existence basis can easily be determined by the automated software system. This will be the most efficient use of spectrum in C-band for Satellite as well as for cellular private network. The power limits and antenna tilt etc. may be prescribed by the government for interference free operation and co-existence.

4.137 As we may get only limited locations for establishment of interference free captive wireless private network in 3700-3800 MHz range due to operation of large number of TV receive stations throughout the country in this band, another option to earmark spectrum for private network in mid-band is to explore the possibility of carving out some spectrum in n79 band (4400-5000 MHz). In this band, ITU has already identified frequency range 4800-4990 MHz for IMT purpose. Total 493 devices supporting n79 band have been launched and network deployments in n79 band have also taken place in few countries. At WRC-19, over 40 countries identified some or all of the spectrum in this range for IMT.

A few countries have assigned spectrum in this range as summarized below:

- Japan, Hong Kong and China have assigned part of the frequency range
- Russia and Kuwait assigned for trial
- Japan and South Korea have earmarked for local/private networks in part of the frequency range.

4.138 In view of above, DoT may consider identifying the frequency range 4800-4990 MHz for IMT purpose and explore the possibility of carving out some spectrum in this frequency range for the purpose of earmarking for private network.

4.139 In the mmWave band also, many countries have earmarked and assigned spectrum for private local use. Hongkong has earmarked 400 MHz in frequency range 27.95-28.35 GHz. South Korea has assigned 600 MHz of spectrum for private network in 28.9-29.5 GHz frequency range. Finland and Sweden have assigned 850 MHz of spectrum for private use in 24.25-25.1 GHz frequency range. Besides, Germany, UK and Malaysia have also assigned spectrum in mmWave for private local use.

4.140 In mmWave bands, frequency range 28.5-29.5 GHz is not earmarked for IMT purpose in India, however, it is part of n257 3GPP band (28 GHz band). This band is being used by Fixed Satellite Service (Earth to space), with which, Private Captive Network can very well coexist considering the propagation characteristics of mmWave spectrum.

4.141 The Authority is of the view that the manner in which the IMT services and Satellite Earth Stations (Earth to space) can co-exist in 27.5-28.5 GHz, in the similar manner the private network and Satellite Earth Stations (Earth to space) can co-exist in 28.5-29.5 GHz frequencies. The operation of private network is confined to the specified premises/geography with low power usage. The location of Satellite Earth Stations (Earth to space) along with its geo-coordinates will be known to the Licensor. The location and geo-coordinates of private network will also be available with licensor. Permission for use of spectrum for private network can be granted based on the physical separation required from existing Earth Stations. Similarly, permission for establishing new Earth Stations can be granted based on the physical separation required from existing private network. A software based transparent system can be built to determine the feasibility of establishment of private networks and Satellite Earth Stations (Earth to space) based on the geo-coordinates of the proposed location, on interference free co-existence basis.

4.142 DoT should develop a digital map with geographic coordinates of all the existing and future Satellite Earth Stations as well as geographic coordinates of the premises of Private Network locations. Based on this database, permissions for establishment of new installations may be provided by the licensor.

4.143 As per comments of the stakeholders, regarding quantum of spectrum, there have been suggestions ranging from 80 to 100 MHz quantity in mid-band and 400-800 MHz in mmWave.

4.144 One of the stakeholders suggested that minimum 100 MHz from 3670-4200 MHz band may be earmarked for private captive network where it can coexist with FSS due to their low power emission and confined geographic operations. For mmWave, the stakeholder suggested around 400-800 MHz spectrum, without compromising capacity and other requirements of MNOs, with co-existence with FSS in 28.5-29.5 GHz.

4.145 For private networks in India, as the applications and business models for 5G are still under development, it is not currently possible to definitely predict the market demand for private network spectrum. Since information on the exact spectrum requirement of the enterprises for private networks is not available, one option is that to begin with, 40 MHz in C-band and 400 MHz in mmWave band may be earmarked for private networks and later on this quantum can be reviewed. Another option is that the DoT may carry out a demand assessment exercise as recommended in the subsequent paras, and based on the outcome of the exercise, the quantum of spectrum to be earmarked for captive wireless private networks can be decided. The Authority is of the view that the exact quantum to be earmarked for private networks should be decided after completion of the demand assessment exercise by DoT and decision on spectrum band(s) that can be earmarked for private networks.

4.146 Therefore, to assess the demand of such entities who are willing to take the spectrum directly from DoT for establishment of Captive Wireless Private Network, DoT may establish a portal to seek the requirement of prospective CWPN permission holders/Licensees about spectrum. In this way, Government will come to know that how much demand exists for direct assignment of spectrum from DoT for establishment of private captive network.

4.147 For assessment of demand of spectrum for private networks, DoT should create a portal and open it for at least for a period of 6 months, seeking demand for spectrum from companies. The following information may be asked to assess the demand:

- Name of the company
- Details of their business, Net Worth, Turnover
- Proposed use of spectrum
- Requirement of spectrum
    - Spectrum Band
    - Quantum of Spectrum
    - Time Period for which spectrum is required
- Area in sq km with exact location
- Technology proposed to be used

The information so collected by DoT should be accessible only to authorized person in DoT and should not be shared with any unauthorized person.

4.148 In view of the foregoing discussion, **the Authority recommends that spectrum in such bands where IMT ecosystem is available but are being used for non-IMT services in India and can coexist with indoor/within premise cellular based private captive networks on shared basis, be earmarked for private captive networks. The Authority recommends DoT may consider the possibility of earmarking spectrum for captive wireless private networks in the following bands:**

a. <u>3700-3800 MHz band</u>

(i) DoT may consider the possibility of earmarking some spectrum (at least 40 MHz) in 3700-3800 MHz frequency range for low power indoor use for private captive network.

(ii) The co-existence of private captive network and satellite C-band receive stations can be made possible by creating an effective exclusion zone around the satellite C-band receive stations.

(iii) For this purpose, a digital map of all the existing satellite C-band receive stations should be created having database of their geo-coordinates with automated software system.

(iv) The location of private network proposed by an applicant to be accommodated on co-existence basis should be analyzed and permitted through the automated software system.

(v) The power limits and antenna tilt etc. for private captive network should be prescribed by the government for interference free operation and co-existence.

b. <u>4800-4990 MHz band</u>

(vi) DoT may also consider identifying the frequency range 4800-4990 MHz for IMT purpose and consider the possibility of carving out some spectrum (at least 40 MHz) in this frequency range for the purpose of earmarking for private captive network.

c. <u>28.5-29.5 MHz band</u>

(vii) DoT may also consider identifying some spectrum (at least 400 MHz) in the frequency range 28.5-29.5 GHz for the purpose of earmarking for private captive network, which can co-exist with satellite earth stations.

(viii) A software based transparent system should be built to permit the establishment of private networks and Satellite Earth Stations based on the geo-coordinates of the proposed location on interference free co-existence basis.

(ix) DoT should develop a digital map with geographic coordinates of all the existing and future Satellite Earth Stations as well as geographic coordinates of the premises of Private Network locations. Based on this database, permissions for establishment of new installations may be provided to the licensees.

4.149 **The Authority recommends that for assessment of demand of spectrum for private networks, DoT should create a portal and open it at least for a period of 6 months, seeking demand for spectrum from companies. The following information may be asked to assess the demand:**

- **Name of the company**
- **Details of their business, Net Worth, Turnover**
- **Proposed use of spectrum**
- **Requirement of spectrum**

- **Spectrum Band**
- **Quantum of Spectrum**
- **Time Period for which spectrum is required**

- **Area in sq km with exact location**
- **Technology proposed to be used**

The information so collected by DoT should be accessible only to authorized person in DoT and should not be shared with any unauthorized person.

4.150 **The Authority recommends that demand assessment will provide the demand factor for direct spectrum assignment from DoT for establishment of private captive network. With such empirical assessment and DoT's decision on the spectrum bands in which spectrum can be earmarked for private networks, the Authority will provide its recommendations on quantum of spectrum, block size, etc.**

(vi) Eligibility conditions, assignment methodology tenure of assignment and its renewal, roll-out obligations

4.151 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[53].

4.152 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.

4.153 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.

4.154 With this background, stakeholders were asked for their opinion on eligibility conditions for assignment of such spectrum to private entities and assignment methodology, tenure of assignment and its renewal, roll-out obligations.

Comments received from the stakeholders

4.155 One of the stakeholders suggested that registered business entities that have a real property interest defined by ownership of buildings and/or land, or a tenancy be a requirement for a private 5G license. Applicant should also have technical know-how and it should not offer commercial for-profit services on the awarded spectrum. It has also been mentioned by stakeholders that NPNs are required to synchronize as necessary, if they are adjacent geographically or spectrally, in order to ensure non-interference with other applications. Equipment deployed for the NPNs should meet all other technical requirements

[53] https://www.netmanias.com/en/?m=view&id=blog&no=15139

such as those relating to Effective Isotropic Radiated Power (EIRP) boundaries.

4.156 One of the stakeholders suggested that Government can review applications based on financial background to build and operate private network, business plan/case, spectrum requirement (one location vs many locations).

4.157 Regarding assignment methodology, many stakeholders opined that spectrum be allocated administratively under registration mechanism to the enterprises directly at nominal fee for private, captive and local network deployments in 5G technology in line with global practices to enable Industry 4.0.

4.158 Many stakeholders suggested that licensing period for private networks needs to be flexible where a companies can acquire license as per their needs. This is necessary to ensure need-based spectrum allocation and optimal spectrum utilization.

4.159 Couple of other stakeholders suggested that spectrum assignment be done for a specific location and be done in an administrative manner using light–touch regulation. Another stakeholder proposed for light licensing and quick/auto approval basis.

4.160 It was also suggested by many stakeholders that to expedite overall allotment process, there should be a simple application and allocation process, and complete process should conclude within 30 days with formal spectrum (frequency channel and other technical details) allocation to the end enterprise / industry vertical. The licensing process be entirely online and be accompanied by time bound approvals for allocation of spectrum for NPN deployments.

4.161 Regarding tenure, one stakeholder suggested for 10 years with provisions for extensions. Other couple of stakeholders suggested that the length of license period should be no different than for TSPs, but with an annual “check-in” or renewal to ascertain that the business continues to exist and continues to use the spectrum.

4.162 One of the stakeholders suggested that access to spectrum must be predictable over a long period of time to support uninterrupted operation and major investments in production processes and industrial facilities having a lifecycle of typically 15–20 years.

4.163 Regarding roll-out obligations, one of the stakeholders submitted that the enterprise should be able to start operations within at least 2 years of assignment of spectrum. Other stakeholder suggested that rollout obligation should be one year from date for assignment of spectrum. Another stakeholder suggested that there should be no roll-out obligation.

(vii) Broad framework for the process of application

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

4.165 With this background, stakeholders were asked for suggestions for filing application(s), payment of spectrum charges, assignment of frequencies, monitoring of spectrum utilization, timeline for approvals etc. In addition, stakeholders were asked for further relevant suggestions, if any.

Comments received from the stakeholders

4.166 In its response, one stakeholder submitted that the broad licensing Framework should include spectrum assignment duration, spectrum charges, rollout obligations, compliance obligations, process for filing application(s) by enterprise at single location and at multiple locations, Company details, monitoring of spectrum utilization, timeline for approvals, etc. Some stakeholders submitted that the policy framework should include and mandate the technical requirements which need to be fulfilled by private networks.

4.167 Regarding filing of applications, many stakeholders suggested for complete digital process, with a web-based application where all companies can apply for the required spectrum, with options for single or multiple location applications. Regarding timeline for approvals, many stakeholders submitted that after successful application, there must be time bound approvals.

4.168 Among other suggestions for earmarked spectrum, couple of stakeholders suggested that 3GPP technologies be used to address the requirements of the private network. This also allows the private networks to leverage the growing ecosystem of devices as well as network deployments in 3GPP supported bands.

Analysis

4.169 **Guidelines for Spectrum Assignment to Captive Wireless Private Network Licensee:** In respect of direct spectrum assignment by DoT to Licensed Captive Wireless Private Network licensees, DoT should come out with a guideline detailing the eligibility conditions, spectrum assignment methodology, validity of spectrum, roll out obligations, framework for application process, monitoring etc. It may be termed as 'Guidelines for Spectrum Assignment to Captive Wireless Private

Network Licensee'. In the following few paragraphs, the key elements to be included in the said guidelines are discussed and analyzed.

4.170 **Eligibility Conditions:** Some of the stakeholders have submitted that the applicant seeking spectrum for private network should possess the required technical know-how, use-case knowledge and financial resources to build, install and operate a private network. It has also been suggested that the applicant should be the owner or lessee of the property on which the private network is to be installed. The applicant should be ready to undertake that the spectrum will be used only within its campus, location, factory or premises and private network coverage will be confined within the same.

4.171 Another stakeholder stated that from a regulatory perspective, it is important that the entities receiving licenses have the capability to understand regulatory requirements in order to stay within the boundaries of the license. One of the stakeholders suggested that assignment of spectrum should be based on (a) Strong financial background to build and operate private Network and (b) Strong Business Plan.

4.172 As discussed earlier, the demand of entities/enterprises/industries for private cellular network can be met by various means:

(i) Enterprise may use a Network Slice from TSP's PLMN network.

(ii) Enterprise may request TSPs to establish an independent isolated private network in enterprise's premises using the TSP's spectrum.

(iii) Enterprise may obtain the spectrum on lease from TSPs and establish their own isolated Captive Wireless Private Network.

(iv) Enterprise may obtain the spectrum directly from DoT and establish their own isolated Captive Wireless Private Network.

4.173 For (i) and (ii) above, there will be no restrictions on eligibility criteria because such enterprises will be the customers (corporate customers) of the TSP. It will be a kind of customized services by TSPs to the enterprises.

4.174 For (iii) and (iv) above, the enterprise will be establishing its own isolated Captive Wireless Private Network and therefore it has to obtain the Captive Wireless Private Network License from DoT. The process and eligibility for obtaining Captive Wireless Private Network License have already been discussed, deliberated and recommended at the beginning of this chapter at Para 4.67.

4.175 For (iii) above, the enterprise will be leasing the spectrum from TSPs for which the process and spectrum leasing guidelines for TSPs have already been discussed, deliberated and recommended earlier in this chapter at Para 4.94. Therefore, no further discussion on eligibility criteria is required here for this category. For this category, the only requirement for the enterprise is to have Captive Wireless Private Network License from DoT.

4.176 However, for (iv) above, the spectrum for private network is to be provided directly by DoT. For this scenario, DoT should define the eligibility criteria for obtaining the spectrum directly from DoT and such criteria should be over and above the requirement of having Captive Wireless Private Network License.

4.177 As the applications and business models for 5G are still under development, it is not currently possible to definitely predict the market demand for private network spectrum. However, any enterprise willing to build captive wireless private network using the spectrum assigned by DoT, will have to make reasonable investment in building the network. Further, direct assignment of Spectrum involves security issues, which necessitates the need for clear understanding of regulatory provisions, various compliances and technical know-how. Therefore, the Authority is of the view that direct assignment of spectrum should be done only to the companies register under the Companies Act, 2013, since they are familiar with the compliance requirements and associated regulatory provisions and it should be based on sound financial strength of the enterprise so as to build and operate captive wireless private network. Therefore, eligibility criteria based on networth should be imposed. One of the eligibility criteria for TSPs to participate in the spectrum auction is net worth of Rs. 100 Crore per LSA. However, since an enterprise will be acquiring spectrum for captive use, to begin with, net worth of Rs. 100 to acquire spectrum at one or more locations across the country may be mandated. However, this can be reviewed later.

4.178 The Authority considers that the following should be the eligibility conditions for assignment of spectrum directly by DoT to entities for establishment of isolated private captive network:

(i) Applicant should be a valid 'Captive Wireless Private Network Permission/License'.

(ii) Captive Wireless Private Network permission holder/Licensee should be the occupant (either owned or on lease) of the geographical area/property on which spectrum is being sought to be deployed for the captive wireless private network.

(iii) The networth of the Captive Wireless Private Network Permission holder/Licensee should not be less than Rs. 100 Crores. However, this can be reviewed later.

4.179 **Spectrum Assignment Methodology:** The Authority has observed that most of the stakeholders are suggesting for assignment of spectrum on administrative basis in line with global practices. One of the stakeholders has stated that Spectrum assignment be done for a specific location and should be done in an administrative manner using light–touch regulation. Couple of stakeholders have submitted that earmarking via administrative allocation of spectrum is based on the legally untenable grounds of first come first serve and substantial revenue opportunity loss to TSPs.

4.180 As already stated, private networks can coexist with Fixed Satellite Service (FSS) due to their low power emission and confined geographic operations. Therefore, assigning spectrum for private network in IMT bands in which IMT ecosystem is available but not being used for IMT in India, will not impact the spectrum availability for TSPs in IMT bands. It will promote efficient utilization of spectrum with multiple use on co-existence basis.

4.181 The Authority has noted that the spectrum for private network will be used within specified limited geography. As it will be used for limited area, it will be used with low power and within the premises. Therefore, the same spectrum can be repeatedly used by other entities for private network at other locations on non-interference basis having different geo-coordinates of the locations. Hence, the spectrum assignment for private network will be for a specified geographic area of its operation and the same spectrum can be reused with multiple assignment to large number of players.

4.182 Spectrum for private network, assigned to enterprises for captive use, is utilized within the specified 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. Regarding method of assignment, practice adopted by other countries namely Germany, UK, France, Finland, Sweden, Australia, South Korea, Hong Kong and Malaysia was examined. It is observed that in all these countries, spectrum for local use/private captive network is being assigned administratively.

4.183 The spectrum for private network is to be assigned for specified limited geography to a Captive Wireless Private Network permission holder/licensee who is the occupant (either owned or on lease) of the geographical area/property on which spectrum use is being sought. Therefore, at a particular location/premise/specified geography, there will be only one contender for the spectrum who will be the occupant of that premise (either owned or on lease). Generally, when there are more than one contenders for the same spectrum at the same geography, then only the question arises as to how to assign the spectrum consistent with the fundamentals of the equality clause. However, as mentioned above, in case of assignment of spectrum for private network there will be only one claimant at a specific location premise. Therefore, the Authority is of the view that the spectrum for private network can be assigned administratively to the eligible licensees on demand through a widely publicized online portal-based process in a fair and transparent manner. The assignment process will register the geo-coordinates of the specified geography for which the spectrum is to be assigned. However, DoT may ascertain that administrative assignment in such cases is legally tenable as per spectrum assignment policy of DoT, before formulating the guidelines for assignment of spectrum for captive wireless private network.

4.184 **Tenure of Spectrum and Roll out obligations**: Stakeholders have submitted varying response in respect of validity of spectrum ranging from 10 to 30 years. For roll out obligations, the stakeholders have suggested that the entity should start using the spectrum within 12 months or two years. One of the stakeholders has suggested that there should not be any roll out obligation.

4.185 On examination of the global practice, it is observed that Germany and France have prescribed the validity period as upto10 years, Hong Kong has prescribed the validity period as 5 years, Malaysia has prescribed upto 5 years, South Korea has prescribed the spectrum license validity as 2-5 years, while UK issues spectrum license for indefinite period with annual fee payment. The Authority feels that any enterprise investing in private networks may like to have certainty and like to go for a longer validity period. However, demand for shorter period of license cannot be ruled out. Therefore, the Authority is of the view that to provide flexibility the spectrum may initially be assigned for a period up to 5 years with a renewal process for further up to 5 years and so on. Further, there should be online portal-based spectrum assignment and renewal process. As regards roll-out obligations, the Authority is of the view that it is necessary that the spectrum assigned to the enterprises is put to efficient use and therefore roll out obligation based on the 'use it or lose it' principle within a period of 12 month from the date of assignment of spectrum frequencies be mandated. Thus, the eligible CWPN permission holder/licensee should put to use the spectrum assigned to it within 12 months from the date of assignment. In case, it is not used within one year, it may be taken back without any refund. Therefore, the Authority considers that a spectrum assignment can be revoked if use of the spectrum has not begun within one year of the assignment ('use it or lose it' principle), or if the spectrum has not been used for the purpose for which it has been assigned.

4.186 **Pricing Mechanism**: One of the stakeholders has submitted that the pricing of the spectrum should be based on duration, required bandwidth, and area to be covered. The spectrum be licensed for use at a rate that reflects the administrative costs associated with licensing the same. Another stakeholder stated that care be taken to ensure that any fees associated with the license are not onerous.

4.187 In the earlier sections, the Authority has suggested some frequency bands in which some spectrum can be earmarked for private networks and has also recommended that DoT should carry out demand assessment for spectrum requirement for private networks. The Authority has also made its recommendation regarding methodology for assignment. Therefore, **considering the outcome of the demand assessment and DoT's decision on (i) spectrum bands in which spectrum can be earmarked for private networks and (ii) the methodology for spectrum assignment, the Authority will provide its recommendations on pricing aspects keeping in view the**

principles of transparency and appropriately factoring in the market determined price, geographical aspects, etc.

4.188 **Broad Framework for Process of Applications**: One of the stakeholders stated that complete process be digital and a web-based application where all companies can apply for the required spectrum, with options for single or multiple location applications. Another stakeholder submitted that licensees should be required as part of an annual check-in process to file a statement affirming that the spectrum licensed is in use or not in use for each location where licensed. Some of the stakeholders submitted that there should be a simple application and allocation process, and complete process should conclude within 30 days with formal spectrum (frequency channel and other technical details) allocation to the end enterprise / industry vertical.

4.189 The Authority is of the view that the entire process of filing of application for spectrum (earmarked for Captive Wireless Private Networks) assignment for Captive Wireless Private Networks and its processing should be done through an online portal. Application processing and spectrum allocation should be done in a time bound process.

4.190 The spectrum should be assigned for captive network deployments using 3GPP compliant technology or technology approved by the Government.

4.191 There are many other key elements which are also required to be included in the proposed guidelines such as:

- A company registered under the Companies Act, 2013 and having valid CWPN permission/License can apply for multiple locations through a single portal. However, documents showing occupancy (either owned or lease) of each of the geographic area will have to be submitted through online portal.

- Prescribed Spectrum charges should be applicable for each location.
- Documents required to be submitted through online portal should be specified so as to make entire process should be paperless.
- It will be the responsibility of the CWPN permission holder/Licensee (enterprise) to ensure that the mobile signals are restricted indoors/within the specified geography. Spectrum cannot be used beyond the assigned geographical area.
- The CWPN permission holder/licensee should be required to ensure efficient and interference-free use of their networks, for instance to design and build their networks in such a way so as to minimize the interference ranges of their spectrum usages. This can be achieved for instance with low transmit powers, low antenna heights and appropriate antenna directional patterns. DoT should prescribe the antenna height, power limits, antenna tilt etc.
- The limits for public exposure to electromagnetic fields from radio equipment must be met.
- Conditions related to no interference to PLMN networks should be prescribed.
- The licensor will have the right to inspect the premises to ascertain the bonafide and legitimate use of spectrum.
- The licensee should be required to submit a compliance certificate annually certifying the compliance to the bonafide use of spectrum, power limits and any other periodical compliance.
- The licensor should have the rights to revoke the spectrum assignment in case of violation of prescribed terms and conditions.
- As the spectrum earmarked for private network has to co-exist with other radio services like FSS stations, to protect these radio services, the licensee should submit the required details of the geo-coordinates of the premises and parameters for the local

usages while applying for the spectrum assignment so as to carry out the necessary radio compatibility calculations.

- The area of operation, that is, the spectrum usage area of the licensee will be the area inside the logical perimeter of the defined premises with clearly specified geo coordinates. WGS84 format of geographic coordinate system or any other suitable geographic coordinate system may be used for this purpose.
- The CWPN permission holder/licensee will be responsible for the correctness of the geographic coordinates of the area for which the spectrum assignment is applied for.
- Spectrum should be used in such a way that the spectrum usage is feasible in the assignment area without causing any interference to adjacent spectrum usages and is compatible with other spectrum usages.
- The application for spectrum assignment should also include the following in particular:
    - Details of the planned coverage area and a geographical map.
    - Type of application planned. (type of industry vertical)
    - Planned purpose of use of spectrum. (For example, machine control etc.)
    - Quantity of spectrum required for the planned purpose of use.
    - Proposed Signal level.
    - Details of the technology to be used, network build, number and technical characteristics of base stations etc.
    - Measures to be taken to ensure efficient spectrum use.
    - Details of the antennas to be used (type, location, height, directional pattern), shielding measures, indoor/outdoor applications.
    - Timescale for the network build and network roll-out.
    - Period for which spectrum is required.

4.192 In view of above, **the Authority recommends that in respect of direct spectrum assignment by DoT to Captive Wireless Private Network Permission holders/Licensees, DoT should come out with a guideline detailing the eligibility conditions, spectrum assignment methodology, validity of spectrum, roll out obligations, framework for application process etc. It may be termed as 'Guidelines for Spectrum Assignment to Captive Wireless Private Network Permission holder/Licensee'.**

4.193 **The Authority recommends that the following should be the eligibility conditions for assignment of spectrum directly by DoT to entities for establishment of isolated private captive network:**

(i) Applicant should be a company registered under the Companies Act, 2013 and have valid 'Captive Wireless Private Network Permission/License'.

(ii) Captive Wireless Private Network Permission holder/Licensee should be the occupant (either owned or on lease) of the geographical area/property on which spectrum is being sought to be deployed the captive wireless private network.

(iii) The networth of the Captive Wireless Private Network Permission holder/Licensee should not be less than Rs. 100 Crores.

4.194 **The Authority recommends that the spectrum for private network can be assigned administratively to the eligible Captive Wireless Private Network Permission holders/Licensees on demand for specified geography on non-interference basis through a widely publicized online portal-based process in a fair and transparent manner. The assignment process will register the geo-coordinates of the specified geography for which the spectrum is to be assigned. The same spectrum can be reused with multiple assignment to large number of players having different geo-coordinates on co-existence basis with FSS services. However, DoT**

may ascertain that administrative assignment in such cases is legally tenable as per spectrum assignment policy of DoT, before formulating the guidelines for assignment of spectrum for captive wireless private network.

4.195 **The Authority recommends that to provide flexibility, the spectrum for private networks should be assigned initially for a period up to 5 years with a renewal process for further up to 5 years and so on. The licensee should put to use the spectrum assigned to it within 12 months from the date of assignment. Spectrum assignment can be revoked if use of the spectrum has not begun within one year of the assignment ('use it or lose it' principle), or if the spectrum has not been used for the purpose for which it has been assigned.**

4.196 **The Authority recommends that the entire process of filing of application for spectrum (earmarked for Captive wireless private networks) assignment for captive wireless private networks and its processing should be done through an online portal. Application processing and spectrum allocation should be done in a time bound process.**

4.197 **The Authority recommends that spectrum should be assigned for captive network deployments using 3GPP compliant technology or technology approved by the Government.**

4.198 **The Authority recommends that there are many other key elements which are also required to be included in the proposed guidelines such as:**

- **A company registered under the Companies Act, 2013 and having valid CWPN permission/License can apply for multiple locations through a single portal. However, documents showing occupancy (either owned or lease) of each of the geographic area will have to be submitted through online portal.**

- **Prescribed Spectrum charges should be applicable for each location.**
- **Documents required to be submitted through online portal should be specified so as to make entire process should be paperless.**
- **It will be the responsibility of the CWPN permission holder/Licensee (enterprise) to ensure that the mobile signals are restricted indoors/within the specified geography. Spectrum cannot be used beyond the assigned geographical area.**
- **The CWPN permission holder/licensee should be required to ensure efficient and interference-free use of their networks, for instance to design and build their networks in such a way so as to minimize the interference ranges of their spectrum usages. This can be achieved for instance with low transmit powers, low antenna heights and appropriate antenna directional patterns. DoT should prescribe the antenna height, power limits, antenna tilt etc.**
- **The limits for public exposure to electromagnetic fields from radio equipment must be met.**
- **Conditions related to no interference to PLMN networks should be prescribed.**
- **The licensor will have the right to inspect the premises to ascertain the bonafide and legitimate use of spectrum.**
- **The licensee should be required to submit a compliance certificate annually certifying the compliance to the specified use of spectrum, power limits and any other periodical compliance.**
- **The licensor should have the rights to revoke the spectrum assignment in case of violation of prescribed terms and conditions.**
- **As the spectrum earmarked for private network has to co-exist with other radio services like FSS stations, to protect**

these radio services, the licensee should submit the required details of the geo-coordinates of the premises and parameters for the local usages while applying for the spectrum assignment so as to carry out the necessary radio compatibility calculations.

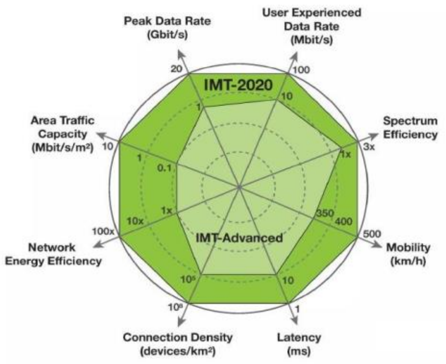
- **The area of operation, that is, the spectrum usage area of the licensee will be the area inside the logical perimeter of the defined premises with clearly specified geo coordinates. WGS84 format of geographic coordinate system or any other suitable geographic coordinate system may be used for this purpose.**
- **The CWPN permission holder/licensee will be responsible for the correctness of the geographic coordinates of the area for which the spectrum assignment is applied for.**
- **Spectrum should be used in such a way that the spectrum usage is feasible in the assignment area without causing any interference to adjacent spectrum usages and is compatible with other spectrum usages.**
- **The application for spectrum assignment should also include the following in particular:**
    - **Details of the planned coverage area and a geographical map.**
    - **Type of application planned. (type of industry vertical)**
    - **Planned purpose of use of spectrum. (For example machine control etc.)**
    - **Quantity of spectrum required for the planned purpose of use.**
    - **Proposed Signal level.**
    - **Details of the technology to be used, network build, number and technical characteristics of base stations etc.**
    - **Measures to be taken to ensure efficient spectrum use.**

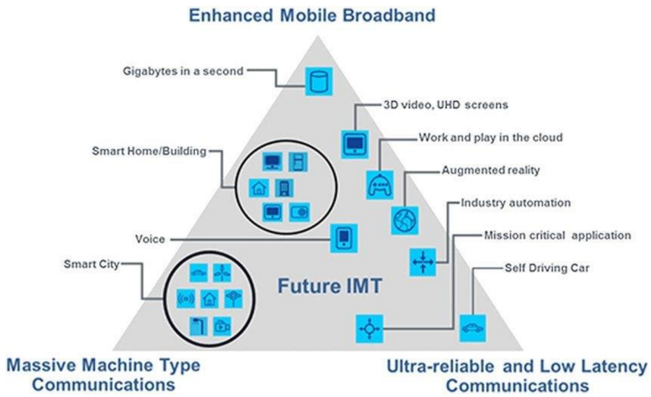
- **Details of the antennas to be used (type, location, height, directional pattern), shielding measures, indoor/outdoor applications.**
- **Timescale for the network build and network roll-out.**
- **Period for which spectrum is required.**

CHAPTER V: IDENTIFICATION, DEVELOPMENT AND PROLIFERATION OF 5G USE CASES

5.1 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 to overcome the major hurdles in the way of 5G.

5.2 The ITU has defined three standard 5G service profiles - Massive 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

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

- **Massive Machine-Type Communications (mMTC**): For 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 requirement of up to 1 milli second, uRLLC will be able to connect controllers, switches, sensors, and actuators at latency and reliability levels equivalent to those of a wired connection. uRLLC service profile addresses several critical applications in different industries and scenarios, such as for manufacturing, automation, and autonomous equipment or vehicle operation.

5.3 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, manufacturing industry, mines, ports, energy, smart cities etc.

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

5.5 With this background, the stakeholders were asked for their suggestions regarding steps that need to be taken to facilitate the identification, development, and proliferation of India-specific 5G use cases for different verticals for the benefit of the economy and citizens of the Country.

Comments received from the stakeholders

5.6 In its response, few stakeholders submitted that there should be timely spectrum availability by following international band plans and releasing usable spectrum as 5G requires spectrum within all three key frequency ranges, that is, low, mid and high band to deliver widespread coverage and support all use cases. It is also required to have investment-friendly terms and conditions with well-established defined rights that allow for trading and avoid onerous rollout obligations. There is a need to ensure the right conditions that avoid power limits, prioritize contiguous spectrum, and carefully decide on protection to adjacent services only when needed.

5.7 Another stakeholder submitted that a 5G Preparedness committee of DoT should actively involve industry, academia, and operators to facilitate the identification, development, and proliferation of India-specific 5G use cases for different verticals.

5.8 One stakeholder proposed that 5G innovation centres can be formulated in alliance with the several IITs & also at prestigious technology-driven centres such as IISc. Each of these incubation centres could need to be made responsible for innovation in the various fields of Agriculture, Medicine, Manufacturing, Infrastructure, Power, and other verticals that will benefit from such investment of R&D.

5.9 Few other stakeholders submitted that the impetus will be required to be given by different Ministries of the Government, Industries across verticals and technology solution providers to have regulatory provisions and cross-industry coordination of Telecom Companies / Enterprises / System Integrators, Innovation labs in fields such as Industry, Healthcare, Agriculture, Automotive, Education, etc. However, the role of Government and Regulators should be limited to acting as facilitators/bridges among various departments/ministries and industry and not extended to mediators in techno-commercial negotiations of use cases.

5.10 A couple of other stakeholders commented that the need of the hour is to ensure robust ubiquitous world-class 5G networks and infrastructure that are capable of supporting the various 5G use cases and the needs of industries and consumers.

5.11 Other stakeholders suggested that Application and Use Case labs may be established, which can be used by industry verticals, wireless technology companies, and application developers to provide many useful functions viz. Showcasing applications, testing interoperability, and promoting the development of innovative applications. These Use case Labs be set up in each economic vertical with the support of the corresponding ministry and public or private sector industries such as Agriculture, Health, Banking, Railways, etc.

5.12 Few other stakeholders submitted that test Labs for Private Networks need to be established to try out various 5G private networks use cases in a controlled environment first even for early adopters to validate their profitability and feasibility. These control environments can be a test lab, customer experience centre, or co-innovation centre. As these testbeds also need spectrum access to deploy a private network, the government should permit enterprises to set up a lab in their own premises using an allocation of private network spectrum license. These licenses should be temporary and free of charge in nature or at nominal charges which are limited to specific areas. The licensing process needs to be time-bound with a 10 days approval period to ensure quick execution. Enterprises should have an obligation to deploy test labs within 3-6 months of allotment to achieve optimal spectrum utilization. System integrators and other service providers shall also be permitted to apply for trial licenses in enterprise premises in case of any proof-of-concept or use-case trials that the enterprise needs to conduct before the final private network spectrum application.

5.13 Another stakeholder submitted for steps that may be taken to ensure a conducive environment for the development of Indian IPR, especially in the technology sector, by facilitating the approval mechanisms. It has also commented that the implementation of TEC's Mandatory Testing and Certification of Telecommunication Equipment (MTCTE) and National Security Directive on Telecommunications (NSDT) testing mechanism needs to be balanced out without any adverse impact on the rollout and expansion of digital networks, most importantly for upcoming 5G services. Considering this and the fact that this is a complex exercise that requires synergy and close coordination of all entities – NSCS, DoT, TEC, TSPs, OEMs, SIs, and others. The entire approval process needs to be revisited to avoid any unnecessary delays.

A. 5G use cases in various verticals

5.14 The beauty of 5G technology lies in the fact that the same network will be able to deliver the three distinct category of use cases with customized requirements namely eMBB, mMTC and uRLLC. These three distinct performances through a single network are possible in 5G because of certain technological development such as:

(i) Network Function Virtualization
(ii) Software Defined Network
(iii) Massive MIMO technology (Multiple Input Multiple Output)
(iv) Network Slicing

5.15 5G technology coupled with Internet of Things (IoT), Artificial Intelligence, Machine Learning and Data Analytics have given rise to numerous use cases covering almost every economic vertical such as:

(i) Agriculture
(ii) Healthcare
(iii) Manufacturing & Industrial Automation
(iv) Mining
(v) Education
(vi) Energy and Grid Power
(vii) Automotive Industry
(viii) Smart Cities
(ix) Media and Entertainment
(x) Financial Markets

5.16 There is a need to develop and implement the use cases in respect of all the verticals including those mentioned above. The high speed, low-latency, high device density and ultra-reliable 5G technology can have applications across different sectors and these applications are commercially feasible too. There are examples of successful implementation of use cases of 5G globally. Some of the sector-wise 5G use cases are described below:

(i) Agriculture

5.17 Some of the illustrative examples of 5G Use cases and applications of IoT & other upcoming technologies in Agriculture includes:

- Soil and crop monitoring - with the help of sensor network
- Precision farming - a technology-enabled approach to farming management that observes, measures, and analyse the needs of individual fields and crops
- Smart irrigation & climate change alignment – using moisture sensor, auto irrigation, and sophisticated local weather forecasting
- Livestock monitoring - IoT sensors in livestock wearables allow farmers to monitor location and health of animals
- Agricultural drones – to get aerial imagery of crop to detect crop damage due to insects

(ii) Healthcare

5.18 Wearable devices, secure online consultations, and remote medical procedures like robotic surgery will improve resource efficiency and meet consumer demands for greater convenience and freedom of choice.

5.19 Some of the main use cases categories in Healthcare sector include:

- **Patient Applications** - Patient centred applications used outside of traditional hospital environments such as - Precision medicine; applications to monitor, alert and administer medicines.

- **Automation**: Remotely operated robotic surgeries, robot assisted therapies and surgeries enabled through mission-critical features of 5G networks requiring high reliability, high availability, and low latency could bring advanced medical treatment which is out of reach of the non-urban population.
- **Online consultations**: Online consultations and virtual doctor-patient interactions on account of high data speeds is expected to reduce the long waiting time for patients.
- **Rural Health**: Solution needs to be developed comprising of mobile device, connected to Medical Device and enabled with Biometric ID, Camera and GPS with network connectivity to the backend Server where vital parameters can be submitted and analyzed.
- **Medical Data Management** - systems to manage and analyze patient's records and other medical data such as - Electronic Health Record, Real time delivery of rich data sets.
- **Quick Access to Medical Assistance** - such as Ambulance Drones etc.
- **5G Connected Ambulance** - The 5G connected ambulance provides an innovative new way to connect patients, ambulance workers and remote medical experts in real time. A camera based in the ambulance transmits high-definition footage to the remote clinician with close to zero latency. Using a VR headset and a joystick, the clinician can then remotely guide the paramedic through a series of procedures based on haptic glove technology. All of this allows the clinician to recognize vital signs, access medical records remotely and ultimately respond much faster.

(iii) Manufacturing & Industrial Automation

5.20 To enable smart manufacturing, every stage of the process must be connected and digitally accessible. Smart manufacturing is the next Industrial Revolution. 5G and the Industrial Internet of Things (IIoT) are enabling factories to seamlessly create a network of wirelessly connected machines and people that can instantaneously collect, analyze, and distribute real-time data. The new technology provides more information to give a bigger picture, allowing for simultaneous product customization and maximum production output, while also offering increased flexibility, traceability, sustainability and safety.

5.21 Some of the main use cases of 5G technology in industrial automation include:

- Autonomous mobile robots (AMR) for real-time production chain automation
- Collaborative robots for more efficient operations
- Augmented Reality (AR) for efficient quality inspections
- Asset condition monitoring for increased uptime

(iv) Mining

5.22 'Smart Mine' is the one in which the use of information, data, autonomous machines, and advanced technologies bring about higher productivity, better safety, and a reduction in operational costs during mining and processing.

5.23 The smart network infrastructure that mining organizations deploy must be able to handle the large amounts of data that vehicles, equipment, and workers will generate. For instance, remote drilling systems and unmanned aerial vehicles (UAVs) produce a live video feed that must be transmitted to a remote operations system. To function properly, it needs ample bandwidth and a highly reliable connection. Communication services are mission-critical to mining operations in order to prevent injury and loss of life, and to minimize economic impacts, especially during emergency situations. 5G-ready private cellular networks are perfectly positioned to deliver on all of these requirements.

5.24 Some of the most beneficial near-term applications for smart mining technologies includes:

- Autonomous vehicles
- Real-time condition monitoring
- Remote controlled drilling rigs
- Unmanned drone inspection
- Smart ventilation control

(v) Education

5.25 The online education and learning through online lectures are gaining momentum nowadays. 5G technology, under its use case of enhanced Mobile Broadband (eMBB), is capable of providing the requisite bandwidth for students as well as for institutions for providing online education.

5.26 Further, innovative technologies like virtual reality could help engage students in new powerful ways and enhance educational experiences. Virtual reality (VR) offers new possibilities for students to interact with educational content within a virtual, three-dimensional learning environment. These VR experiences require high-bandwidth and high refresh rates. Because of 5G's ability to support increased data volumes with low latency, it can be ideal for supporting VR or other augmented reality (AR) experiences.

(vi) Energy and Grid Power

5.27 Digitization of energy sector in India could enhance electricity access to the population as well as improve energy efficiency and utilization. Higher levels of energy consumption and new patterns of energy flow (for example electric vehicle charging) mean a greater need for visibility and identification of bottlenecks to maximize service performance. Therefore, utility companies must modernize and digitalize in line with the changing market for greater stability and resilience through monitoring and automation. Technology can help to find faults more precisely and in near real time, and then reconfigure the network to restore services automatically. It will also increase network monitoring and visibility to improve power network stability and resilience through remotely optimized operations.

5.28 This can also help reduce unplanned outages through close monitoring of equipment, help spot human errors and quickly localize damages due to external factors such as extreme weather. Low latency feature and high data rates offered by 5G networks have the potential to meet these requirements, which eventually could translate into effective utilization of resource and reduced losses.

5.29 Some of the 5G enabled uses cases across energy and utility sector include:

- Distribution of energy within a smart grid
- Smart meters for the smart homes
- Remote monitoring of energy sites
- Energy efficiency and reducing the effects of climate change
- Smart Power generation, Green energy, and distribution automation

(vii) Automotive Industry

5.30 Significant investment in the research for V2X (Vehicle to everything) communication, where the vehicle communicates with varied elements such as other vehicles, infrastructure, devices, grids etc. could enable a plethora of use cases / features such as collision avoidance, real time traffic routing, pedestrian's safety alerts, emergency braking etc.

5.31 Some of the common use cases include - Connected cars platforms and basic features, Vehicle sensing, virtual assistants, Real time data analytics, over the air software upgradation / deployment, High-Definition maps for autonomous vehicles, and monitoring systems.

5.32 Further, traffic management, fleet management, vehicle tracking, especially school bus tracking and monitoring of over speeding etc. are the immediate use cases to be implemented.

(viii) Smart Cities

5.33 In the smart city context, the connected city could enable use cases such as:

- Video surveillance and analytics - Providing surveillance and security services enabling assurance and mitigating concerns over safety
- Intelligent transport and traffic management - Managing traffic could be easier through controlled traffic signals and sensors regulating the flow of traffic throughout the city in response to demand
- Smart grids and metering systems with smart streetlight - Enabling better management and conservation of energy, thereby, keeping a check over pollution and further reducing outages
- Solid waste management - Improving operational costs by optimising routes for garbage trucks through elimination of unnecessary pick-ups, providing dynamic collection routes and schedules for a complete optimisation of the collection operations
- Intelligent parking - Smart parking stations can send 5G data about the free parking spots and pricing straight to the driver's onboard vehicle system. Such solutions can reduce traffic congestion and increase revenue per parking space.

(ix) Media & Entertainment

5.34 Media & Entertainment is a sector which is driven by consumer preferences and behavior. With increasing usage of smartphones and adoption of digital initiatives by consumers in this space, there has been rapid development in the media and entertainment industry which is gradually moving towards enhancing customer experience.

5.35 Future use cases in this sector are seen primarily requiring ubiquitous connectivity and high data rates with low latency include:

- Immersive experiences: Online AR/ VR gaming of the future will require tactile internet experience (high data rates at low latency). This in combination with voice recognition technology is likely to evolve towards voice interaction with virtual characters through smart wearables.
- Enriching gaming experience: This will comprise of features such as replays, player views from different angles, real time language translation between players etc.
- User/machine generated content from smart devices could help users to share data real time which is likely to improve the user experience.
- Cooperative media production could allow content to be worked upon by different users in multiple locations simultaneously.
- Distributed performance is expected to have the capability of distributed content sourced from different locations in real time.

(x) Financial Markets

5.36 Stock trading has always been hungry of reliable real-time connectivity. Financial markets have been one of the early and heavy users of dedicated internet connectivity solutions like VSATs, etc. A nanosecond delay in trading could mean a potential loss of millions if not billions. Online trading has grown over the years and we see several users joining the primary financial markets for investments. To support this trend, 5G could potentially evolve as a reliable and fast network offering connectivity of desired grade and quality.

B. Institutional Mechanism for 5G use cases development- International Scenario

5.37 Institutional mechanism for development of 5G use cases and applications was examined in respect of few countries namely South Korea, Japan, Australia, USA and China. The findings are described below.

(i) South Korea

5.38 Ministry of Science and ICT (MSIT), South Korea has constituted a **5G+ Strategy Committee**. The Committee is responsible for coordinating cross-ministerial and joint tasks between the public and private sectors.

5.39 It establishes the action plans and monitors the implementation of tasks through a monthly **5G+ Strategy Review Meeting**. Based on the results of the assessments, the Committee revises its strategies to reflect the latest market development.

5.40 For each of the **5G strategic industries**, the Committee designates sector representatives from MSIT to lead communication and collaboration among relevant ministries, industries, academia, and research institutes. Additionally, the Committee establishes a direct communication channel for the private sector to raise regulatory issues to be promptly addressed.

5.41 The 5G+ Strategy includes specific policies and measures to support ten strategic 5G-related industries and five core services to transform the economy.

- **Ten strategic industries:** network equipment, next-generation smartphones, VR-AR devices, wearable devices, intelligent CCTV, (future) drones, connected robots, 5G V2X, information security, edge computing

- **Five core services:** immersive content, smart factories, autonomous vehicles, digital healthcare, smart cities

5.42 After identifying 5G strategic industries and core services, the government-funded 5G trials and testbeds in these strategic verticals, such as digital healthcare, smart drones, and smart factories.

- **'Smart Korea Fund' to support startups:** Create a KRW 6 trillion (approximately USD 5.3 billion) fund to invest in startups developing digital solutions for e-commerce and online services, digital infrastructure for remote jobs, remote working solutions to SMEs, and digital healthcare infrastructure

(ii) Japan

5.43 In order to create new markets, Ministry of Internal Affairs and Communications (MIC) of Japan has been conducting **5G Comprehensive Demonstration Tests**[54] since 2017-18 with the cooperation of stakeholders in various related fields, including:

- Ensuring crane operations safety with high-resolution images
- Remote control and integrated construction management system for construction equipment
- Remote medical examinations enhancement
- Driving assistance in dense fog
- Self-guided sightseeing using VR and body sharing technology
- Support to ensure safety in underground railway sections
- Truck platooning
- Improve the efficiency of dairy and livestock industries
- Safety management for workers in tunnels
- Monitoring system for mountain climbers
- Enhancement of emergency transportation

[54] https://www.jetro.go.jp/en/invest/attractive_sectors/ict/government_initiatives.html

5.44 To promote the introduction of local 5G in various situations such as factories, farmland, transportation, medical care, construction sites, disaster sites etc., MICA has set up a **"Public-private Liaison Conference to Spread Local 5G"**[55] in January 2021, consisting of interested bodies and local 5G promotion organizations in respective regions.

(iii) Australia

5.45 The Australian Government has launched a supporting scheme called '**Australian 5G Innovation Initiative**[56] for development of 5G use cases**:**

- The Australian Government has funded the Initiative to help small to large businesses in Australia test and develop 5G uses, applications, services and products.
- The Initiative provides $40 million in funding through two open and competitive grant rounds.

Program Objectives:

- Supporting innovative and emerging commercial use cases of 5G in key industry sectors
- Demonstrating the value of 5G to businesses in Australia
- Supporting private sector investment in 5G trials

(iv) USA

5.46 US Government has invested 400 million dollars in the R&D of Advanced Wireless Research Initiative (AWRI), a research program related to 5G networks[57].

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[55] https://5gmf.jp/kanmin/about/

[56] https://spatial.infrastructure.gov.au/portal/apps/sites/#/5g-innovation-initiative-1

[57] https://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/presentation/pdf/Vision_toward_Beyond_5G.pdf

5.47 In August 2021, the FCC created two **new innovation zones** to allow for advanced wireless communications and network innovation research. Innovation zones provide opportunities for qualified licensees to test new advanced technologies and prototype networks, including Open RAN as well as those that can support 5G technologies, outside a traditional small campus or laboratory setting. These zones create geographic areas within which experimental program licensees can conduct tests and other experiments in addition to their specifically licensed areas[58].

(v) China

5.48 Ministry of Industry and Information Technology (MIIT), the National Development and Reform Commission (NDRC), and the Ministry of Science and Technology (MOST) have jointly set up the **IMT-2020 5G Promotion Group** in 2013 to push an all-government and all-industry alliance on 5G. Its targets included standardization and industrialization, promoting China's competence in 5G R&D, and strengthening international R&D cooperation. It has collaborated with operators, vendors, the 5G Automotive Association, the European Commission's 5G Infrastructure Association – Public-Private Partnership (5G PPP), etc. The Group has also worked with the China Academy of Information and Communication Technology (CAICT) and 5G Applications Industry Array to organize the 'Blooming Cup' 5G Application Pitch Competition to scout for and incubate innovative 5G applications and ensure quick access to the market.

5.49 To accelerate the integration of digital and real economies as a part of the policy framework for the nation's industrial development until 2025, 14th Plan Informatization Development has been released by China's MIIT. Certain quantitative objectives put forward by the same are as follows:

[58] https://docs.fcc.gov/public/attachments/DOC-374691A1.pdf

- To grow the penetration rate of industrial internet platforms to 45% and the popularization rate of digital research, development, and design tools to 85%
- To increase China's gigabit broadband users from 6.4 million in 2020 to 60 million in 2025
- To increase the value of the big data industry to 3 trillion yuan ($471 billion), up from more than 1 trillion yuan in 2020, and to maintain the average compound annual growth rate at about 25%

5.50 In December 2019, MIIT's **'5G + Industrial Internet'** plan was issued. The 'Working Plan for the Industrial Internet Special Task Force 2019' was aimed at the establishment of the China Industrial Internet Research Institute (CIIRI). In January 2021, the government has launched industrial 5G network pilot projects. It planned to focus on 10 key industries including mining, coal, electricity, petrochemicals, construction materials, ports, textiles, and home appliances.

C. Benefits of Digitalization/Automation of Processes/Industry 4.0

5.51 The benefits of digital transformation with implementation of ICT based processes are becoming visible globally. 'Industry 4.0' is a digital transformation in which the use of information, data, autonomous machines, and advanced technologies bring about higher productivity, better safety, and a reduction in operational costs during production and processing. Smart manufacturing requires flexible automation and such automation requires robust wireless connectivity, the catalyst for industry transformation.

5.52 For smart manufacturing, every stage of the process must be connected and digitally accessible. Autonomous robotics can provide real-time, closed loop, machine-to machine (M2M) communications, as well as untethered robots that can collaborate to complete tasks. Enhanced video services enable three-dimensional, video-driven interactions between robots and humans. 5G-ready cellular networks are perfectly positioned to deliver on all these requirements.

5.53 The 5G enabled digital transformation is going to benefit all the economic verticals. The most important stakeholders who may need Government's handholding the most are the Micro, Small and Medium Enterprises (MSMEs).

5.54 The bigger Industrial groups are already inclined to go for industrial automation using the latest Telecom and IoT technologies especially Industrial IoT, Artificial Intelligence, AR/VR, robotics, Machine Learning and Data Analytics. However, there is a need to assess the degree of intention and inclination among the 'Micro, Small and Medium Enterprises' (MSMEs), both in formal and informal sectors, towards automation and digital transformation. It appears that if the MSMEs are not timely nudged for adopting automation and digital transformation, there are chances of their operations becoming obsolete, which can eventually push them to the corner due to technological disruptions. Timely intervention and hand holding of MSME sector will also help India to increase its share in the international value chain system and play a significant role in the Indian and global digital economy.

5.55 For all this to happen, a collaborative approach is required to be followed. The Government may identify the verticals where the digital transformation/automation is immediately needed, and initiatives may be taken collectively in collaboration with concerned Ministries/Departments.

D. Digital Inclusion

5.56 Digitalization is transforming the way we live and work together. Digital technologies have become omnipresent and rise of the digital economy is one of the defining features of the 21st century. Telecom sector will play the bigger role as it serves as the backbone for digital world.

Reliable digital connectivity of the rural and remotest areas is crucial to achieve digital inclusion.

5.57 Empowering the digitally excluded to use digital services is highly important for sustained digital inclusion. The concept of digital inclusion and digital literacy are to be relooked to bring-in the marginalized stakeholders also into the arena of digital economic activities.

5.58 For digital inclusion, Central government, State Government and Local bodies have to work in sync and facilitate development of telecom infrastructure in every nook and corner of the country. People cannot benefit from ICTs if they cannot understand its use and benefit. This may be due to lack of awareness, availability, affordability, language or lack of skills and knowledge.

5.59 Therefore, the enabling Policies need to ensure the:

a. Digital Connectivity - Broadband Availability
b. Device affordability
c. Digital literacy – for economic participation
d. Relevance: Citizens are able to use the delivered Content and Applications (Social Inclusion)

Government Initiatives on Digital Inclusion

5.60 The Government has taken many successful initiatives for digital inclusion such as connectivity to villages through BharatNet project, online delivery of various services through Common Service Centre (CSC), online payments to beneficiaries under Direct Benefit Transfer schemes, proliferation of telecom connectivity under various USOF schemes, implementation of National Digital Literacy Mission and envisaging provisioning of broadband for all in NDCP-2018. DoT has come out with the National Broadband Mission (NBM), which is expected to enable holistic measures which will provide equitable access to Digital Communications across all sections and strata of our society and bridge the Digital Divide. The Digital India push has resulted into manifold benefits for the people of the country. Monthly UPI transactions have reached to 5,405 million in March 2022 having total value of transactions at Rs. 9,60,581 Crores. Under the Pradhan Mantri Jan Dhan Yojana (PMJDY), total 45.06 Crore beneficiaries have been provided bank accounts to receive benefits through online mechanism and so far, having ₹166,459.16 Crore balance in beneficiary accounts. Further, under Common Service Centre (CSC) 2.0 Scheme, at least one CSC is being setup in each of the 2.5 lakh Gram Panchayat across the country and it will be strengthened and integrated by additional 1.5 lakh CSCs in the country.

E. Initiatives taken in India

5.61 Many initiatives have been taken by the Government for identification and development of 5G use cases and applications in India.

(i) TRAI's Initiatives

5.62 TRAI initiated dialogue and sensitized few Ministries/Departments namely Ministry of Agriculture, Cooperation and Farmers' Welfare, Department of School Education and Literacy, Department of Higher Education, Ministry of Health & Family Welfare, Department of Promotion of Industry and Internal Trade, Ministry of Mines, Ministry of Ports, Shipping and Waterways, Ministry of Power, Ministry of Road Transport & Highways and Ministry of Micro, Small & Medium Enterprises to start deliberation with stakeholders and technology solution providers for a focused approach on identification, development and deployment of sector specific use cases.

5.63 TRAI also suggested to these Ministries/Departments that a special dedicated permanent Cell may be established in these Ministries/Departments with dedicated technical manpower to formulate the use of digital technologies like 5G, IoT, M2M, AI etc. and development of relevant and affordable use cases involving start-up companies, entrepreneurs, application providers etc.

5.64 TRAI emphasized that there is need for automation in MSME sector and suggested that Ministry of MSME may carry out a study to find out the actual details about the level of acceptance and adoption of industrial automation and digital technologies by the MSME sector in the country as compared to other industries. Such study may also examine the constraints faced by such small players towards adoption of digitalization. Study may also cover areas like awareness towards digital automation, level of digital literacy, the status of skills required to handle new technologies and access to the online inputs and product markets. Further, it may require assessing capital need for upgrading their plants and machinery, cost of capital of such upgradation so as to achieve the digital transformation. Based on learning from such study, appropriate schemes, including interest subvention scheme, for upgradation of plant and machinery, may be required to be devised to facilitate the micro, small and medium enterprises to overcome various constraints and move towards industrial automation.

5.65 **Rating of Buildings or Areas for Digital Connectivity**: Considering the importance of in-building digital connectivity, TRAI has released a Consultation Paper on “Rating of Buildings or Areas for Digital Connectivity” suggesting a roadmap for creating an enabling environment for the creation of an ecosystem in designing, implementing, operating, maintaining, expanding connectivity through up-gradations to meet future challenges of digital connectivity inside buildings and areas. The paper highlights the importance of collaborative partnerships between all relevant stakeholders in decision making processes at an early stage, in co-designing and co-creation of the digital connectivity infrastructure inside the building/society or area. The Consultation Paper proposes value addition to the buildings or areas by introducing digital connectivity infrastructure evaluations and award ratings, based on the quality of experience assessed in a scientific way involving a combination of field measurements, users' experience of digital connectivity provided in their buildings or premises. Based on the outcome of the consultation process, TRAI will be sending its recommendations to the Government.

5.66 **Use of Street Furniture for Small Cell and Aerial Fiber Deployment**: To actualize the real potential of 5G, highly dense network consisting of large number of small cells at very short distances will be required, which necessitates the requirement of use of use of street furniture for small cell deployment and aerial fiber deployment. Street furniture like utility poles, billboards, lamp posts, traffic signals, and public structures like gazebos, bus stops etc. provide utility services to city dwellers but with little or no change, they can also be utilized to mount small cells and aerial fibers for providing telecom services as well. Street furniture are under various public and private authorities that have administrative jurisdictions in municipal bodies, smart city administrations, government departments, railways, airports, ports and metro train systems, stadia etc. Granting access to street furniture by these controlling authorities could remove a significant hurdle in 5G small cell deployment in the country. In turn, 5G when deployed on infrastructure owned by these authorities creates a win-win situation where the authorities can be benefited from 5G use cases like smart waste disposal, smart traffic light, smart metering, smart grid monitoring, disaster management, automation, energy management, new streams of revenue generation etc. In this regard, on 23rd March 2022, TRAI has released a consultation paper on 'Use of Street Furniture for Small Cell and Aerial Fiber Deployment'. Based on the outcome of the consultation process, TRAI will be sending its recommendations to the Government.

5.67 **Pilot project for deployment of small cells**: For the deployment of Small Cells using street furniture, TRAI has initiated four pilot projects one each covering a Port, Airport, Metro line and a congested city area in a smart city. These pilots are being carried out at Deendayal Port

Kandla, Delhi International Airport, Nama Metro Bengaluru, and Smart City Bhopal. The pilot aims to put in place the enabling Regulatory and Policy framework for deployment of small cells and aerial fiber using street furniture, much ahead of actual deployment of 5G networks in higher frequencies. TRAI's initiative is in sync with PM Gati-Shakti initiative which aims to harness benefits of cross sector collaboration among government entities.

5.68 **Utilization of OFC duct infrastructure and utility corridors being developed by NHAI under PM Gati Shakti**: Ministry of Road Transport and Highways (MoRT&H) under national broadband mission is developing OFC duct infrastructure along its various greenfield and brownfield highways and expressways throughout the country, through National Highway Logistic Management Limited (NHLML), a 100 % owned SPV of National Highways Authority of India (NHAI) under PM Gati Shakti National Master Plan. To explore the opportunities of utilizing this OFC and leasing of duct infrastructure for further connecting small town/ village along the aforesaid pilot project corridors, TRAI initiated a discussion with all major TSPs and ISPs in presence of representatives of DoT, MoRT&H & NHLML. The service providers discussed the technical, financial and business model in respect of the assets being offered for lease. TRAI requested NHLML to undertake further interactions with TSPs/ISPs for effective utilization of proposed OFC duct infrastructure along highways and expressways. There is a need to prepare a comprehensive common duct infrastructure plan by DoT for National/State and other roads for inclusion in PM Gati Shakti National Master Plan.

(ii) DoT's Initiatives

5.69 DoT has set up Inter-Ministerial Committee for setting up of India specific Use Case labs in different economic verticals like Education, Healthcare, Agriculture, Public safety, FinTech etc.

5.70 The Department of Telecommunications launched "5G Hackathon" in collaboration with MeitY, NITI Aayog, Start-up India and other stakeholders to identify and promote applications, relevant to India in different categories like Healthcare, Education, Governance, Banking, Finance, Insurance, Cyber Security, Enterprise transformation, Industry 4.0, Agritech, Livestock, Smart Cities & Infrastructure etc. in the 5G realm that will be developed into workable products and services. The main objective of the "5G Hackathon" was to bring all the players together in the ecosystem such as tech companies, mobile operators, manufacturers, developers to work together and convert their ideas into workable products and services. During phase 1 of 5G Hackathon, 100 best ideas have been selected in different sectors mentioned above. These 100 selected applicants were awarded with prize money of Rs. 1.0 Lakh each. Thereafter the 5G Hackathon entered into phase 2, wherein these ideas converted into workable products and services under the mentorship of Industry and academia and 30 best products have been selected and awarded in Phase 2 on which the further progress is being made.

5.71 Keeping in view India's specific requirements and to take lead in 5G deployment, DoT also started work on setting up an 'Indigenous 5G Test Bed' in India in March 2018 in collaboration with premier academic institutes. The testbed is likely to enhance national capability in telecom technology, development of indigenous Intellectual Property (IP), and give a fillip to Indian telecom manufacturers. It is likely to pave the way for end-to-end testing of 5G User and network equipment by 5G stakeholders developing 5G Products/Services/Use cases. The indigenous 5G test bed, a technology development project initiated in telecom space, will enable development, testing and proliferation of 5G technology system components, cross-sectoral use cases, besides setting up foundation for the development of "6G Technology landscape" in the country.

F. Analysis

5.72 Mission 'Propel India' set out by the National Digital Communications Policy (NDCP) 2018 envisages 'Enabling Next Generation Technologies and Services through Investments, Innovation and IPR generation'. Under this mission, it has been mentioned that:

> *"To harness the power of emerging digital technologies, including 5G, AI, IoT, Cloud and Big Data to enable provision of future ready products and services; and to catalyse the fourth industrial revolution (Industry 4.0) by promoting Investments, Innovation and IPR."*

5.73 In NDCP 2018, it has also been mentioned that the convergence of a cluster of revolutionary technologies including 5G, the cloud, IOT and data analytics, along with a growing start-up community, promise to accelerate and deepen its digital engagement, opening up a new horizon of opportunities.

5.74 5G technology will not only provide seamless coverage, high data rate, low latency, and highly reliable communications but also enable a massive expansion of digital products and services across industrial, commercial, education, healthcare, agriculture, financial, and social sectors. Thus, different Ministries of the Government will play an important role in providing the necessary impetus and support for the identification, scaling, and implementation of India-focused cutting-edge ideas in various verticals, which can be converted into workable 5G products and solutions. An institutional coordination mechanism is needed between DoT and different verticals (Ministries/Departments) to have a collaborative approach and focused development of 5G use cases.

5.75 Therefore, to identify, develop and proliferate telecom-driven use cases across different sectors, there is a need to establish an inter-ministerial working group for better coordination and complementing each other's efforts to realize the benefits of 5G technology for achieving overall economic growth of the Country.

5.76 The approach to 5G Policy requirements in India was finalized by DoT in the 5G High-Level Forum (5G-HLF) Report titled “Making India 5G Ready” released in August 2018. To achieve the objectives outlined in the Report, many initiatives have been taken by DoT, however there is a need for time bound and focused implementation strategy in identified core areas so that conducive ecosystem for 5G use cases is developed in a coordinated manner.

5.77 In view of the above, **the Authority recommends that**:

a. A 5G-dedicated Inter-Ministerial Working Group (IMWG), under the Chairmanship of Member (Technology), DoT should be formed comprising Ministry of Electronics and Information Technology, Department for Promotion of Industry and Internal Trade, Ministry of Information and Broadcasting, Department of Space, Ministry of Finance, Ministry of Education, Department of Science & Technology, Ministry of Micro, Small and Medium Enterprises (MSME) and Niti Ayog as members, which should be represented by JS Level officers.

b. The IMWG may co-opt officers from other concerned Ministry(ies) / Department(s) as per requirement.

c. The concerned Ministries/Departments shall establish a special dedicated Digital Cell, headed by the JS Level officer nominated as member in IMWG, with dedicated technical manpower to formulate the use of digital technologies like 5G, IoT, M2M, AI etc. and development of relevant and affordable use cases involving start-up companies, entrepreneurs, application providers etc. The scope of the Digital Cell shall include, but not limited to, involving the relevant stakeholders in discussions, framing and monitoring short-term (annual),

medium-term (5-year), and long-term (10-year) plans with quantitative targets in respect of sector specific 5G use cases, providing platform and promoting 5G use cases. The Digital Cell may also need to focus on issues relating to digital literacy, connectivity and affordable user devices for their sector.

d. **The Ministries/Departments should take up short-term (annual), medium-term (5-year), and long-term (10-year) plans with quantitative targets in respect of sector specific 5G use cases and the same can be considered by IMWG for consistent and coordinated development of use cases and start-up ecosystems to align issues such as connectivity, privacy, data security etc. in the country.**

e. **The participating members of IMWG should be responsible for outlining strategies, defining targets, and budgetary provisions for achieving defined targets for their respective Ministries / Departments.**

f. **The IMWG should conduct periodic meetings and discussions, at least once in 3 months, in which progress achieved will be reviewed and outline path for achieving planned objectives will be framed.**

g. **The IMWG should present consolidated status/proposals to the Department of Telecommunications (DoT) being nodal Ministry, on a regular basis.**

h. **The progress of digital transformation and implementation of 5G use cases in various verticals should also be monitored and documented by IMWG and be submitted to DoT for perusal and appropriate decision.**

5.78 As already discussed, timely intervention and hand holding of MSME sector will also help India to increase its share in the international value chain system and play a significant role in the Indian and global digital economy. Therefore, **the Authority recommends that DoT should take up the matter with Ministry of Micro, Small and Medium Enterprises (MSME) to carry out a study to find out the actual details about the level of acceptance and adoption of 5G based industrial automation and digital technologies by the MSME sector in the country as compared to other industries. Based on the learning from such study, appropriate schemes, including interest subvention scheme, for upgradation of plant and machinery, may be devised to facilitate the micro, small and medium enterprises to overcome various constraints and move towards industrial automation. In this regard, budgetary provisions (if required), may be created by the Ministry of MSME.**

5.79 Currently, DoT is working with different Ministries/Departments for setting up of India specific Use Case labs in Education, Health care, Agriculture, Public safety, FinTech etc. Therefore, this collaborative approach is required to be taken further for its success. In this regard, one of the stakeholders has suggested that the 5G Preparedness committee of DoT should actively involve industry, academia, operators, startups, and individuals to facilitate identification and development of India specific 5G use cases for different verticals and their adoption by the industries for their proliferation.

5.80 In view of the above, **the Authority recommends that Telecom Innovation Centres, may be formulated in alliance with different academic institutions and ministries. These innovation centres could be specialized for development of innovative solutions for 5G use cases and applications in different verticals / sectors such Agriculture, Medicine, Manufacturing, Infrastructure, Power, Telecom, etc. and be made responsible for desired outcome. DoT should be the nodal ministry to monitor and coordinate the activities of the Telecom Innovation Centres.**

CHAPTER-VI: SUMMARY OF RECOMMENDATIONS

6.1 The Authority recommends that:

a) Considering the facts that presently (i) band plan(s) for the frequency range 526-612 MHz is yet to be defined by 3GPP/ITU, (ii) development of ecosystem for IMT in 526-612 MHz frequency range will take some time and (iii) MIB is using 526-582 MHz band extensively across the country for TV transmitters; the 526-612 MHz frequency range should not be put to auction in the forthcoming auction.

b) As per the propagation characteristics, lower frequency bands provide wider and deeper coverage, which could be very useful in enhancing terrestrial mobile coverage, particularly for in-building coverage and rural coverage. ITU has already identified this frequency range for IMT services. Therefore, frequency range 526-612 MHz should be reserved for IMT services.

c) DoT should come out with a plan for refarming 526-582 MHz band to be utilized for IMT deployments. To make 526-582 MHz band available for IMT, DoT should work with MIB to prepare a plan for an early migration from Analogue to Digital Transmission, so that the frequency band from 526-582 MHz can be vacated for IMT services. Considering that ITU has identified spectrum in 470-698 MHz as an IMT band in Region 2 & Region 3, DoT may adopt a holistic approach and review the entire frequency range starting from 470 MHz to 582 MHz.

d) In case, complete refarming of 526-582 MHz frequency range for IMT is not feasible, DoT may explore the possibility of this band being used for IMT as well as for broadcasting by MIB on coexistence basis. Refarming of this frequency range for IMT may be performed in a phased manner so that as and when

some frequency carriers are vacated, the same can be auctioned for IMT services.

e) **Considering the work going on in the APT to develop a regional band plan for 600 MHz (APT 600) for APT region, portion 612-617 MHz should be included as part of the 600 MHz band.**

f) **DoT should liaise with the APT, ITU and 3GPP for development of a regional band plan for the band 526-612 MHz and declare the timeline for vacation of this band and adoption of this band for IMT services so that ecosystem starts developing.**

[Para 2.22]

6.2 The Authority recommends that for 600 MHz frequency range 612-703 MHz, Band Plan APT 600 (Option B1) should be adopted in India. It is also proposed that entire 40 MHz (paired) spectrum [612-652 MHz/663-703 MHz] should be put to auction in the forthcoming auction.

[Para 2.47]

6.3 The Authority recommends that unlike FDD band plans where duplex gap is fixed for a given band plan, TDD band plans are flexible; therefore, in frequency range 3300-3670 MHz, both the band plans i.e., n77 and n78 should be permitted and flexibility be given to the TSPs to adopt any band plan i.e., n77 or n78, based on their business/commercial considerations.

[Para 2.61]

6.4 The Authority recommends that:

a) **As the IMT emissions in the 3300-3670 MHz may saturate the Low Noise Block (LNB) of the FSS earth station which traditionally operates in the 3400-4200 MHz, there is a need to make use of high-quality bandpass filters operating in**

3700-4200 MHz range. Therefore, DoT should ask the Ministry of Information and Broadcasting (MIB) to take appropriate action and sensitize the MSOs, DTH operators, and other users to ensure the use of high-quality bandpass filters operating in 3700-4200 MHz range to avoid interference from IMT stations.

b) In order to avoid unwanted out of band emissions of the IMT stations falling within the FSS operating band 3700-4200 MHz, DoT should prescribe for having a sharp Spectrum Mask for IMT transmitters with an out-of-band PFD limit.

[Para 2.64]

6.5 Considering the global trend and 3GPP TDD configuration-based band plans availability, the Authority recommends that TDD based configuration should be adopted for spectrum 24.25 to 28.5 GHz.

[Para 2.83]

6.6 The Authority recommends that in frequency range 24.25-28.5 GHz MHz, flexibility be given to the TSPs to adopt any band plan i.e., n257 or n258, based on the frequencies assigned to them and other business/commercial considerations.

[Para 2.88]

6.7 The Authority recommends that

a. As mmWave spectrum is going to be used for capacity requirement, its deployment is not likely to be ubiquitous rather it is more likely to be kind of hotspots or urban micro cells. Therefore, IMT Stations and Satellite Earth Stations Gateway (Earth to Space) can co-exist in 27.5-28.5 GHz frequency range. The Satellite Earth Station Gateway should be permitted to be established in frequency range 27.5-28.5

GHz at uninhabited or remote locations on case-to-case basis, where there is less likelihood of 5G IMT services to come up.

b. **DoT should prescribe the exclusion zone requirement for co-existence of IMT and satellite earth stations (Earth to space) in 27.5-28.5 GHz frequency range.**

c. **DoT should create a software defined automated process on a portal having database of coordinates of the IMT base stations in mmWave. The geofencing coordinates of the proposed earth station in 27.5-28.5 GHz can provide the feasibility results through the portal for establishing the earth station.**

d. **Access to 27.5-28.5 GHz should also be allowed for Earth Stations In Motion (ESIMs) for In-flight and Maritime terminals, with appropriate sharing conditions, as in such cases, the operation would be geographically separated from terrestrial IMT.**

e. **Spectrum dues for 27.5-28.5 GHz frequency range can be revised on pro-rata basis for the mobile operator holding spectrum in the LSA, in which the permission for establishing earth station is given in the same frequency range, on account of creation of exclusion zone.**

f. **Provisions of the WRC-19 Resolution 242 to provide protection to Satellite (FSS) receiver and Resolution 750 w.r.t. power limitations to provide protection to EESS (passive), applicable for 24.25-27.5 GHz band, should also be made appropriately applicable for 27.5-28.5 GHz frequency range.**

[Para 2.102]

6.8 The Authority recommends that considering that with the closure of CDMA services, 800 MHz band is being utilized for LTE, which does not require separate provision of inter-operator guard band, the channel plan of 800 MHz band be revised from existing channel bandwidth of 1.23 MHz to 1.25 MHz and the provision of guard band should be done away with.

[Para 2.114]

6.9 The Authority recommends that

a) As regards assignment of the last block from 887.75-889 MHz, DoT should carry out limited field trial to ascertain the inter-band guard band requirement between 800 & 900 MHz bands. In case, the outcome of the field trial shows that the assignment can be made till 889 MHz without causing any interference to existing users in 900 MHz band, the last block in each LSA can also be put to auction, else the last block with reduced size (considering the guard band requirement) can be put to auction. In case, it is not possible to conduct and conclude the study before forthcoming auction, the forthcoming auction should be conducted considering 15 blocks of 1.25 MHz each as total availability of spectrum in 800 MHz band and later on decision about the last block can be taken and included in the subsequent spectrum auction.

b) DoT should carry out harmonization exercise in 800 MHz band immediately after conducting the auction so that frequencies assigned to the TSPs are in contiguous manner and any vacant spectrum is available towards the end of the spectrum band. Further, the spectrum harmonization exercise should be completed within a time frame of not more than 6 months from the date of conclusion of Auction.

[Para 2.122]

6.10 The Authority recommends that DoT should carry out harmonization exercise in 900 MHz band immediately after conducting the auction and such exercise should be completed within a time frame of not more than 6 months from the date of conclusion of Auction.

[Para 2.128]

6.11 The Authority recommends that DoT should carry out harmonization exercise in 1800 MHz band immediately after conducting the auction and such exercise should be completed within a time frame of not more than 6 months from the date of conclusion of Auction.

[Para 2.133]

6.12 The Authority recommends that DoT should examine whether the guard band of 0.2 MHz provisioned in 1800 MHz band in each LSA, can be done away with and wherever feasible, 0.2 MHz may be included in the forthcoming auction.

[Para 2.134]

6.13 Considering that there are certain additional bands which are already identified by ITU for IMT services and few additional bands are under consideration in WRC-23 for IMT identification, the Authority recommends that DoT should explore the possibility to make these bands available for IMT services at the earliest and come out with a spectrum roadmap for opening up of new bands for IMT to meet the future demand. At least a 5-year roadmap on spectrum likely to be made available for IMT in each year and likely date/month of auction should be made public. Such a spectrum roadmap will provide certainty, enable the

bidders to take informed decisions and may also encourage new entrants.

[Para 2.150]

6.14 The Authority recommends that in 600 MHz (APT 600 Option B1), 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3670 MHz and 24.25-28.5 GHz spectrum bands, the entire available spectrum should be put to auction in the forthcoming auction. The Authority also notes that the Government is already considering assignment of spectrum to BSNL/MTNL for 5G Services.

[Para 2.156]

6.15 The Authority recommends that for existing bands the block size and minimum amount of spectrum that a bidder is required to bid for should be prescribed as given below:

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

[Para 2.174]

6.16 The Authority recommends that considering the global trend and to provide flexibility to the TSPs, block size of 5 MHz should be prescribed for 600 MHz band.

[Para 2.183]

6.17 The Authority recommends that for 3300-3670 MHz band block size of 10 MHz should be prescribed. Further, DoT should ensure that if a TSP acquires more than one block, entire spectrum assigned to a TSP is in contiguous form.

[Para 2.194]

6.18 The Authority recommends that Block size for 24.25-28.5 GHz band be kept as 50 MHz. Further, DoT should ensure that if a TSP acquires more than one block, entire spectrum assigned to a TSP is in contiguous form.

[Para 2.203]

6.19 The Authority recommends that DoT should take a decision on the TRAI recommendations on "Enabling Unbundling of Different Layers Through Differential Licensing" of August 2021 at the earliest, preferably before conducting the Auction and make suitable provision for Network Service Provider (similar to Access Service providers) in the NIA under eligibility criteria for participating in Auction and other related clauses such as spectrum sharing, spectrum trading, etc.

[Para 2.216]

6.20 The Authority recommends that to mitigate inter-operator interference in TDD configuration bands, the following measures should be taken:

a) In case a TSP acquires more than one block, the entire spectrum should be assigned to it in contiguous form.

b) In case a TSP acquires spectrum in more than one LSA, same frequency spots should be assigned to it in all those LSAs, to the extent possible.

c) Interference mitigation be left to the mutual coordination between the TSPs.

[Para 2.235]

6.21 The Authority recommends that:

a. As per the NIA 2021 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 as per the provisions of NIA for 2021 Auction, are specific to the use of respective bands, which seems to be continuing due to oversight. Therefore, DoT should make changes in the roll out obligations for 2100 MHz (Metro LSAs) and 2300/2500 MHz (non-Metro LSAs) to rectify this by removing "using the spectrum in 2100 MHz" and "using 2300/2500 MHz band".

b. To facilitate the new entrants, in respect of roll out obligations for 700 MHz, 800 MHz, 900 MHz and 1800 MHz bands, the time period of 1 year for meeting the MRO for Metros LSAs (coverage of 90% of the LSA within one year from the effective date of license or the date of assignment of spectrum won in this auction process, whichever is later), should be enhanced to 2 years (40% coverage by the end of 1st year and 90% coverage by the end of 2nd year)

c. Besides the above, 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 be continued for the forthcoming spectrum auction.

[Para 2.247]

6.22 The Authority recommends that the roll-out obligations and associated conditions for 600 MHz band shall be same as that applicable for 700 MHz band.

[Para 2.259]

6.23 The Authority recommends that

a. Band specific minimum roll out obligations for 3300-3670 MHz band for all TSPs i.e., existing as well as the new entrants should be specified as under:

(i) Metros LSAs

Time Period	Roll Out Obligations
By the end of 1st year	Commercial launch of services anywhere in the LSA
By the end of 3rd Year	Cumulative number of sites to be deployed: 2800
By the end of 5th Year	Cumulative number of sites to be deployed: 4600

(ii) Non-Metro LSAs

Time Period	Roll Out Obligations
By the end of 1st year	Commercial launch of services in at least 1 city in the LSA
By the end of 3rd Year	Cumulative number of sites to be deployed: Category A LSAs: 7000

	Category B LSAs: 4600 **Category C LSAs: 2600**
By the end of 5th Year	**Cumulative number of sites to be deployed (at least 5% of the sites to be in rural SDCA, including economic zones):** **Category A LSAs: 10000** **Category B LSAs: 7000** **Category C LSAs: 4700**

b. To keep the customers informed, the TSPs should be mandated to publish the network deployment map on their website depicting the areas where the services have been launched using 3300-3670 MHz spectrum band.

c. Since the Minimum Roll Out Obligations will be equally applicable for all the TSPs i.e., existing as well as the new TSPs, the clause 8.1.4 of the NIA for spectrum auction held in March 2021 on 'Rollout obligation using any technology in any band' shall not be applicable for 3300-3670 MHz band.

[Para 2.273]

6.24 The Authority recommends that

a. Band specific minimum roll out obligations for 24.25-28.5 GHz band for all TSPs i.e., existing as well as the new entrants should be specified as under:

(i) Metros LSAs

Time Period	Roll Out Obligations
By the end of 1st year	**Commercial launch of services anywhere in the LSA**
By the end of 3rd Year	**Cumulative number of sites to be deployed: 900**
By the end of 5th Year	**Cumulative number of sites to be deployed: 1500**

(ii) Non-Metro LSAs

Time Period	Roll Out Obligations
By the end of 1st year	**Commercial launch of services anywhere in the LSA**
By the end of 3rd Year	**Cumulative number of sites to be deployed:** **Category A LSAs: 2400** **Category B LSAs: 1500** **Category C LSAs: 800**
By the end of 5th Year	**Cumulative number of sites to be deployed** **Category A LSAs: 3300** **Category B LSAs: 2300** **Category C LSAs: 1500**

b. To keep the customers informed, the TSPs should be mandated to publish the network deployment map on their website depicting the areas where the services have been launched using 24.25-28.5 GHz spectrum band.

c. Since the Minimum Roll Out Obligations will be equally applicable for all the TSPs i.e., existing as well as the new TSPs, the clause 8.1.4 of the NIA for spectrum auction held in March 2021 on 'Rollout obligation using any technology in any band' shall not be applicable for 24.25-28.5 GHz band.

[Para 2.283]

6.25 The Authority recommends that while assessing the fulfilment of roll out obligations of Access Network provider, the network elements (such BTS, BSC etc.), created by the attached VNO(s) should also be included.

[Para 2.293]

6.26 The Authority recommends that a Cap of 40% be prescribed on the combined spectrum holding in the sub-1 GHz bands i.e., 600 MHz (APT 600 Option B1), 700 MHz, 800 MHz and 900 MHz bands.

[Para 2.310]

6.27 The Authority recommends that for 3300-3670 MHz and 24.25-28.5 GHz bands, band-specific (intra-band) spectrum cap should be kept as 40% (rounded off considering the block size in each of these bands) of the total spectrum put to auction.

[Para 2.325]

6.28 The Authority recommends that the overall cap is no longer relevant and therefore, should be removed. However, a separate Cap on the combined spectrum holding in 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands be introduced and the spectrum cap for this group of bands be kept as 40%.

[Para 2.341]

6.29 The Authority recommends that in respect of surrender of spectrum, DoT should take an appropriate decision with regard to the issue of interest or principal paid for the post surrender period and accordingly include the decision in the guidelines for surrender of spectrum so that the TSPs can take an informed decision.

[Para 2.358]

6.30 The Authority recommends the following for formulating 'Guidelines for Surrender of Spectrum':

a. DoT should come out with "Guidelines for Surrender of Spectrum". The spectrum surrender conditions should be simple and transparent. The process with defined timelines

should be clearly specified and be implemented through an online portal-based system.

b. **A Telecom Service Provider should be permitted to surrender spectrum after a minimum period of 10 (ten) years from the date of acquisition of spectrum by the TSP through the auctions conducted henceforth.**

c. **TSP should make a request for surrender of spectrum at least 12 months prior to the proposed date of surrender.**

d. **DoT should convey in-principle approval or otherwise within a period of sixty days from the date of application for surrender of spectrum.**

e. **Outstanding spectrum payment till the proposed date of surrender, if any, in respect of proposed quantity of spectrum being surrendered, should be communicated to the TSP along with the in-principle approval.**

f. **Other payments/dues should not be linked to surrender of the spectrum under consideration.**

g. **Within a period of three months from date of demand raised by DoT, the TSP shall clear the dues so communicated by DoT.**

h. **Upon clearance of dues, the final approval to the surrender of spectrum, effective from proposed date of surrender, should be communicated by DoT to the TSP within 15 days.**

i. **On the proposed date of surrender of spectrum, the TSP should submit a declaration to DoT that the surrendered spectrum has been vacated and is no longer in use.**

j. **DoT should put to auction the surrendered spectrum immediately, once the final approval to surrender of spectrum (upon clearance of dues up to the proposed date of surrender) is issued.**

[Para 2.362]

6.31 The Authority recommends that the following conditions may be included in the 'Guidelines for Surrender of Spectrum':

a. In case, a TSP surrenders partial or complete spectrum in a band, it will be barred to take part in the auction of spectrum in that band for a period of 2 years from date of surrender of spectrum.

b. In case, a TSP has acquired some spectrum in a band, a lock-in period of 2 years will be applicable, before surrendering the qualifying spectrum in that band acquired earlier.

[Para 2.367]

6.32 The Authority recommends that a TSP should be permitted to surrender the spectrum after a minimum period of 10 (ten) years from the date of acquisition of spectrum by the TSP whether acquired through auction, trading or any other permitted means of acquisition.

[Para 2.372]

6.33 The Authority recommends that DoT may appropriately examine the possibility for creation of provision for surrender of spectrum for the existing spectrum holding of the TSPs acquired through past auctions.

[Para 2.379]

6.34 The Authority recommends that surrender fee should not be kept high to make the provision ineffective. It should be a kind of administrative fee for the purpose of processing of surrender application. Surrender fee may be kept as Rs. 1,00,000 (Rupee One lakh) per spectrum band per LSA.

[Para 2.386]

6.35 The Authority recommends that to enable an early launch of 5G services, Section 2.3 of the NIA of 2021, pertaining to the technology to be deployed, should be suitably modified to include IMT-2020 (5G technology) along with the other already mentioned technologies.

[Para 2.392]

6.36 The Authority reiterates its recommendation made in 'Ease of Doing Telecom Business', dated 30th November 2017, that Department of Telecommunications should review the SACFA fee being levied upon the TSPs / other agencies.

[Para 2.397]

6.37 The Authority reiterates its recommendation made in 'Ease of Doing Telecom Business', dated 30th November 2017, that the testing fee should be charged only for the sites which are actually tested by LSA unit instead for all sites which are offered for testing.

[Para 2.402]

6.38 The Authority is of the view that the Department of Telecommunications should take the decision on the recommendations made in 'Enhancement of Scope of Infrastructure Providers Category-I (IP-I) Registration', dated 13th March 2020 at the earliest.

[Para 2.415]

6.39 The Authority is of the view that the Department of Telecommunications may take the decision on the recommendations made in 'Roadmap to Promote Broadband Connectivity and Enhanced Broadband Speed' dated on

31.08.2021 at the earliest for faster rollout of 5G networks and fixed line broadband services.

[Para 2.421]

6.40 **The Authority recommends that the reserve price of spectrum allocation in case of 30 years should be equal to 1.5 times (one-and-a-half times) the reserve price of spectrum allocation for 20 years for the respective band.**

[Para 3.23]

6.41 **The Authority recommends that DoT shall prepare a comprehensive report analysing critically the outcomes of each forthcoming auction to be shared with the Authority within 90 days of conclusion of the auction.**

[Para 3.38]

6.42 **As there will be regular conduct of spectrum auctions on annual basis (or at shorter intervals), the Authority recommends that**

(I) For existing bands (including for the bands being put to auction for the first time in the forthcoming auction), a fresh spectrum valuation exercise be conducted once every three years; a suitable reference be made to the Authority by Government for this purpose.

(II) For auctions conducted in the interim period between periodic valuation exercises conducted once every three years,

(1) for LSAs where the spectrum put to auction in a previous auction is sold, the auction determined prices (duly indexed using applicable MCLR if more than one year has elapsed since the previous auction) should be used for arriving at the reserve prices for the next auction;

(2) for LSAs, where spectrum remains unsold in previous auctions, past recommended reserve price (without indexation) should be used.

(III) For new spectrum bands, to be put to auction for first time, a reference be sent to the Authority, as per established procedure as and when these bands are proposed to be put to auction.

(IV) However, if required, DoT may seek fresh reserve prices from the Authority for the existing bands, providing a full and reasoned justification for the same.

[Para 3.40]

6.43 The Authority recommends that the reserve price for North East and Jammu & Kashmir LSAs in 800 MHz, 900MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz bands should be fixed at a discount of 50% on the reserve price. This discount for the North East and Jammu & Kashmir LSAs will also be applicable while arriving at reserve prices of other spectrum bands as well.

[Para 3.138]

6.44 The Authority recommends that the reserve price for the 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz bands should be set as follows:

a) At 70% of the average valuation;

b) In the LSAs where spectrum in a band was completely sold in the March, 2021 auction, the reserve price shall be the higher of the two figures – (1) 70% of the average valuation; and (2) auction determined price of the March, 2021 auction, duly indexed.

[Para 3.139]

6.45 Accordingly, the recommended reserve price of 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz spectrum bands for each LSA is tabulated below:

TABLE 3.4: RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN 800 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	478.79	479
Kolkata	Metro	152.61	153
Mumbai	Metro	467.70	468
Andhra Pradesh	A	292.12	292
Gujarat	A	262.17	262
Karnataka	A	198.44	198
Maharashtra	A	337.73	338
Tamilnadu	A	224.77	225
Haryana	B	61.57	62
Kerala	B	103.16	103
Madhya Pradesh	B	136.03	136
Punjab	B	101.43	101
Rajasthan	B	141.91	142
U. P. (East)	B	160.30	160
U.P. (West)	B	133.25	133
West Bengal	B	88.91	89
Assam	C	50.17	50
Bihar	C	126.33	126
Himachal Pradesh	C	22.27	22
Jammu & Kashmir	C	13.82	14
North East	C	13.38	13
Orissa	C	53.62	54

TABLE 3.5: RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN 900 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	436.02	436
Kolkata	Metro	152.79	153
Mumbai	Metro	389.15	389
Andhra Pradesh	A	288.17	288
Gujarat	A	399.11	399
Karnataka	A	203.59	204
Maharashtra	A	317.27	317
Tamilnadu	A	221.78	222
Haryana	B	67.69	68
Kerala	B	212.93	213
Madhya Pradesh	B	155.66	156
Punjab	B	104.10	104
Rajasthan	B	134.59	135
U. P. (East)	B	166.11	166
U.P. (West)	B	151.79	152
West Bengal	B	98.80	99
Assam	C	55.98	56
Bihar	C	147.16	147
Himachal Pradesh	C	25.83	26
Jammu & Kashmir	C	16.38	16
North East	C	13.80	14
Orissa	C	64.22	64

TABLE 3.6: RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN 1800 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	269.60	270
Kolkata	Metro	96.70	97
Mumbai	Metro	236.16	236
Andhra Pradesh	A	171.57	172
Gujarat	A	150.43	150
Karnataka	A	120.87	121
Maharashtra	A	190.33	190
Tamilnadu	A	140.59	141
Haryana	B	40.58	41
Kerala	B	58.10	58
Madhya Pradesh	B	87.94	88
Punjab	B	61.16	61
Rajasthan	B	74.88	75
U. P. (East)	B	91.06	91
U.P. (West)	B	86.88	87
West Bengal	B	57.57	58
Assam	C	31.76	32
Bihar	C	81.76	82
Himachal Pradesh	C	14.45	14
Jammu & Kashmir	C	9.11	9
North East	C	8.49	8
Orissa	C	35.12	35

TABLE 3.7: RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN 2100 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	223.77	224
Kolkata	Metro	80.26	80
Mumbai	Metro	196.01	196
Andhra Pradesh	A	142.40	142
Gujarat	A	124.86	125
Karnataka	A	100.32	100
Maharashtra	A	157.97	158
Haryana	B	33.68	34
Kerala	B	48.22	48
Madhya Pradesh	B	72.99	73
Punjab	B	50.76	51
U.P. (West)	B	72.11	72
West Bengal	B	37.00	37
Assam	C	24.41	24
Bihar	C	67.86	68
Himachal Pradesh	C	11.99	12
Jammu & Kashmir	C	7.56	8
North East	C	4.65	5
Orissa	C	29.15	29

TABLE 3.8: RECOMMENDED RESERVE PRICE PER MHz (UNPAIRED) IN 2300 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	104.34	104
Kolkata	Metro	32.17	32
Mumbai	Metro	103.07	103
Andhra Pradesh	A	58.57	59
Karnataka	A	63.54	64
Tamilnadu	A	81.06	81

TABLE 3.9: RECOMMENDED RESERVE PRICE PER MHz (UNPAIRED) IN 2500 MHz BAND (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	85.87	86
Kolkata	Metro	28.17	28
Mumbai	Metro	81.05	81
Andhra Pradesh	A	50.73	51
Gujarat	A	44.13	44
Karnataka	A	46.88	47
Maharashtra	A	53.39	53
Tamilnadu	A	58.10	58
Punjab	B	13.95	14
Bihar	C	15.07	15
Himachal Pradesh	C	2.65	3
Jammu & Kashmir	C	1.62	2

[Para 3.140]

6.46 **The Authority recommends that the reserve price of spectrum in the 700 MHz band should be set at 70% of the valuation arrived at. The reserve price of the spectrum in the 600 MHz band should be equal to the reserve price of 700 MHz spectrum band.**

[Para 3.167]

6.47 Thus, the recommended reserve price of the 600 MHz and 700 MHz spectrum bands for each LSA are:

TABLE 3.12: RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN THE 600 MHz AND 700 MHz BANDS (20 years)

(Rs. in crore)

(1)	**(2)**	**(3)**	**(4)**
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	509.00	509
Kolkata	Metro	173.00	173
Mumbai	Metro	470.01	470
Andhra Pradesh	A	317.63	318
Gujarat	A	281.52	282
Karnataka	A	220.09	220
Maharashtra	A	359.19	359
Tamilnadu	A	252.97	253
Haryana	B	71.36	71
Kerala	B	109.68	110
Madhya Pradesh	B	155.96	156
Punjab	B	111.87	112
Rajasthan	B	145.84	146
U. P. (East)	B	171.21	171
U.P. (West)	B	153.50	154
West Bengal	B	102.03	102
Assam	C	56.84	57
Bihar	C	144.92	145
Himachal Pradesh	C	25.58	26
Jammu & Kashmir	C	16.02	16
North East	C	15.18	15
Orissa	C	61.93	62

[Para 3.168]

6.48 The Authority recommends that the reserve price of spectrum in the 3300-3670 MHz band should be set at 70% of the valuation arrived at.

[Para 3.180]

6.49 Accordingly, the recommended reserve price of the 3300-3670 MHz spectrum band for each LSA is tabulated below:

TABLE 3.14: RECOMMENDED RESERVE PRICE PER MHz IN 3300-3670 MHz BAND (UNPAIRED) (20 years)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	40.44	40
Kolkata	Metro	14.50	15
Mumbai	Metro	35.42	35
Andhra Pradesh	A	25.74	26
Gujarat	A	22.57	23
Karnataka	A	18.13	18
Maharashtra	A	28.55	29
Tamilnadu	A	21.09	21
Haryana	B	6.09	6
Kerala	B	8.71	9
Madhya Pradesh	B	13.19	13
Punjab	B	9.17	9
Rajasthan	B	11.23	11
U. P. (East)	B	13.66	14
U.P. (West)	B	13.03	13
West Bengal	B	8.64	9
Assam	C	4.76	5
Bihar	C	12.26	12
Himachal Pradesh	C	2.17	2
Jammu & Kashmir	C	1.37	1
North East	C	1.27	1
Orissa	C	5.27	5

[Para 3.181]

6.50 The Authority recommends that the reserve price of the spectrum in the 24.25 GHz – 28.5 GHz band should be set at 70% of the valuation arrived at.

[Para 3.194]

6.51 Accordingly, the recommended reserve price of 24.25 – 28.5 GHz band for each LSA, is tabulated below:

TABLE 3.18: RECOMMENDED RESERVE PRICE PER MHz IN 24.25 – 28.5 GHz BAND (UNPAIRED) (20 years)

(in Rs.)

(1) LSA	(2) Category	(3) Reserve Price (as calculated)	(4) Recommended Reserve Price (Rounded off)
Delhi	Metro	88.97 lakh	89 lakh
Kolkata	Metro	31.91 lakh	32 lakh
Mumbai	Metro	77.93 lakh	78 lakh
Andhra Pradesh	A	56.62 lakh	57 lakh
Gujarat	A	49.64 lakh	50 lakh
Karnataka	A	39.89 lakh	40 lakh
Maharashtra	A	62.81 lakh	63 lakh
Tamilnadu	A	46.39 lakh	46 lakh
Haryana	B	13.39 lakh	13 lakh
Kerala	B	19.17 lakh	19 lakh
Madhya Pradesh	B	29.02 lakh	29 lakh
Punjab	B	20.18 lakh	20 lakh
Rajasthan	B	24.71 lakh	25 lakh
U. P. (East)	B	30.05 lakh	30 lakh
U.P. (West)	B	28.67 lakh	29 lakh
West Bengal	B	19.00 lakh	19 lakh
Assam	C	10.48 lakh	10 lakh
Bihar	C	26.98 lakh	27 lakh
Himachal Pradesh	C	4.77 lakh	5 lakh
Jammu & Kashmir	C	3.00 lakh	3 lakh
North East	C	2.80 lakh	3 lakh
Orissa	C	11.59 lakh	12 lakh

[Para 3.195]

6.52 The Authority recommends that for collecting the bid amount from the successful bidder in case spectrum is not available in a part of the LSA, the existing methodology, as followed by DoT in the NIA for the March, 2021 auction, be followed in the forthcoming auction as well.

[Para 3.199]

6.53 The Authority recommends that the following options be allowed to the buyers for making payments:

a. Option I: Full or part upfront payment of the bid amount within 10 days of declaration of final price;
Where part upfront payment has been made, the buyer shall have the option of availing moratorium for the proportionate number of years for which the upfront payment has been made, and the balance amount shall be payable in equal annual instalments over the remaining period in advance at the beginning of the year, after the period of moratorium if any (duly protecting the net present value of the bid amount at the applicable rate of interest); the annual instalments shall become due and payable on the same date of each year.

b. Option II: Payment of 30 equal annual instalments of the bid amount (duly protecting the net present value of the bid amount at the applicable rate of interest) in advance at the beginning of the year, the first instalment becoming payable within 10 days of declaration of final price. The balance 29 instalments shall become due and payable on the same date of each following year.

[Para 3.212]

6.54 The Authority recommends that

(i) Access Service providers can provide private network as a service to an enterprise by using network resources (such as through network slicing) over its PLMN public network. For the sake of clarity, specific provisions should be made in the License.

(ii) Enabling provisions should be incorporated in the License/ Notice Inviting Applications (NIA) for Auction of Spectrum to permit the Access Service Licensee to set-up private

network, also known as Non-Public Network (which is isolated from public network), using the IMT spectrum assigned to it for establishing PLMN.

(iii) While creating the above provisions, it should be clearly mentioned that it will be the responsibility of the TSP to ensure that the prescribed QoS to their customers through public network is maintained.

[Para 4.37]

6.55 The Authority recommends that the Licensees having Access Spectrum be permitted to lease their access spectrum to enterprises having Captive Wireless Private Network Permission/License for localized Captive wireless private network.

[Para 4.60]

6.56 The Authority recommends that for establishing isolated captive wireless private network using IMT spectrum, the entity/enterprise should be provided a Permission/license under Section 4 of the Indian Telegraph Act, 1885. The permission/license may be named as 'Captive Wireless Private Network (CWPN) permission/License'.

[Para 4.66]

6.57 The Authority recommends that DoT should come out with the guidelines for grant of permission/License for 'Captive Wireless Private Network' for entities desirous of establishing captive wireless private network using IMT spectrum. The following key elements should be included in the guidelines:

- **A company registered under the Companies Act, 2013, will be eligible to apply for the Captive Wireless Private Network permission/license to establish indoor/within premise**

captive wireless private network using IMT spectrum in localized basis (specified geographic area to be governed through spectrum leasing agreement of the licensed enterprise with the Licensed TSPs and/or spectrum assignment by DoT).

- **The process of filing application and processing of application for grant of permission/license should be through online portal based system.**
- **The permission/license should be granted for a period of 10 years; however, there should be provision for renewal of the same through the online portal.**
- **The guidelines should clearly specify the required documents and the same should be submitted through online portal only. The portal should accept the application only if all the necessary documents have been uploaded by the applicant. Entire process should be paperless.**
- **Applicable Processing fee may be specified as Rs. 50,000/-**
- **No entry fee or permission/license fee should be charged from the permission holder/licensee. However, the spectrum charges will be levied as per policy of the DoT, in case the spectrum is assigned by DoT. As the spectrum assignment by DoT also have eligibility conditions based on networth of the CWPN permission holder/licensee, the applicant should be asked to submit the networth certificate while applying and networth of the permission holder/licensee should be mentioned in the permission/license so granted.**
- **Timelines for grant of permission/license should be specified and it should not be more than a period of 30 days from the filing of application, if the information/documents submitted by the applicant are found fit.**
- **Permission /License number should be issued by DoT, which will be used while applying for leasing of spectrum and/or**

seeking the spectrum earmarked for private captive networks from DoT.

- **Any change in the details (such as name of the enterprise, ownership, address, contact details, etc.) provided during obtaining the permission/license, are required to be intimated through the online portal within 15 days of such change.**
- **For an enterprise operating at more than one location in the country, only one permission/license should be required. Therefore, grant of permission/license should be one time activity and the permission/license should be valid throughout the territory of India. There should be no need to specify the specific geographic area of operation while applying for permission/license. However, while applying for spectrum, the specific details regarding area of operation along with coordinates need to be provided as per specified format. Spectrum is to be obtained separately for each individual geographic unit/ location.**
- **SACFA clearance requirements and applicable charges should be clearly specified.**
- **EIRP limits and EMF compliances should be specified.**
- **The area of operation, that is, the spectrum usage area of the licensee will be the area inside the logical perimeter of the defined premises with clearly specified geo coordinates. World Geodetic System (WGS84) format of geographic coordinate system or any other suitable geographic coordinate system may be used for mapping geographic coordinates.**
- **The permission holder /licensee of CWPN shall not offer any commercial telecom service. The permission/license as well as spectrum will be used only for its own captive usage as per the usage declared while applying for spectrum, and the**

permission holder /licensee shall not use it for any commercial purpose.

- **Permission holder/licensee of CWPN will deploy network elements as per TEC standards, wherever made mandatory, else as per relevant standards set by International Standardization bodies.**
- **Relevant network security conditions and instructions regarding procurement of telecom equipment from trusted sources may be specified.**
- **CWPN should not be connected to public network in any manner. The public network includes PSTN, PLMN, GMPCS and public internet. However, in case the licensee enterprise wants to have connectivity between its own multiple locations, the same may be permitted through leased line obtained through licensed telecom service providers.**
- **The Licensor should be having a right to inspect the established CWPN and its bonafide use.**

[Para 4.67]

6.58 The Authority recommends that Entities holding 'Captive Wireless Private Network Permission/License' should be permitted to obtain IMT spectrum either on lease from Access Service Providers or directly from DoT, as the case may be, for establishing Captive wireless private network.

[Para 4.68]

6.59 The Authority recommends that necessary guidelines for leasing of access spectrum by Telecom Service Providers to the Captive Wireless Private Network Permission holder/Licensees should be put in place specifying the terms and conditions and also providing the online process for submission of intimation regarding leasing of spectrum. The key elements to be included in the Access Spectrum leasing guidelines are:

- **TSPs will be permitted to lease their spectrum acquired through auction or liberalized spectrum holding to entities having Captive Wireless Private Network Permission/License.**
- **The 'Captive Wireless Private Network Permission holder/Licensee' should be permitted to take IMT spectrum on lease from one or more than one TSP in an LSA.**
- **TSP and the Captive Wireless Private Network permission holder/Licensee should give a joint intimation to DoT within 15 days of the effective date of leasing of spectrum. The joint intimation should include details of spectrum band(s), quantum of spectrum in each band, period of lease, geographic area of lease and use of spectrum.**
- **Use of leased spectrum by the CWPN permission holder/licensee should not cause interference to any public network. Any condition(s) imposed on the TSPs such as network synchronization, frame structure, DL:UL ratio etc. will also be applicable to the CWPN permission holder/licensee.**
- **It will be the responsibility of the TSP to ensure that prescribed QoS to the customers through public network is maintained, while leasing out the spectrum.**
- **The spectrum leasing charges shall form part of the AGR of the TSP.**
- **The leasing agreement should be mutually negotiated between the TSP and the enterprise.**

[Para 4.94]

6.60 The Authority recommends that certain spectrum be earmarked for Captive Wireless Private Networks to be assigned directly by DoT to Captive Wireless Private Network Permission holders/Licensees.

[Para 4.110]

6.61 The Authority recommends that spectrum in such bands where IMT ecosystem is available but are being used for non-IMT services in India and can coexist with indoor/within premise cellular based private captive networks on shared basis, be earmarked for private captive networks. The Authority recommends DoT may consider the possibility of earmarking spectrum for captive wireless private networks in the following bands:

a. <u>3700-3800 MHz band</u>

(i) DoT may consider the possibility of earmarking some spectrum (at least 40 MHz) in 3700-3800 MHz frequency range for low power indoor use for private captive network.

(ii) The co-existence of private captive network and satellite C-band receive stations can be made possible by creating an effective exclusion zone around the satellite C-band receive stations.

(iii) For this purpose, a digital map of all the existing satellite C-band receive stations should be created having database of their geo-coordinates with automated software system.

(iv) The location of private network proposed by an applicant to be accommodated on co-existence basis should be analyzed and permitted through the automated software system.

(v) The power limits and antenna tilt etc. for private captive network should be prescribed by the government for interference free operation and co-existence.

b. <u>4800-4990 MHz band</u>

(vi) DoT may also consider identifying the frequency range 4800-4990 MHz for IMT purpose and consider the possibility of carving out some spectrum (at least 40 MHz) in this frequency range for the purpose of earmarking for private captive network.

c. <u>28.5-29.5 MHz band</u>

(vii) DoT may also consider identifying some spectrum (at least 400 MHz) in the frequency range 28.5-29.5 GHz for the purpose of earmarking for private captive network, which can co-exist with satellite earth stations.

(viii) A software based transparent system should be built to permit the establishment of private networks and Satellite Earth Stations based on the geo-coordinates of the proposed location on interference free co-existence basis.

(ix) DoT should develop a digital map with geographic coordinates of all the existing and future Satellite Earth Stations as well as geographic coordinates of the premises of Private Network locations. Based on this database, permissions for establishment of new installations may be provided to the licensees.

[Para 4.148]

6.62 The Authority recommends that for assessment of demand of spectrum for private networks, DoT should create a portal and open it at least for a period of 6 months, seeking demand for

spectrum from companies. The following information may be asked to assess the demand:

- **Name of the company**
- **Details of their business, Net Worth, Turnover**
- **Proposed use of spectrum**
- **Requirement of spectrum**
    - **Spectrum Band**
    - **Quantum of Spectrum**
    - **Time Period for which spectrum is required**
- **Area in sq km with exact location**
- **Technology proposed to be used**

The information so collected by DoT should be accessible only to authorized person in DoT and should not be shared with any unauthorized person.

[Para 4.149]

6.63 The Authority recommends that demand assessment will provide the demand factor for direct spectrum assignment from DoT for establishment of private captive network. With such empirical assessment and DoT's decision on the spectrum bands in which spectrum can be earmarked for private networks, the Authority will provide its recommendations on quantum of spectrum, block size, etc.

[Para 4.150]

6.64 Considering the outcome of the demand assessment and DoT's decision on (i) spectrum bands in which spectrum can be earmarked for private networks and (ii) the methodology for spectrum assignment, the Authority will provide its recommendations on pricing aspects keeping in view the principles of transparency and appropriately factoring in the market determined price, geographical aspects, etc.

[Para 4.187]

6.65 The Authority recommends that in respect of direct spectrum assignment by DoT to Captive Wireless Private Network Permission holders/Licensees, DoT should come out with a guideline detailing the eligibility conditions, spectrum assignment methodology, validity of spectrum, roll out obligations, framework for application process etc. It may be termed as 'Guidelines for Spectrum Assignment to Captive Wireless Private Network Permission holder/Licensee'.

[Para 4.192]

6.66 The Authority recommends that the following should be the eligibility conditions for assignment of spectrum directly by DoT to entities for establishment of isolated private captive network:

(i) Applicant should be a company registered under the Companies Act, 2013 and have valid 'Captive Wireless Private Network Permission/License'.

(ii) Captive Wireless Private Network Permission holder/Licensee should be the occupant (either owned or on lease) of the geographical area/property on which spectrum is being sought to be deployed the captive wireless private network.

(iii) The networth of the Captive Wireless Private Network Permission holder/Licensee should not be less than Rs. 100 Crores.

[Para 4.193]

6.67 The Authority recommends that the spectrum for private network can be assigned administratively to the eligible Captive Wireless Private Network Permission holders/Licensees on demand for specified geography on non-interference basis through a widely publicized online portal-based process in a fair and transparent manner. The assignment process will register the geo-coordinates of the specified geography for which the spectrum is to be assigned. The same spectrum can be reused with multiple assignment to large number of players having different geo-coordinates on co-existence basis with FSS services. However, DoT may ascertain that administrative assignment in such cases is legally tenable as per spectrum assignment policy of DoT, before formulating the guidelines for assignment of spectrum for captive wireless private network.

[Para 4.194]

6.68 The Authority recommends that to provide flexibility, the spectrum for private networks should be assigned initially for a period up to 5 years with a renewal process for further up to 5 years and so on. The licensee should put to use the spectrum assigned to it within 12 months from the date of assignment. Spectrum assignment can be revoked if use of the spectrum has not begun within one year of the assignment ('use it or lose it' principle), or if the spectrum has not been used for the purpose for which it has been assigned.

[Para 4.195]

6.69 The Authority recommends that the entire process of filing of application for spectrum (earmarked for Captive wireless private networks) assignment for captive wireless private networks and its processing should be done through an online portal. Application processing and spectrum allocation should be done in a time bound process.

[Para 4.196]

6.70 The Authority recommends that spectrum should be assigned for captive network deployments using 3GPP compliant technology or technology approved by the Government.

[Para 4.197]

6.71 The Authority recommends that there are many other key elements which are also required to be included in the proposed guidelines such as:

- **A company registered under the Companies Act, 2013 and having valid CWPN permission/License can apply for multiple locations through a single portal. However, documents showing occupancy (either owned or lease) of each of the geographic area will have to be submitted through online portal.**
- **Prescribed Spectrum charges should be applicable for each location.**
- **Documents required to be submitted through online portal should be specified so as to make entire process should be paperless.**
- **It will be the responsibility of the CWPN permission holder/Licensee (enterprise) to ensure that the mobile signals are restricted indoors/within the specified geography. Spectrum cannot be used beyond the assigned geographical area.**

- **The CWPN permission holder/licensee should be required to ensure efficient and interference-free use of their networks, for instance to design and build their networks in such a way so as to minimize the interference ranges of their spectrum usages. This can be achieved for instance with low transmit powers, low antenna heights and appropriate antenna directional patterns. DoT should prescribe the antenna height, power limits, antenna tilt etc.**
- **The limits for public exposure to electromagnetic fields from radio equipment must be met.**
- **Conditions related to no interference to PLMN networks should be prescribed.**
- **The licensor will have the right to inspect the premises to ascertain the bonafide and legitimate use of spectrum.**
- **The licensee should be required to submit a compliance certificate annually certifying the compliance to the specified use of spectrum, power limits and any other periodical compliance.**
- **The licensor should have the rights to revoke the spectrum assignment in case of violation of prescribed terms and conditions.**
- **As the spectrum earmarked for private network has to co-exist with other radio services like FSS stations, to protect these radio services, the licensee should submit the required details of the geo-coordinates of the premises and parameters for the local usages while applying for the spectrum assignment so as to carry out the necessary radio compatibility calculations.**
- **The area of operation, that is, the spectrum usage area of the licensee will be the area inside the logical perimeter of the defined premises with clearly specified geo coordinates. WGS84 format of geographic coordinate system or any other**

suitable geographic coordinate system may be used for this purpose.

- **The CWPN permission holder/licensee will be responsible for the correctness of the geographic coordinates of the area for which the spectrum assignment is applied for.**
- **Spectrum should be used in such a way that the spectrum usage is feasible in the assignment area without causing any interference to adjacent spectrum usages and is compatible with other spectrum usages.**
- **The application for spectrum assignment should also include the following in particular:**
    - **Details of the planned coverage area and a geographical map.**
    - **Type of application planned. (type of industry vertical)**
    - **Planned purpose of use of spectrum. (For example, machine control etc.)**
    - **Quantity of spectrum required for the planned purpose of use.**
    - **Proposed Signal level.**
    - **Details of the technology to be used, network build, number and technical characteristics of base stations etc.**
    - **Measures to be taken to ensure efficient spectrum use.**
    - **Details of the antennas to be used (type, location, height, directional pattern), shielding measures, indoor/outdoor applications.**
    - **Timescale for the network build and network roll-out.**
    - **Period for which spectrum is required.**

[Para 4.198]

6.72 The Authority recommends that:

a. A 5G-dedicated Inter-Ministerial Working Group (IMWG), under the Chairmanship of Member (Technology), DoT should be formed comprising Ministry of Electronics and Information Technology, Department for Promotion of Industry and Internal Trade, Ministry of Information and Broadcasting, Department of Space, Ministry of Finance, Ministry of Education, Department of Science & Technology, Ministry of Micro, Small and Medium Enterprises (MSME) and Niti Ayog as members, which should be represented by JS Level officers.

b. The IMWG may co-opt officers from other concerned Ministry(ies) / Department(s) as per requirement.

c. The concerned Ministries/Departments shall establish a special dedicated Digital Cell, headed by the JS Level officer nominated as member in IMWG, with dedicated technical manpower to formulate the use of digital technologies like 5G, IoT, M2M, AI etc. and development of relevant and affordable use cases involving start-up companies, entrepreneurs, application providers etc. The scope of the Digital Cell shall include, but not limited to, involving the relevant stakeholders in discussions, framing and monitoring short-term (annual), medium-term (5-year), and long-term (10-year) plans with quantitative targets in respect of sector specific 5G use cases, providing platform and promoting 5G use cases. The Digital Cell may also need to focus on issues relating to digital literacy, connectivity and affordable user devices for their sector.

d. The Ministries/Departments should take up short-term (annual), medium-term (5-year), and long-term (10-year) plans with quantitative targets in respect of sector specific 5G use cases and the same can be considered by IMWG for consistent and coordinated development of use cases and start-up

ecosystems to align issues such as connectivity, privacy, data security etc. in the country.

e. **The participating members of IMWG should be responsible for outlining strategies, defining targets, and budgetary provisions for achieving defined targets for their respective Ministries / Departments.**

f. **The IMWG should conduct periodic meetings and discussions, at least once in 3 months, in which progress achieved will be reviewed and outline path for achieving planned objectives will be framed.**

g. **The IMWG should present consolidated status/proposals to the Department of Telecommunications (DoT) being nodal Ministry, on a regular basis.**

h. **The progress of digital transformation and implementation of 5G use cases in various verticals should also be monitored and documented by IMWG and be submitted to DoT for perusal and appropriate decision.**

[Para 5.77]

6.73 The Authority recommends that DoT should take up the matter with Ministry of Micro, Small and Medium Enterprises (MSME) to carry out a study to find out the actual details about the level of acceptance and adoption of 5G based industrial automation and digital technologies by the MSME sector in the country as compared to other industries. Based on the learning from such study, appropriate schemes, including interest subvention scheme, for upgradation of plant and machinery, may be devised to facilitate the micro, small and medium enterprises to overcome various constraints and move towards industrial automation. In

this regard, budgetary provisions (if required), may be created by the Ministry of MSME.

[Para 5.78]

6.74 The Authority recommends that Telecom Innovation Centres, may be formulated in alliance with different academic institutions and ministries. These innovation centres could be specialized for development of innovative solutions for 5G use cases and applications in different verticals / sectors such Agriculture, Medicine, Manufacturing, Infrastructure, Power, Telecom, etc. and be made responsible for desired outcome. DoT should be the nodal ministry to monitor and coordinate the activities of the Telecom Innovation Centres.

[Para 5.80]

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

Information provide by DoT vide its letter dated 13.09.2021 has been updated based on the addiitonal spectrum availability informed by DoT vide its letters dated 27.11.2021 and 22.02.2022

Sl. No.	Service Area	Quantum available for auction (in MHz)						
		700 MHz band (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	5.20	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	3.00	13.80	10.00	-	10.00
6	Haryana	30.00	1.25	5.40	28.20	5.00	-	-
7	Himachal Pradesh	30.00	5.00	4.20	18.00	15.00	-	10.00
8	Jammu & Kashmir	30.00	2.50	7.60	4.00	5.00	-	10.00
9	Karnataka	30.00	3.75	5.40	4.60	10.00	10.00	40.00
10	Kerala	30.00	3.75	1.60	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	5.40	0.20	5.00	-	-
16	Orissa	30.00	6.25	3.00	15.00	10.00	-	-
17	Punjab	30.00	5.00	2.60	9.60	5.00	-	10.00
18	Rajasthan	30.00	2.50	5.20	16.80	-	-	-
19	Tamil Nadu	30.00	3.75	9.20	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	7.00	14.60	10.00	-	-
22	West Bengal	30.00	2.50	1.60	3.20	5.00	-	-
	Total	**660.00**	**81.25**	**99.20**	**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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COMPOSITION OF THE STANDING COMMITTEE ON INFORMATION TECHNOLOGY (2020-21)

Dr. Shashi Tharoor - Chairperson

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2. Smt. Locket Chatterjee
3. Shri Karti P. Chidambaram
4. Shri Sunny Deol
5. Dr. Nishikant Dubey
6. Smt. Raksha Nikhil Khadse
7. Dr. Sukanta Majumdar
8. Shri Dhairyasheel Sambhajirao Mane
9. Ms. Mahua Moitra
10. Shri P. R. Natarajan
11. Shri Santosh Pandey
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14. Dr. Gaddam Ranjith Reddy
15. *Shri Jayadev Galla
16. Shri Sanjay Seth
17. Shri Chandan Singh
18. Shri L.S. Tejasvi Surya
19. Dr. T. Sumathy (A) Thamizhachi Thangapandian
20. Shri Bhanu Pratap Singh Verma
21. #Smt. Sumalatha Ambareesh

Rajya Sabha

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23. Dr. Subhash Chandra
24. Shri Y. S. Chowdary
25. Shri Shaktisinh Gohil
26. Shri Suresh Gopi
27. Shri Md. Nadimul Haque
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29. Shri Syed Zafar Islam
30. Dr. Narendra Jadhav
31. Shri Nabam Rebia

Secretariat

1.	Shri Y. M. Kandpal	-	Joint Secretary
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:

> —ffe 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) <u>Spectrum Audit</u>

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:

> ―If 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.

SP Sood 23/9/2021
(Sukhpal Singh)
Joint Wireless Adviser

Annexure 1.3

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 (Part) Date: 22.02.2022

To,

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

Subject: Additional spectrum availability for auction of spectrum in 800 MHz, 900 MHz and 1800 MHz bands.

References: (1) DoT letter No. L-14006/01/2021-NTG dated 13.09.2021 and 23.09.2021.
(2) TRAI letter No. C-15/2/(1)/2021-NSL-II dated 27.09.2021.
(3) DoT letter of even no. dated 02.11.2021 and 27.11.2021.

Sir,

Vide DoT's above-referred letters dated 13.09.2021 and 27.11.2021, quantum of spectrum available for auction in different LSA-band combinations was conveyed to TRAI.

2. Recently, Indian Railways in 23 States/UTs has surrendered spectrum earmarked to them in 900 MHz band which has resulted in availability of additional 1.6 MHz (paired) quantum of spectrum in 900 MHz band in 7 LSAs namely Andhra Pradesh, Himachal Pradesh, Karnataka, Kerala, North East, Orissa, Tamilnadu LSAs.

2.1. Further, certain quantum of spectrum reserved for Government's use in 900 MHz at certain locations spread across 6 LSAs namely Gujarat, Haryana, Jammu and Kashmir, Punjab, Rajasthan and Uttar Pradesh (West) LSAs is also available now for auction. In Gujarat, Haryana, Punjab LSAs, this spectrum is available for assignment with immediate effect; whereas in other 3 LSAs, this spectrum will be available for assignment latest by 01.07.2022.

2.2. In view of the above surrender/vacation, spectrum availability in 900 MHz band in certain LSAs has increased. Table showing revised spectrum availability in 900 MHz band in different LSAs is attached as Annexure-I.

3. Vide DoT's letter dated 27.11.2021, revised spectrum availability in 1800 MHz band in 5 LSAs namely Kerala, Orissa, Haryana, Mumbai, Kolkata was communicated. In continuation to it, this is to further inform that in Haryana LSA, 10 MHz (paired) quantum in the spectrum block 1765-1775/1860-1870 MHz is available for assignment in entire Haryana LSA except Sirsa (with safe keep off distance). The required safe keep distance around Sirsa is being determined and will be communicated subsequently.

4. In 800 MHz band, frequency carriers with channel bandwidth of 1.23 MHz (paired) are assigned to TSPs/Government. With present 1.23 MHz channel plan, a total of only 14 blocks of 1.23 MHz are available. This channel plan was in use in view of the spectrum requirements of earlier CDMA networks deployed in the band. Further, inter-operator guard band of 0.3 MHz was also provided for interference-free operation of different CDMA networks operating in the band. After the introduction of LTE technology in 800 MHz band, there are no more CDMA networks operating in the band as on date. In view of the current trend of LTE networks in 800 MHz band and existing spectrum holdings of TSPs/Government in different service areas, channel plan in 800 MHz band can be revised from existing channel bandwidth of 1.23 MHz (paired) to 1.25 MHz (paired) and frequency carriers assigned to TSPs/Government may be revised accordingly. As a result, inter-operator guard band may also be removed due to inherent characteristic of LTE technology, which may result in availability of up to 16 spectrum blocks in place of existing 14 carriers in each of the 22 LSAs.

4.1. Revision of channel plan in 800 MHz band was discussed with TSPs. While M/s Reliance Jio has agreed to revision of channel plan from existing 1.23 MHz to 1.25 MHz and making available total 16 spectrum blocks in 800 MHz band, M/s Bharti Airtel and M/s Vodafone Idea have raised their concerns towards possibility of interference from downlink (higher power) of 800 MHz band (869-889 MHz) to uplink (lower power) of 900 MHz band (890-915 MHz) in case of making available 16 blocks in the downlink of 800 MHz band, due to slightly reduced band gap between 800 MHz (downlink) and 900 MHz (uplink) band. Guard band requirement being demanded by M/s Bharti Airtel and M/s Vodafone Idea is around 1.6 MHz. In case it is decided to allot all 16 blocks (each of 1.25 MHz), the guard band available will be 1.5 MHz (for 5 MHz LTE carrier in both 800 MHz and 900 MHz band), instead of 1.6 MHz being demanded by them. If demand of M/s Bharti Airtel and M/s Vodafone Idea is agreed to, only 15 blocks will be available for allotment. In any case, spectrum availability in each LSA will increase at least by 1 block of 1.25 MHz. Further, with regard to existing assignments in 800 MHz band, no additional payment is required to be made by the incumbent spectrum holders as market price for block size of 1.25 MHz has already been charged on them.

4.2. Revision of channel plan from 1.23 MHz to 1.25 MHz with no inter-operator guard band within the band will result in availability of additional spectrum blocks in 800 MHz band in each of the 22 LSAs. In case spectrum blocks, each of 1.25 MHz bandwidth, across entire band i.e. 824-844/869-889 MHz band are carved out, total availability in 800 MHz band will go up by 55 MHz (paired) quantum [=22*2.5 MHz (paired), 2 blocks of 1.25 MHz (paired) bandwidth in each of the 22 LSAs]. However, if one spectrum block (ending at 889 MHz downlink) is not made available in view of possibility of interference to 900 MHz band uplink spectrum, total availability in 800 MHz band will go up by 27.5 MHz (paired) quantum [=22*1.25 MHz (paired), 1 block of 1.25 MHz (paired) bandwidth in each of the 22 LSAs]. Table showing revised spectrum availability in 800 MHz band in different LSAs, in the above 2 scenarios, is attached as Annexure-II.

4.3. In view of the above, TRAI is requested to examine the need to review channel plan in 800 MHz band and number of spectrum blocks that can be made available for telecom services in 800 MHz band while providing their recommendations in response to DoT's reference dated 13.09.2021 regarding upcoming spectrum auction.

5. In reference to decisions/action points emanating from deliberations of a monitoring group, PMO has requested DoT to work towards the initial launch of 5G by 15^{th} August 2022 and also explore the possibility of obtaining requisite recommendations from TRAI before March-2022. In view of the above, TRAI is requested to expedite the matter and provide the recommendations at the earliest.

This issues with the approval of Secretary (T).

Encl: As above.

(Gulab Chand)
Joint Wireless Adviser

Annexure-I

Spectrum availability in 900 MHz band (paired)

Sl. No.	LSA	Quantum already communicated to TRAI on 13.09.2021 (in MHz)	Released due to surrender by Indian Railways (in MHz)	To be released due to vacation by Defence (in MHz)	Revised availability (in MHz)
1	Andhra Pradesh	3.6	1.6		5.2
2	Assam	5.8			5.8
3	Bihar	7			7
4	Delhi	2.2			2.2
5	Gujarat	0		3	3
6	Haryana	0.8		4.6	5.4
7	Himachal Pradesh	2.6	1.6		4.2
8	Jammu and Kashmir	3		4.6	7.6
9	Karnataka	3.8	1.6		5.4
10	Kerala	0	1.6		1.6
11	Kolkata	4.2			4.2
12	Madhya Pradesh	5.8			5.8
13	Maharashtra	4.2			4.2
14	Mumbai	2.2			2.2
15	North East	3.8	1.6		5.4
16	Orissa	1.4	1.6		3
17	Punjab	1.2		1.4	2.6
18	Rajasthan	0.6		4.6	5.2
19	Tamilnadu	7.6	1.6		9.2
20	Uttar Pradesh (East)	1.4			1.4
21	Uttar Pradesh (West)	2.4		4.6	7
22	West Bengal	1.6			1.6
	Total	**65.2**	**11.2**	**22.8**	**99.2**

Annexure-II

Spectrum availability in 800 MHz band (paired)

Sl. No.	LSA	Quantum already communicated to TRAI on 13.09.2021 (in MHz)	*Additional quantum that can be made available (in MHz)*		Revised availability (in MHz)	
			In case 1 additional carrier is considered	*In case 2 additional carriers is considered*	In case 1 additional carrier is considered	In case 2 additional carriers is considered
1	Andhra Pradesh	7.5	*1.25*	*2.5*	**8.75**	**10**
2	Assam	2.5	*1.25*	*2.5*	**3.75**	**5**
3	Bihar	7.5	*1.25*	*2.5*	**8.75**	**10**
4	Delhi	3.75	*1.25*	*2.5*	**5**	**6.25**
5	Gujarat	1.25	*1.25*	*2.5*	**2.5**	**3.75**
6	Haryana	1.25	*1.25*	*2.5*	**2.5**	**3.75**
7	Himachal Pradesh	5	*1.25*	*2.5*	**6.25**	**7.5**
8	Jammu and Kashmir	2.5	*1.25*	*2.5*	**3.75**	**5**
9	Karnataka	3.75	*1.25*	*2.5*	**5**	**6.25**
10	Kerala	3.75	*1.25*	*2.5*	**5**	**6.25**
11	Kolkata	2.5	*1.25*	*2.5*	**3.75**	**5**
12	Madhya Pradesh	2.5	*1.25*	*2.5*	**3.75**	**5**
13	Maharashtra	2.5	*1.25*	*2.5*	**3.75**	**5**
14	Mumbai	2.5	*1.25*	*2.5*	**3.75**	**5**
15	North East	2.5	*1.25*	*2.5*	**3.75**	**5**
16	Orissa	6.25	*1.25*	*2.5*	**7.5**	**8.75**
17	Punjab	5	*1.25*	*2.5*	**6.25**	**7.5**
18	Rajasthan	2.5	*1.25*	*2.5*	**3.75**	**5**
19	Tamilnadu	3.75	*1.25*	*2.5*	**5**	**6.25**
20	Uttar Pradesh (East)	7.5	*1.25*	*2.5*	**8.75**	**10**
21	Uttar Pradesh (West)	2.5	*1.25*	*2.5*	**3.75**	**5**
22	West Bengal	2.5	*1.25*	*2.5*	**3.75**	**5**
Total		**81.25**	***27.5***	***55.0***	**108.75**	**136.25**

Annexure 3.1

VALUATION OF SPECTRUM IN 1800 MHz BAND THROUGH MULTIPLE REGRESSION MODEL

A. Introduction

1. Linear regression is a commonly used predictive analysis technique. Linear regression estimates are used to explain the relationship between one dependent variable and one or more independent/explanatory variables. The regression equation with one dependent and one independent variable is called simple linear regression model. When more than one independent variable is used, it is called multiple regression model. A multiple regression equation may be expressed as below:

$$Y = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \ldots\ldots\ldots\ldots + \beta_n * X_n + \varepsilon$$

Where Y is the dependent variable.
$X_1, X_2, \ldots, X_n$ are the explanatory variables.
β_0 is the intercept.
$\beta_1, \beta_2, \ldots, \beta_n$ are the coefficients of explanatory variables.
ε is the error term.

2. The regression analysis examines significance of the explanatory variables by analyzing certain statistical parameters of the model such as ‘p-value’ of the coefficients of the explanatory variables and ‘Adjusted R-Squared’ of the model. The effect of an explanatory variable is also analyzed through the magnitude and sign of the beta (coefficient) estimates.

B. Methodology

3. In the present exercise, Multiple Regression model has been used for forecasting the price per MHz of spectrum in various bands in the upcoming auction. For this purpose, the observed auction determined

price (hereinafter, referred to as, 'ADP') in the past auctions from the year 2010 (the auction of 3G and BWA spectrum) to the year 2021 (the latest auction of spectrum) has been regressed upon certain economic and market variables that may have a linkage with demand for spectrum and hence may have a bearing on the price of spectrum.

4. In the model, the ADP of the past auctions has been taken as the dependent variable. It has been regressed upon the following explanatory variables for each LSA:
   (a) LSA-wise number of mobile subscribers in an LSA
   (b) LSA-wise gross domestic product (GSDP) per capita
   (c) LSA-wise population density

5. For this purpose, a panel data set for the dependent variable (ADP) from the year 2010 to 2021 and the explanatory variables for the corresponding years was prepared for each LSA.

6. The following regression model was run for ADP for the spectrum in (a) 800 MHz band, (b)1800 MHz band, and (c) 2300 MHz band separately:

$$\ln ADP_{it} = \beta_0 + \beta_1 * POPDEN_{it} + \beta_2 * \ln GSDPperCap_{it} + \beta_3 * \ln SUB_{it} + \beta_4 * Dmet_{it} + \varepsilon_{it}$$

Where:
'i' is an index for the LSAs;
't' is an index for the time of the auction;
'ADP' stands for the auction determined price of the past auctions in an LSA;
'POPDEN' stands for the population density of an LSA;
'GSDPperCap' stands for Gross domestic product (GSDP) per Capita of an LSA;
SUB stands for mobile subscriber base of an LSA;
Dmet stands for LSA fixed effect;

Dmet is 0 for the LSAs of category-B and C; and
Dmet is 1 for the LSAs of Category-A and Metro;

7. The results of the Multiple Regression model for 800 MHz, 1800 MHz and 2300 MHz band were examined through the value of 'Adjusted R-squared' and 'p-value' of each coefficient. The results indicated that the overall model and each explanatory variable was statistically significant for the regression of ADP for the spectrum in 800 MHz, 1800 MHz and 2300 MHz band. Accordingly, the afore-mentioned explanatory variables have been included in the regression model for forecasting of ADP per MHz for the spectrum in 800 MHz, 1800 MHz and 2300 MHz band in the upcoming auction.

8. The forecasted values of ADPs per MHz of spectrum in 800 MHz band, 1800 MHz band and 2300 MHz band respectively have been termed as valuation per MHz of spectrum in 800 MHz band, 1800 MHz band and 2300 MHz band respectively for a period of 20 years through the Multiple Regression model.

Annexure 3.2

VALUATION OF SPECTRUM IN 1800 MHz BAND THROUGH PRODUCER SURPLUS MODEL

A. Introduction

1. Spectrum can be valued as the producer surplus that arises when additional spectrum is allotted to an existing telecom service provider (TSP). As there is an inverse relationship between the quantum of spectrum allocated and the expenditure on the radio access network (RAN) required for serving a particular level of demand, the allocation of additional spectrum to an existing TSP will create a producer surplus.

2. Let us consider a TSP offering wireless access services has 'x' MHz of spectrum. The TSP has drawn its long-term demand model and thereby it has made projections of (i) geographical coverage requirements and (ii) network capacity requirements in each year with 'x' MHz of spectrum available to it. In order to fulfill its requirements of coverage and capacity, the TSP will have to make capital expenditure on the network apart from incurring operating expenditure to run the network every year. Accordingly, the TSP has estimated the total expenditure on the network to be incurred in each year during the next 'y' years, which will be required to fulfill its projected demand. If the TSP obtains an additional spectrum of 'a' MHz today, the capital investment on the network and operating expenditure to run the network required to fulfill the same demand, will be lower owing to the inverse relationship between the spectrum available and the expenditure on the network. It is expected that the value that the TSP places on the additional spectrum is approximately equal to the cost savings upon acquiring the additional spectrum.

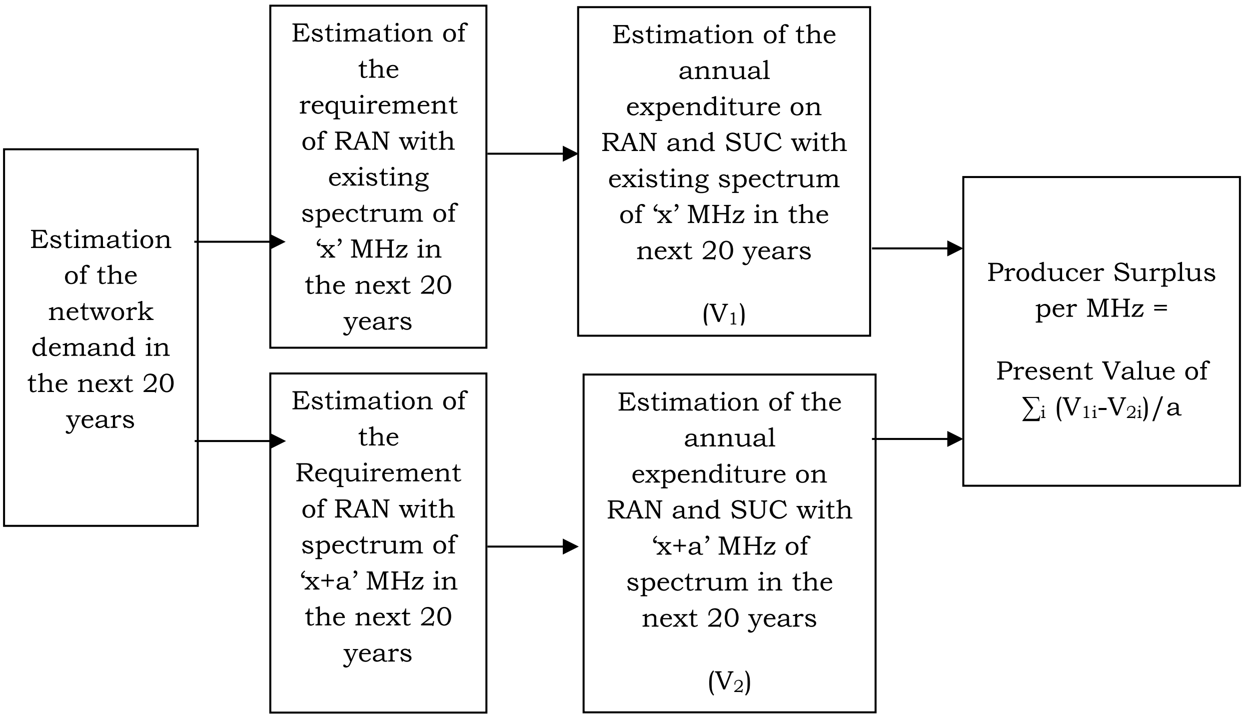
3. Essentially, the Producer Surplus model is an approach to determine the opportunity of net saving to an average TSP on expenditure in the RAN and spectrum usage charge (SUC) in the next 20 years upon getting

additional spectrum. The opportunity of the net saving in expenditure made by the TSP has been termed as 'Producer Surplus'. The producer surplus so obtained is the valuation of spectrum.

4. A block schematic diagram of the Producer Surplus model is given below:

FIGURE-A:

BLOCK SCHEMATIC DIAGRAM OF THE PRODUCER SURPLUS MODEL



5. For the purpose of estimation of producer surplus per MHz in 1800 MHz band, annualized expenditure comprising of capital expenditure (CAPEX) and operating expenditure (OPEX) on RAN in urban areas and SUC in the two scenarios viz. (i) with existing spectrum of 'x' MHz in 1800 MHz band, and (ii) with 'x+a' MHz of spectrum in 1800 MHz band needs to be estimated. It is noteworthy that for this purpose, only the expenditure upon RAN in urban areas is relevant for the following reasons:

(a) There is an inverse relationship between the quantum of spectrum allocated and the expenditure on RAN required to serve a particular level of demand. In case, additional spectrum is allocated to a TSP, it would be able to save upon the expenditure on RAN. On the other hand, additional spectrum would have no impact on the expenditure on core network.

(b) RAN consists of base stations which connect end-user devices. A base station operating in a particular spectrum band (such as 1800 MHz band) in a particular network technology (such as 4G) is characterized by (a) coverage, and (b) traffic carrying capacity.

(c) An existing TSP would install a new base station to cater to either or both –

 (i) capacity constraint, if the existing cluster of base stations in a geographical area is not able to cater to the increased traffic;

 (ii) coverage constraint, if the existing cluster of base stations is not able to cover the populated area adequately.

(d) Generally, the urban areas have much higher population densities than the rural areas. Therefore, the capacity constraints owing to increased traffic arise mainly in urban areas. On the other hand, situations of coverage constraints arise mainly in rural areas which remain uncovered/ under-covered by the existing clusters of base stations. Hence, the urban areas are generally capacity constrained while rural areas are generally coverage constrained. For this reason, a TSP would, generally, install a new base station in order to meet – (i) new capacity requirements in urban areas; and (ii) new coverage requirements in rural areas.

(e) The TSPs in India have already been allotted spectrum in 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz spectrum bands. At present, the spectrum in 800 MHz band and 900 MHz is generally used for catering to the coverage constraints. An existing TSP, which holds spectrum in 800 MHz and/or 900 MHz band, would get no additional benefit of coverage in case it gets additional spectrum in 1800 MHz band. However, owing to an inverse relationship between the quantum of spectrum available and number of base stations required to meet a particular level of demand, the TSP would need to install fewer additional base stations in future in capacity constrained areas (i.e. urban areas) in case it gets additional spectrum in 1800 MHz band. Clearly, additional spectrum in 1800 MHz band would help an existing TSP in reducing its expenditure mainly on the base stations in urban areas only.

6. Accordingly, requirement of the base stations in urban areas in the next 20 years needs to be estimated in the two scenarios viz. (i) with existing spectrum of 'x' MHz in 1800 MHz band, and (ii) with 'x+a' MHz of spectrum in 1800 MHz band, in order to arrive at the savings in the expenditure on RAN upon obtaining additional spectrum of 'a' MHz in 1800 MHz band.

7. As per the existing SUC regime in the country, the SUC is levied on a TSP on the basis of weighted average of SUC rates across all spectrum assigned to a TSP in all access spectrum bands. Accordingly, the SUC payable in the next 20 years needs to be estimated in the two scenarios viz. (i) with existing spectrum of 'x' MHz, and (ii) with 'x+a' MHz of spectrum,

8. The value of producer surplus would vary with the TSPs depending upon their respective projected demands (i.e. subscriber base and mobile traffic per subscriber), annual expenditure on base stations (CAPEX *plus* OPEX), spectrum holdings and profile of subscribers in various LSAs. Therefore, the average of the values of producer surplus for various TSPs would best capture the expected value of producer surplus upon acquiring additional spectrum in 1800 MHz band. Accordingly, in order to arrive at the expected value of producer surplus per MHz, an average TSP having an average level of projected demand (i.e. subscriber base and mobile traffic per subscriber), average annual expenditure on base stations, average spectrum holdings and average profile of subscribers in each LSA has been considered. At present, the 4th generation (4G) networks cater to the most of mobile traffic in the country. Accordingly, the Producer Surplus

model has been run for a 4G network. Data has either been provided by the TSPs or industry benchmarks have been adopted.

9. In the model, the present values (PVs) of the expenditures (CAPEX <u>*plus*</u> OPEX) on 4G base stations in urban areas and SUC to be incurred during the next 20 years for the two cases described above viz. (a) with 'x' MHz of spectrum in 1800 MHz band, and (b) with 'x+a' MHz of spectrum in 1800 MHz band have been estimated for an average TSP. The difference of the PVs in the two cases is the producer surplus.

Producer Surplus on acquiring 'a' MHz of spectrum in 1800 MHz band = (Present Value of expenditure on 4G base stations in urban areas and SUC during the next 20 years with 'x' MHz of spectrum in 1800 MHz band) <u>minus</u> (Present Value of expenditure on 4G base stations and SUC during the next 20 years with 'x+a' MHz of spectrum in 1800 MHz band)

B. Methodology

10. As indicated earlier, in the present exercise, the Producer Surplus model has been run for an average TSP offering 4G network based mobile services in the country. For this purpose, information in respect of the top-three TSPs which offer 4G network based mobile services in the country have been used in the model.

11. The following steps have been taken for estimation of producer surplus in case a TSP acquired 'a' MHz of spectrum in 1800 MHz band ('a' has been taken as 5 MHz in the model):
    (a) Estimation of the 4G network demand in urban areas of an average TSP
    (b) Estimation of the number of 4G base stations in urban areas in the two scenarios-
        (i) with average spectrum holding of 'x' MHz in 1800 MHz band; and

(ii) with average spectrum holding of 'x' MHz in 1800 MHz band <u>plus</u> ('a' MHz in 1800 MHz band)

(c) Estimation of the annual expenditure on 4G base stations in urban areas and SUC in the two scenarios

(d) Estimation of producer surplus per MHz of spectrum in 1800 MHz band

(1) Estimation of the 4G Network Demand in Urban Areas of an Average TSP

12. LSA-wise 4G network demand in urban areas in an LSA in the Financial Year 2021-22 in respect of an average TSP has been estimated as below:

Busy hour demand for the 4G network in urban areas in an LSA in respect of an average TSP
= Number of urban 4G subscribers of the average TSP *in the LSA * Amount of Busy Hour 4G mobile traffic per 4G subscriber in the LSA*

13. The number of urban 4G subscriber of the average TSP in an LSA has been estimated using the Herfindahl-Hirschman Index (HHI) as below:

Number of urban 4G subscribers of the average TSP in an LSA
*= Total number of urban 4G subscribers in the LSA * HHI of the urban 4G subscribers market in the LSA/ 10000*

14. For this purpose, the LSA-wise number of 4G urban subscribers of the top-three TSPs has been estimated as below:

Number of urban 4G subscribers of a TSP
= (Number of urban subscribers of the TSP <u>divided by</u> Number of total subscribers of the TSP) <u>multiplied by</u> Number of 4G subscribers of the TSP

15. The LSA-wise Busy Hour 4G mobile traffic (comprising of 4G data download, voice MOU and SMS) as a percentage of monthly 4G mobile

traffic has been estimated on the basis of information on traffic handled by 4G network on hourly basis for a period of seven days (from 01.02.2022 to 07.02.2022) for each LSA obtained from TSPs. Based on this information, amount of 4G mobile traffic per 4G subscriber in busy hour in each LSA in respect of the average TSP has been estimated as below:

Amount of Busy Hour 4G mobile traffic (in Mbps) per 4G subscriber in an LSA in respect of the average TSP
= Busy Hour voice minutes of usage (MOU) per subscriber converted to data (in Mbps) <u>plus</u> Busy Hour SMS per subscriber converted to data (in Mbps) <u>plus</u> Busy Hour 4G data download per 4G subscriber (in Mbps)

16. For the purpose of estimation of the Busy Hour 4G mobile traffic per 4G subscriber in the following 20 years (from F.Y. 2022-23 to 2041-42), the annual rate of growth in (a) number of subscribers, (b) voice MOU per subscriber per month, (c) SMS per subscriber per month and (d) data per subscriber per month apart from (e) revenue have been considered as below:

TABLE-A:
PROJECTED GROWTH RATES

Financial Year	Annual rate of growth in the number of subscribers	Annual rate of growth in the revenue	Annual rate of growth in the voice MOU per subscriber per month	Annual rate of growth in the SMS per subscriber per month	Annual rate of growth in the data per subscriber per month
2022-23	2.50%	5.00%	0%	0%	12%
2023-24	2.00%	4.50%	0%	0%	10%
2024-25	1.50%	4.00%	0%	0%	10%
2025-26	1.50%	3.50%	0%	0%	8%
2026-27	1.00%	3.50%	0%	0%	8%
2027-28	1.00%	3.00%	0%	0%	8%
2028-29	0.75%	2.50%	0%	0%	6%

2029-30	0.75%	2.50%	0%	0%	6%
2030-31	0.50%	2.00%	0%	0%	6%
2031-32	0.50%	2.00%	0%	0%	4%
2032-33	0.50%	2.00%	0%	0%	4%
2033-34	0.50%	2.00%	0%	0%	4%
2034-35	0.50%	1.00%	0%	0%	2%
2035-36	0.50%	1.00%	0%	0%	2%
2036-37	0.50%	0.50%	0%	0%	2%
2037-38	0.50%	0.50%	0%	0%	2%
2038-39	0.50%	0.50%	0%	0%	2%
2039-40	0.50%	0.50%	0%	0%	2%
2040-41	0.50%	0.50%	0%	0%	2%
2041-42	0.50%	0.50%	0%	0%	2%

(2) Estimation of the Number of 4G Base Stations Required by the Average TSP in Urban Areas in each LSA in the two Scenarios

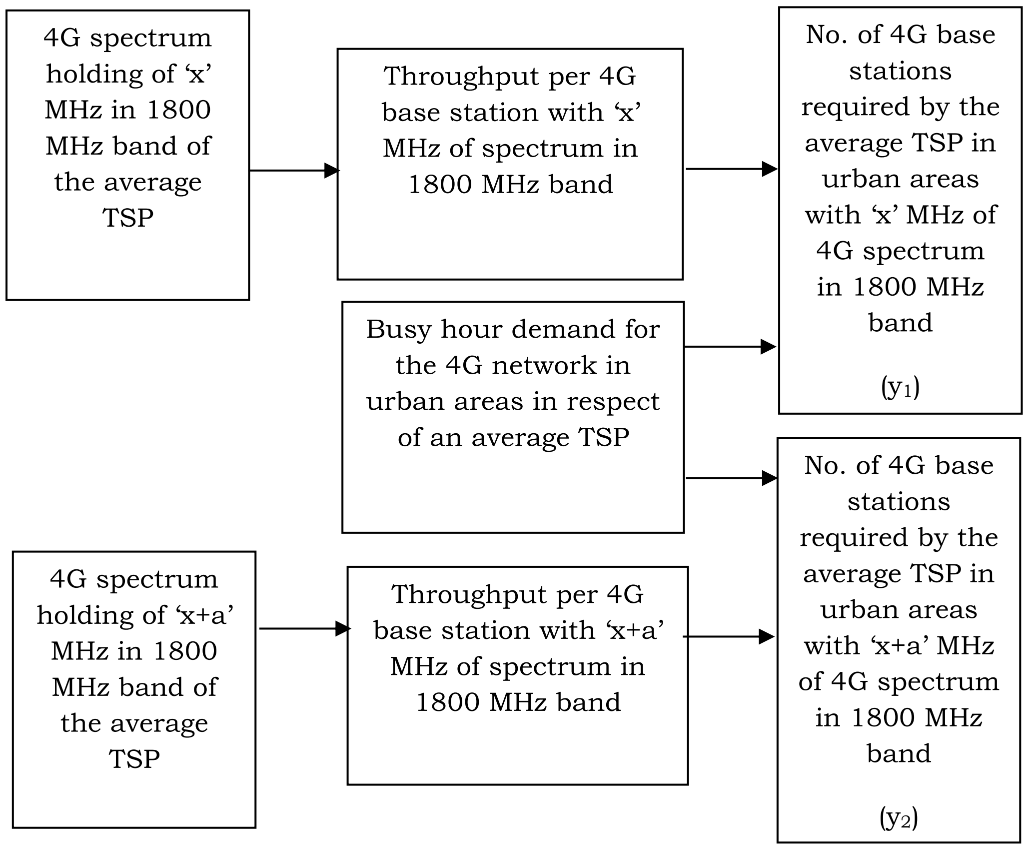
17. Prior to estimating the number of 4G base stations in urban areas required by the average TSP in each LSA, the equivalent 4G spectrum holding of the average TSP in 1800 MHz band has been estimated. The 4G spectrum holding of a TSP refers to the spectrum which has been put to use by the TSP in its 4G network. In respect of each TSP, the 4G spectrum holdings of the TSP in various spectrum bands have been converted into the equivalent 4G spectrum holding in 1800 MHz band on the basis of download capacity of the respective spectrum bands. Thereafter, the equivalent 4G spectrum holding of the average TSP in 1800 MHz band in an LSA has been estimated as the weighted average of the equivalent 4G spectrum holdings in the 1800 MHz band of the three TSPs in the LSA, weighted with TSP-wise 4G subscriber base in the LSA.

18. Based on the estimated 4G spectrum holding in 1800 MHz band of the average TSP, the number of 4G base stations has been estimated in both the scenarios i.e. (a) with additional spectrum, and (b) without additional spectrum). A block schematic diagram depicting the method to determine

the number of 4G base stations required by the average TSP in urban areas in each LSA is given below:

FIGURE-B:

BLOCK SCHEMATIC DIAGRAM FOR ESTIMATION OF THE NUMBER OF 4G BASE STATIONS REQUIRED BY THE AVERAGE TSP IN URBAN AREAS IN EACH LSA



(3) Estimation of Annual Expenditure on 4G base Stations in Urban Areas and SUC in the two Scenarios

19. In order to estimate the total annual expenditure (CAPEX *plus* OPEX) on the 4G base stations in urban areas in each LSA in respect of the average TSP, the following steps have been taken:

(a) The capital cost (Gross Block) as on 31.03.2021 per 4G base station has been estimated on the basis of the Accounting Separation Report (ASR) for the financial year (F.Y.) 2020-21. The annual operating cost per 4G base station for the F.Y. 2020-21 in the Metro

LSAs has been taken as Rs. 6 lakh, and for the LSAs of the category-A, B and C, it has been taken as Rs. 4.32 lakh. Further, the capital cost per 4G base station has been assumed to be reducing by 5% year-on-year (Y-o-Y) and annual operating cost per 4G base station has been assumed to be increasing by 1% on Y-o-Y basis for the next 20 years. Useful Life of 4G Base station equipment has been taken as 10 years.

(b) Based on the number of 4G base stations required in urban areas in an LSA in the next 20 years to cater to the projected 4G network demand, and the capital cost (Gross Block) per 4G base station in the LSA, the total capital cost of the 4G base stations in urban areas in the LSA has been calculated. Further, straight line depreciation @10% per year and prevalent cost of capital @15% have been applied to estimate annualized CAPEX of the 4G base stations in urban areas for the average TSP in each LSA in the next 20 years.

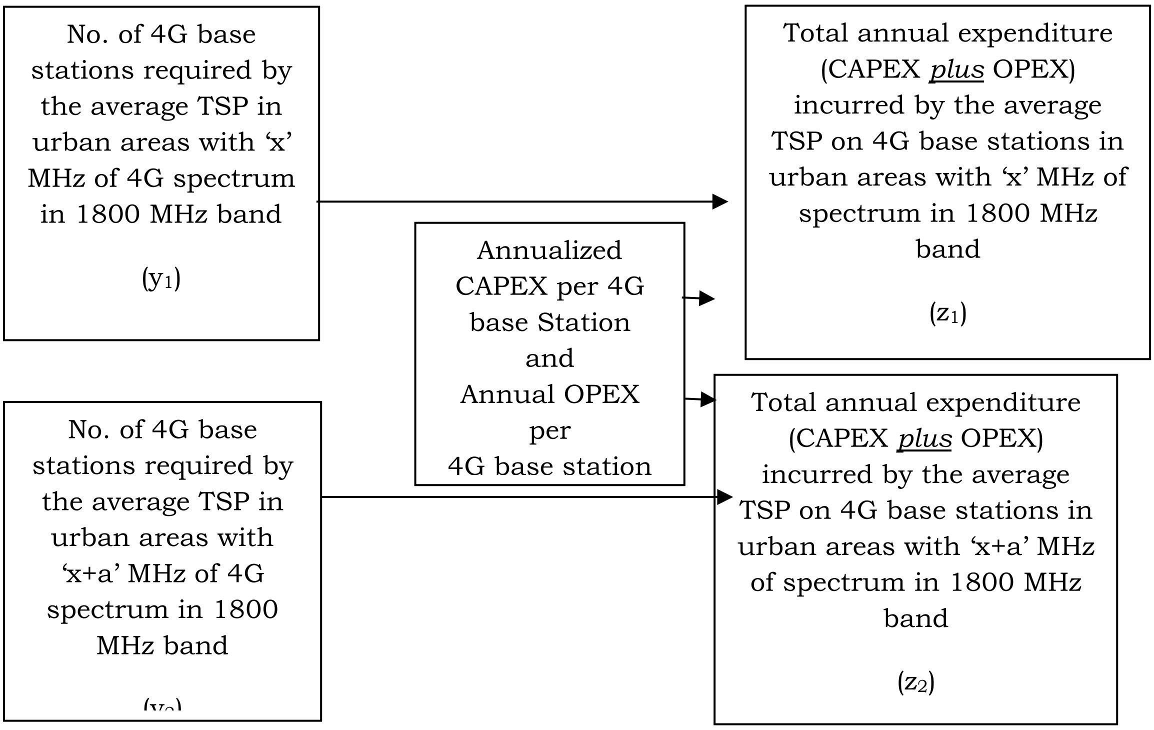
(c) Based on the number of 4G base stations required in urban areas in an LSA in the next 20 years, and annual operating cost per 4G base station in the LSA, the total annual OPEX of the 4G base stations in urban areas for the average TSP in each LSA in the next 20 years has been estimated.

(d) The total annual expenditure on the 4G base stations in urban areas in each LSA in the next 20 years in respect of the average TSP has been estimated by way of adding the annualized CAPEX and annual OPEX for the respective years.

20. The annual expenditure on 4G base stations in urban areas for the average TSP in the next 20 years in the two scenarios has been estimated as per the following block schematic diagram.

FIGURE-C:

BLOCK SCHEMATIC DIAGRAM FOR ESTIMATION OF TOTAL EXPENDITURE (CAPEX *PLUS* OPEX) ON 4G BASE STATIONS IN URBAN AREAS IN THE TWO SCENARIOS



21. As indicated before, the SUC is levied on a TSP on the basis of weighted average of SUC rates across all spectrum assigned to the TSP in all access spectrum bands. For computing the SUC payable by the average TSP in each LSA for the next 20 years in the two scenarios i.e. with ‘x’ MHz of spectrum and ‘x+a’ MHz of spectrum, the following steps have been taken:

(a) The SUC rate for the average TSP in an LSA in the first scenario (i.e. with ‘x’ MHz of spectrum) has been taken to be equal to the average SUC rate of wireless access service providers in the F.Y. 2020-21 in the LSA, computed on the basis of information provided by the TSPs in the Adjusted Gross Revenue (AGR) reports and Accounting Separation Reports (ASR) for the F.Y. 2020-21.

(b) The SUC rate in the second scenario (i.e. with ‘x+a’ MHz of spectrum) has been computed with the help of the weighted average SUC formula.

(c) The annual rate of growth in average revenue per user (ARPU) in the next 20 years (from F.Y. 2022-23 to 2041-42) has been computed on the basis of (a) the projected rate of growth in revenue, and (b) the projected rate of growth in the subscriber base in the next 20 years, indicated in the Table-A above; and

(d) SUC payable by the average TSP in the next 20 years in the two scenarios has been estimated on the basis of (a) weighted average SUC rate in the two scenarios, (b) 4G subscriber base, and (c) ARPU in the next 20 years for the average TSP.

(4) Estimation of Producer Surplus per MHz of Spectrum in 1800 MHz Band

22. In order to arrive at the present value of the expenditure on 4G base stations, a discounting rate of 12.5% has been used.

23. The producer surplus per MHz of spectrum in 1800 MHz band has been estimated as below:

Producer Surplus per MHz of spectrum in 1800 MHz band
= (Present Value of the expenditure on 4G base stations in urban areas and SUC during the next 20 years with 'x' MHz of spectrum in 1800 MHz band <u>minus</u> Present Value of the expenditure on 4G base stations and SUC during the next 20 years with 'x+a' MHz of spectrum in 1800 MHz band) <u>divided by</u> 'a'

24. Producer Surplus per MHz of spectrum in 1800 MHz band so obtained is termed as 'Valuation per MHz of spectrum in 1800 MHz band for a period of 20 years through the Producer Surplus model'.

Annexure 3.3

VALUATION OF SPECTRUM IN 1800 MHz BAND THROUGH PRODUCTION FUNCTION MODEL

A. Introduction

1. The Production Function model estimates the value of spectrum through the Cobb-Douglas production function with spectrum and base stations as two factor inputs to produce mobile traffic. The Cobb-Douglas production function is a commonly used functional form for estimating the relationship between inputs and output. The form of the production function is specified as below:

   $X= A * y^{\alpha} * z^{\beta}$

2. The above specification is based on the assumption that the two inputs viz. quantum of spectrum holding (y), and base stations (z) may be substituted for each other over a range of output viz. mobile traffic (X). An optimal mix of the two inputs will be used by the telecom service providers (TSPs) to produce the required mobile traffic and this optimal mix is determined by input prices. A higher charge for spectrum will induce TSPs to substitute spectrum for the less expensive base stations to produce the same mobile traffic, and vice versa. One way of estimating the value of spectrum is to take a panel data set of the mobile traffic, spectrum allocated and base stations in different LSAs over the past time periods and estimate the coefficients of the production function through regression analysis which can then be used to predict the value of spectrum for each LSAs, with the help of rational assumptions.

3. The predicted value of spectrum would vary with the TSPs depending upon their projected mobile traffic and present spectrum holdings. Therefore, the average of the predicted values of spectrum for various TSPs would best capture the expected value of spectrum. Accordingly, to arrive at the expected valuation of spectrum per MHz, an average TSP

having an average level of mobile traffic and average spectrum holding in each LSA has been considered. At present, the 4th generation (4G) networks cater to the most of mobile traffic in the country. Accordingly, the Production Function model has been run for a 4G network. Data has either been provided by the TSPs or industry benchmarks have been adopted.

B. Brief description of the model

4. This model is based on the opportunity cost principle. It works on substitutability between spectrum and base stations that are assumed to be the two essential inputs for the supply of mobile services. The specification of the Cobb-Douglas production function is given below:

$$\mathbf{X = A * y^{\alpha} * z^{\beta}} \qquad \text{... (1)}$$

5. In the present exercise, the dependent variable (X) is the mobile traffic. The independent or explanatory variables are – allocated amount of spectrum (y), and number of base stations deployed by a TSP (z). The parameters α and β reflect the changes in mobile traffic for a unit change in spectrum and base stations respectively.

6. To estimate the above production function (equation-1), it has been linearized by taking logarithm on both the sides as follows:

$$\mathbf{\ln X = \ln A + \alpha * \ln y + \beta * \ln z} \qquad \text{... (2)}$$

7. The log linearized model (equation- 2) can be solved by calculus techniques to arrive at the optimal input mix of both spectrum and base stations. The optimal condition is derived as follows:

$$\frac{MPy}{Py} = \frac{MPz}{Pz} \qquad \text{... (3)}$$

Where,

MP_y = marginal productivity of spectrum and,

MP_z = marginal productivity of base stations

Py and Pz are prices of spectrum and base stations respectively.

8. The above equation indicates that at the optimum, a TSP will allocate expenditure between the two inputs in such a manner that they yield the same marginal productivity per rupee spent.

9. MPy and MPz can be calculated by differentiating the above specified production function (equation-1) as follows:

$$\mathbf{MPy} = \frac{\alpha * A * y^{\alpha} * z^{\beta}}{y} \qquad \mathbf{...(4)}$$

$$\mathbf{MPz} = \frac{\beta * A * y^{\alpha} * z^{\beta}}{z} \qquad \mathbf{...(5)}$$

10. With the optimality condition and MPy & MPz calculated above (using the equations 3, 4 and 5) the value of spectrum, denoted by Py is derived as follows:

$$\mathbf{Py} = \frac{\alpha * Z}{\beta * y} * \mathbf{Pz} \qquad \mathbf{....(6)}$$

Where, Py = value per MHz of spectrum, i.e. the variable of interest

Pz = known price of a base stations

z is the number of base stations deployed.

y is the amount of spectrum allocated.

α and β are the coefficients of the production function.

C. Methodology

11. As indicated earlier, in the present exercise, the Production Function model has been run for an average TSP offering 4G network based mobile services in the country. For this purpose, information in respect of the

top-three TSPs which offer 4G network based mobile services has been used in the model.

12. For running the Production Function model, information on 4G mobile traffic (consisting of 4G data download, voice MOU and SMS), 4G base stations and 4G spectrum holdings of different TSPs for all LSAs from the year 2018 to 2021 has been gathered. The 4G spectrum holding of a TSP refers to the quantum of spectrum in various spectrum bands which has been used by the TSP in its 4G network. In respect of each TSP, the 4G spectrum holdings of the TSP in various spectrum bands have been converted into the equivalent 4G spectrum holding in 1800 MHz band on the basis of the download capacity of the respective spectrum bands.

13. Based on the information on 4G mobile traffic, 4G base stations and equivalent 4G spectrum holding in 1800 MHz band for different TSPs for all LSAs from the year 2018 to 2021, the weighted average 4G mobile traffic, weighted average 4G base stations and weighted average equivalent 4G spectrum holding in 1800 MHz band for the average TSP have been estimated for each LSA for the F.Y. 2018-19 to F.Y. 2020-21. For obtaining the weighted averages for each LSA, TSP-wise number of 4G mobile subscribers in the LSA were used as weights.

14. With the help of the panel data set of LSA-wise 4G mobile traffic, 4G base stations and equivalent 4G spectrum holdings for the average TSP for the F.Y. 2018-19 to F.Y. 2020-21, regression analysis has been conducted on the equation (2) above to estimate the coefficients $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$. Two separate regression analysis have been run for the two groups - (a) LSAs of Metro category combined, and (b) LSAs of the category-A, B and C combined.

15. After estimating the coefficients $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ for the above two groups of LSAs, the value per MHz of spectrum in 1800 MHz band in each LSA has been estimated with the help of the equation (6) above. The following steps have been followed to arrive at the value of (**z * Pz**) which is the present value

of the total expenditure incurred by the average TSP on the 4G base stations for a period of 20 years:

(a) LSA-wise amount of 4G mobile traffic for an average TSP has been forecasted for the next 20 years based on the 4G mobile traffic for the FY. 2021-22 and the projected annual rate of growth in (a) number of subscribers, (b) voice MOU per subscriber per month, (c) SMS per subscriber per month, and (d) data per subscriber per month as mentioned in the Annexure 3.2 related to the valuation of spectrum in 1800 MHz band through the Producer Surplus model.

(b) On the basis of the forecasted 4G mobile traffic for each year in the next 20 years and the estimated value of the coefficient $\boldsymbol{\beta}$, the number of 4G base stations for each year in the next 20 years have been forecasted using the following equation (which has been derived from the equation-1 above using marginal analysis):

$$\left(\frac{\mathbf{4G\ BaseStations\ n}}{\mathbf{4GBaseStations\ n-1}}\right)^{\wedge}\boldsymbol{\beta} = \frac{\mathbf{4G\ MOBILE\ TRAFFICn}}{\mathbf{4G\ MOBILE\ TRAFFICn-1}}$$

(c) The Capital Cost (Gross Block) as on 31.03.2021 per 4G Base Station has been estimated on the basis of the Accounting Separation Report (ASR) for the financial year (F.Y.) 2020-21. The annual operating cost per 4G Base Station for the F.Y. 2020-21 in the Metro LSAs has been taken as Rs. 6 lakh, and for the LSAs of the category-A, B and C, it has been taken as Rs. 4.32 lakh. Further, the capital cost per 4G base station has been assumed to be reducing by 5% year-on-year (Y-o-Y) and annual operating cost per 4G base station has been assumed to be increasing by 1% on Y-o-Y basis for the next 20 years. Useful Life of 4G Base station equipment has been taken as 10 years.

(d) Based on the forecasted number of 4G base stations required in an LSA in the next 20 years and the capital cost (Gross Block) per 4G base station in the LSA, the total capital cost of the 4G base stations in the LSA has been calculated. Further, straight line depreciation @10% per year and prevalent cost of capital @15% have been applied to estimate annualized CAPEX of the 4G base stations for the average TSP in each LSA in the next 20 years.

(e) Based on the number of 4G base stations required in an LSA in the next 20 years, and annual operating cost per 4G base station in the LSA, the total annual OPEX of the 4G base stations for the average TSP in each LSA in the next 20 years has been estimated.

(f) The total annual expenditure on the 4G base stations in each LSA in the next 20 years in respect of the average TSP has been estimated by way of adding the annualized CAPEX and annual OPEX for the respective years.

(g) In order to arrive at the present value of the total expenditure on 4G base stations for the next 20 years, a discounting rate of 12.5% has been used.

(h) The present value of the total expenditure on 4G base stations for the next 20 years is the value of (**z* Pz**) appearing in the equation (6).

16. With the help of the estimated values of the coefficients $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$**,** the value of (**z * Pz)** and the equivalent spectrum holding in 1800 MHz band in respect of the average TSP for each LSA (**y**), the valuation per MHz of spectrum in 1800 MHz band in each LSA has been estimated using the equation (6) above.

Annexure 3.4

VALUATION OF SPECTRUM IN 1800 MHz BAND THROUGH REVENUE SURPLUS MODEL

A. Introduction

1. The Revenue Surplus Model for valuation of spectrum in 1800 MHz is premised on the assumption that the net present value (NPV) of the projected revenue surplus over the next 20 years could potentially represent the maximum amount which a telecom service provider (TSP) would be willing to pay for additional spectrum in 1800 MHz band. The business models adopted by different TSPs would influence the respective valuations if firm-level calculations were to be adopted. Hence, a full industry approach using aggregate data of wireless access service segment has been used in the valuation exercise using this approach.

2. NPV of Revenue surplus of wireless access service segment in an LSA for a period of 20 years (from F.Y. 2022-23 to 2041-42)
= NPV [(projected total revenue) *minus* (all operating expenditures) *minus* (all capital expenditures excluding spectrum related capital expenditures)] of all wireless access service providers in the LSA for a period of 20 years

3. Valuation of 1 MHz of spectrum in an LSA for a period of 20 years
= (NPV of Revenue Surplus of wireless access service segment in the LSA) *divided by* (total spectrum holding of all wireless access service providers in the LSA

B. Methodology

4. For arriving at the valuation per MHz of spectrum in 1800 MHz band for a period of 20 years through the Revenue Surplus model, the following method has been used:
   a) Separate calculations have been done for each LSA.

b) LSA-wise Gross Revenue from wireless access services has been taken from Accounting Separation Reports (ASR) for the financial year (F.Y.) 2020-21 furnished by access service providers to the Authority. The annual rate of growth of revenue in F.Y. 2021-22 has been assumed to be 6% with respect to F.Y. 2020-21. The annual rates of growth in (a) revenue, and (b) subscribers in the next 20 years (from F.Y. 2022-23 to F.Y. 2041-42) have been taken as those tabulated in the Producer Surplus model described in the Annexure 3.2 of these recommendations.

c) The Earning Before Interest, Tax, Depreciation and Amortization (EBITDA) margin as a percentage of Gross Revenue varies across LSAs as well as across TSPs. In the present model, a uniform EBITDA margin of 30% of Gross Revenue in the next 20 years has been taken to ensure that the incentive to invest is incorporated into the calculation.

d) Capital cost per mobile subscriber has been taken as Rs. 2000. This cost does not include the spectrum related capital costs such as the prices of spectrum acquired through auction.

e) Initial capital investment in an LSA would be equal to the total number of mobile subscribers in the LSA multiplied by the capital cost per mobile subscriber. For the subsequent years, additional capital investment has been calculated on the basis of the number of incremental mobile subscribers added during the year. Capital investment for each year can be projected for the next 20 years in the following manner:

Capital investment in the 0^{th} *year in an LSA* = $N_{S(0)} * I_S$

Capital investment in the n^{th} *year in an LSA* = $[N_{S(n)} - N_{S(n-1)}] * I_S$

Where $\mathbf{N_{S(n)}}$ is the total number of mobile subscribers in the n^{th} year in an LSA and $\mathbf{I_S}$ is the capital cost per mobile subscriber.

f) Useful life for the capital investments has been assumed to be 10 years. Straight line depreciation @10% per year has been assumed.

g) Return on capital employed has been allowed @ 15%.

h) Annualized Capital Expenditure (CAPEX) for a year has been computed on the basis of afore-mentioned rates of depreciation and return on capital employed.

i) Revenue surplus of wireless access service segment in an LSA for each year which is equal to [(projected total revenue) <u>*minus*</u> (all operating expenditures) <u>*minus*</u> (all capital expenditures excluding spectrum related capital expenditures)] of all wireless access service providers in the LSA has been calculated as below:

Revenue surplus in an LSA for a year

= EBITDA for the year <u>net of</u> Annualized CAPEX (excluding spectrum related CAPEX) for the year

As indicated before, EBITDA in each year has been taken as 30% of the annual Gross Revenue from wireless access service segment.

j) Net present value (NPV) of the revenue surplus for the next 20 years has been computed using a discounting factor of 12.5%.

k) The NPV of the revenue surplus for the next 20 years in an LSA represents the blended present value of the revenue surplus from the spectrum holdings in 800 MHz band, 900 MHz band, 1800 MHz band, 2100 MHz band, 2300 MHz and 2500 MHz band in the LSA. In order to work out the valuation of the spectrum in 1800 MHz band, the present spectrum holdings in various spectrum bands in an LSA have been converted into the equivalent spectrum holding in 1800 MHz band on the basis of the factor of technical efficiency of the spectrum in the respective bands vis-à-vis the spectrum in 1800 MHz band.

5. In order to estimate the LSA-wise valuation per MHz of spectrum in the 1800 MHz band for a period of 20 years, the NPV of revenue surplus of each LSA has been divided by the total equivalent spectrum holding in 1800 MHz band in the LSA. The revenue surplus per MHz of spectrum in 1800 MHz band so obtained is termed as 'Valuation per MHz of spectrum in 1800 MHz band for a period of 20 years through the Revenue Surplus model'.

Annexure 3.5

VALUATION OF SPECTRUM IN 1800 MHz BAND AND 2300 MHz BAND THROUGH THE TREND-LINE APPROACH

A. Introduction

1. A new approach, namely 'the Trend-line approach' has been introduced by the Authority in the present exercise. Trend-line approach is a statistical method which identifies and fits any systematic time patterns which may be present in the variable of interest through a time-series analysis.

2. The auction determined prices (hereinafter, referred to as 'ADPs') in the previously held auctions have consistently been considered by the Authority as one of the possible valuations of spectrum. In the Consultation Paper (CP) dated 30.11.2021, it was envisaged that on the basis of time series information on ADPs, a trend-line may be drawn for predicting expected ADP in the forthcoming auction; it was stated that under the Trend-line approach, a linear relationship may be established between the ADPs in the previously held auctions and time (t) as below:

   ADP = a + b * t … Equation (1)

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

3. In a trend-line fitted between ADPs and time (t), 'a' is the intercept of the trend-line (the point at which the trend-line crosses the y-axis), and 'b' is the slope of the trend-line (the change in ADP per unit time).

4. Under the Trend-line approach, using the time-series information on ADPs per MHz (spectrum band-wise and LSA-wise) in the spectrum auctions held from the year 2010 (the auction of 3G and BWA spectrum) to the year 2021 (the latest auction of spectrum), the constant 'a' and the coefficient 'b' may

be estimated using linear regression technique. The values of constant 'a' and the coefficient 'b' estimated from the linear regression may then be plugged in the above equation (1) to forecast the value of ADP per MHz in the spectrum band in the forthcoming auction.

B. Methodology

5. At present, there are 22 LSAs in the country. Under Unified License (UL), a licensee may obtain separate access service authorization for each LSA. Traditionally, the 22 LSAs were grouped into four categories viz.
   (a) Metro LSAs (Delhi, Kolkata and Mumbai);
   (b) LSAs of Category-A (Andhra Pradesh, Gujarat, Karnataka, Maharashtra and Tamil Nadu);
   (c) LSAs of Category-B (Haryana, Kerala, Madhya Pradesh, Punjab, Rajasthan, Uttar Pradesh (East), Uttar Pradesh (West) and West Bengal); and
   (d) LSAs of Category-C (Assam, Bihar, Himachal Pradesh, Jammu & Kashmir, North East and Orissa)

6. The LSAs in a particular category have largely similar characteristics such as per-capita income, infrastructure and other developmental variables. Keeping the above in view, in the present exercise, linear regressions between ADPs and time (t) have been run by combining LSAs of the same category. In total, three separate regressions have been run; one regression for the LSAs of Category-C together, one regression for the LSAs of Category-B together, while another regression has been run for the LSAs of Category-A and Metro together. The above approach has been used for running separate trend-line regressions between ADPs and time (t) for the spectrum in 1800 MHz and 2300 MHz band. While running the regressions, the characteristics (such as per-capita income, infrastructure, and other developmental variables) that may have an impact on the ADPs have been incorporated in the model through appropriate dummy variables.

7. The resulting linear regressions yielded statistically significant results indicative of strong systematic time patterns in the LSA-wise ADPs per MHz of spectrum in 1800 MHz band and 2300 MHz band. Based on the values of constant 'a' and the coefficient 'b' estimated from the trend-line regressions, the Authority has obtained the expected values of LSA-wise ADPs per MHz in the spectrum band of 1800 MHz band and 2300 MHz band in the forthcoming auction. These expected values of ADPs per MHz of spectrum in 1800 MHz band and 2300 MHz band respectively may be termed as valuation per MHz of spectrum in 1800 MHz band and 2300 MHz band respectively for a period of 20 years through the Trend-line approach.

Annexure 3.6

VALUATION (PER MHz) USING DIFFERENT APPROACHES – 1800 MHz SPECTRUM (20 YEARS)

(Rs. in crore)

LSA	Multiple Regression Model	Producer Surplus Model	Production function Model	Revenue Surplus Model	Trend line Model	Achieved Price – March 2021 of 1800 MHz (duly indexed)	Average (mean) Value
Delhi	590.06	243.46	398.80	145.41	444.14	488.99	**385.14**
Kolkata	129.87	126.17	179.38	33.04	175.26	185.11	**138.14**
Mumbai	536.16	120.59	200.41	88.60	478.20	600.27	**337.37**
Andhra Pradesh	341.92	204.20	214.19	132.48	279.28	298.53	**245.10**
Gujarat	291.82	182.14	151.94	90.27	281.15	292.11	**214.91**
Karnataka	282.36	160.33	174.27	111.19	191.24	116.63	**172.67**
Maharashtra	379.62	192.75	181.19	145.18	342.09	390.55	**271.90**
Tamilnadu	347.29	215.38	182.72	108.90	243.74	107.00	**200.84**
Haryana	60.64	61.38	58.35	28.22	78.22	60.99	**57.97**
Kerala	90.90	69.78	80.61	47.11	107.94	101.65	**83.00**
Madhya Pradesh	124.07	202.94	199.31	24.31	101.52	101.65	**125.63**
Punjab	71.17	106.30	87.21	61.82	103.56	94.16	**87.37**
Rajasthan	100.59	134.03	130.54	67.58	102.11		**106.97**
U. P. (East)	115.90	149.58	140.86	72.06	138.41	163.71	**130.09**
U.P. (West)	102.64	140.45	181.99	63.32	133.23	123.05	**124.11**
West Bengal	92.19	109.13	116.52	49.25	69.69	56.71	**82.25**
Assam	33.64	45.18	67.68	28.92	47.56	49.22	**45.37**
Bihar	102.94	141.22	199.59	90.79	72.08	94.16	**116.80**
Himachal Pradesh	17.99	16.15	31.11	11.05	28.26	19.26	**20.64**
Jammu & Kashmir	15.70	35.49	47.04	14.08	25.59	18.19	**26.02**
North East	17.54	25.13	38.74	19.45	26.45	18.19	**24.25**
Orissa	50.58	58.31	98.82	25.02	39.40	28.89	**50.17**

Annexure 3.7

VALUATION OF SPECTRUM IN 900 MHz BAND: PREMIUM BASED ON ECONOMIC EFFICIENCY (ECONOMIC PREMIUM MODEL)

A. Introduction

1. The spectrum in 900 MHz band is more technically efficient as compared to the spectrum in 1800 MHz band on technical parameters and propagation characteristics. The technical efficiency of the spectrum in 900 MHz band leads to economic efficiency in comparison to the spectrum in 1800 MHz band in the form of lesser expenditure on radio network.

2. The present method derives a relative valuation of the spectrum in 900 MHz band from the valuation of spectrum in 1800 MHz band by estimating the saving in the expenditure (CAPEX and OPEX) on radio network when the spectrum in the technically more efficient 900 MHz band is used in place of the spectrum in the technically less efficient 1800 MHz band. The additional cost per MHz to a telecom service provider (TSP) operating in the 1800 MHz band represents the saving to the TSP if it switches operations to the 900 MHz band. This saving may be viewed as the premium that a TSP would be willing to pay for acquiring spectrum in 900 MHz band *vis-a-vis* the spectrum in 1800 MHz band. Other things being equal, the maximum price that a TSP may pay for 1 MHz of spectrum in 900 MHz band would be equal to the price of 1 MHz of spectrum in 1800 MHz band plus the expenditure (CAPEX and OPEX) on the radio network that the TSP saves by using the spectrum in 900 MHz band instead of the spectrum in 1800 MHz band, i.e.

$$\mathbf{V_{900\ MHZ} \leq V_{1800\ MHz} + \Delta\ CAPEX + \Delta\ OPEX}$$

B. Methodology

3. At present, the 4th generation (4G) networks cater to the most of mobile traffic in the country. Accordingly, the premium per 1 MHz of spectrum in 900 MHz band over 1 MHz of spectrum in 1800 MHz band has been estimated for an average operator offering 4G network based mobile services in the country.

4. Through the Production Function model (a model for valuation of spectrum in 1800 MHz band), the number of 4G base stations in 1800 MHz band required by an average TSP in the next 20 years (from F.Y. 2022-23 to F.Y. 2041-42) has been estimated. For details of the Production Function model, please refer to the Annexure 3.3 of these Recommendations. In the present model, the number of 4G base stations in 1800 MHz band deployed by an average TSP for each year in the next 20 years (from F.Y. 2022-23 to F.Y. 2041-42) has been assumed to be the same as that considered in the Production Function model.

5. The additional expenditure (CAPEX and OPEX) per MHz while operating in the 1800 MHz band as compared to the 900 MHz for the next 20 years (beginning with the Financial Year 2022-23) has been worked out for each LSA separately based on the following assumptions:

   (a) Since disaggregation of the number of 4G base stations into urban and rural base stations is not available, the following percentages have been used for the LSAs in each category to determine the number of urban 4G base stations and number of rural 4G base stations:

Category	**Percent urban 4G base stations**	**Percent rural 4G base stations**
Metro	100%	0%
Category-A	70%	30%
Category-B	60%	40%
Category-C	60%	40%

(b) After shifting from 900 MHz band to 1800 MHz band, the number of 4G base stations would have to be increased by 25% in urban areas and by 100% in rural areas. The additional requirement of 4G base stations in urban areas would be comparatively lower than that in rural areas as there is a concentration of population in urban areas and 4G base stations have already been installed at comparatively close distances.

(c) The Capital Cost (Gross Block) as on 31.03.2021 per 4G Base Station has been estimated on the basis of the Accounting Separation Report (ASR) for the financial year (F.Y.) 2020-21. The annual operating cost per 4G Base Station for the F.Y. 2020-21 in the Metro LSAs has been taken as Rs. 6 lakh, and for the LSAs of the category-A, B and C, it has been taken as Rs. 4.32 lakh. Further, the capital cost per 4G base station has been assumed to be reducing by 5% year-on-year (Y-o-Y) and annual operating cost per 4G base station has been assumed to be increasing by 1% on Y-o-Y basis for the next 20 years. Useful Life of 4G Base station equipment has been taken as 10 years.

(d) Straight line depreciation @10% per year and prevalent cost of capital @15% have been applied to estimate annualized CAPEX of the additional 4G base stations.

(e) Estimation of the additional expenditure (CAPEX and OPEX) has been carried out for a period of 20 years (from F.Y. 2022-23 to F.Y. 2041-42) and the net present value (NPV) of the additional expenditure over a period of 20 years has been computed using a discounting rate of 12.5%.

(f) For the purpose of estimating additional expenditure per MHz in 1800 MHz band, the total additional expenditure so obtained has been divided by the equivalent 4G spectrum holding of the average TSP in 1800 MHz band as obtained in the Production Function model.

6. Based on the above assumptions, the additional expenditure per MHz to an average TSP operating in 1800 MHz band as compared to 900 MHz band has been estimated for each LSA. This additional expenditure per MHz may be termed as 'per MHz economic premium of 900 MHz band over 1800 MHz band for a period of 20 years'. After adding the per MHz economic premium of 900 MHz band over 1800 MHz band to the average valuation per MHz of 1800 MHz band, the valuation per MHz of 900 MHz band has been obtained as below:

Valuation per MHz of 900 MHz band for a period of 20 years through the Economic Premium model
= (Average valuation per MHz of 1800 MHz band for a period of 20 years) *plus* *(Per MHz economic premium of 900 MHz band over 1800 MHz band for a period of 20 years)*

Annexure 3.8

VALUATION (PER MHz) USING DIFFERENT APPROACHES - 900 MHz BAND (20 YEARS)

(Rs. in crore)

LSA	Auction determined price of March 2021 of 900 MHz band (duly indexed)	2 times of average valuation of 1800 MHz band	1.5 times of average valuation of 1800 MHz band	Technical Efficiency (Equal to average valuation of 800 MHz band)	Economic efficiency over 1800 MHz band plus average valuation of 1800 MHz band	Average (mean) Value
Delhi		770.28	577.71	683.99	459.53	**622.88**
Kolkata		276.28	207.21	218.01	171.59	**218.27**
Mumbai		674.74	506.06	668.15	374.75	**555.92**
Andhra Pradesh		490.20	367.65	417.32	371.52	**411.67**
Gujarat	399.11	429.81	322.36	374.53	304.58	**366.08**
Karnataka		345.34	259.01	283.49	275.53	**290.84**
Maharashtra		543.79	407.84	482.47	378.84	**453.24**
Tamilnadu	251.45	401.68	301.26	321.10	308.68	**316.83**
Haryana		115.93	86.95	87.96	95.96	**96.70**
Kerala	212.93	165.99	124.50	147.36	135.49	**157.26**
Madhya Pradesh		251.27	188.45	194.33	255.44	**222.37**
Punjab		174.74	131.05	144.90	144.16	**148.71**
Rajasthan		213.94	160.46	202.74	191.98	**192.28**
U. P. (East)	280.34	260.18	195.13	229.01	221.82	**237.30**
U.P. (West)		248.22	186.17	190.36	242.63	**216.85**
West Bengal	132.68	164.50	123.37	127.02	158.14	**141.14**
Assam		90.73	68.05	71.67	89.44	**79.97**
Bihar	215.07	233.59	175.19	180.47	246.78	**210.22**
Himachal Pradesh	39.59	41.28	30.96	31.81	40.89	**36.90**
Jammu & Kashmir		52.03	39.02	39.49	56.65	**46.80**
North East	24.61	48.50	36.37	38.24	49.47	**39.44**
Orissa	92.02	100.34	75.25	76.60	114.53	**91.75**

Annexure 3.9

VALUATION (PER MHz) USING DIFFERENT APPROACHES – 800 MHz BAND (20 YEARS)

(Rs. in crore)

LSA	Auction determined price – March 2021 auction of 800 MHz (duly indexed)	2 times of average valuation of 1800 MHz band	1.5 times of average valuation of 1800 MHz band	Multiple Regression	Average (mean) Value
Delhi	684.80	770.28	577.71	703.17	**683.99**
Kolkata	171.20	276.28	207.21	217.36	**218.01**
Mumbai	777.89	674.74	506.06	713.89	**668.15**
Andhra Pradesh	417.30	490.20	367.65	394.11	**417.32**
Gujarat	411.95	429.81	322.36	334.01	**374.53**
Karnataka	205.44	345.34	259.01	324.18	**283.49**
Maharashtra	545.70	543.79	407.84	432.54	**482.47**
Tamilnadu	186.18	401.68	301.26	395.27	**321.10**
Haryana	60.99	115.93	86.95	87.96	**87.96**
Kerala	167.99	165.99	124.50	130.98	**147.36**
Madhya Pradesh	153.01	251.27	188.45	184.58	**194.33**
Punjab	167.99	174.74	131.05	105.83	**144.90**
Rajasthan	284.62	213.94	160.46	151.93	**202.74**
U. P. (East)	268.57	260.18	195.13	192.15	**229.01**
U.P. (West)	172.27	248.22	186.17	154.78	**190.36**
West Bengal	79.18	164.50	123.37	141.03	**127.02**
Assam		90.73	68.05	56.22	**71.67**
Bihar	145.52	233.59	175.19	167.60	**180.47**
Himachal Pradesh	25.68	41.28	30.96	29.33	**31.81**
Jammu & Kashmir		52.03	39.02	27.43	**39.49**
North East		48.50	36.37	29.84	**38.24**
Orissa	50.29	100.34	75.25	80.50	**76.60**

Annexure 3.10

VALUATION (PER MHz) USING DIFFERENT APPROACHES – 2100 MHz BAND (20 YEARS)

(Rs. in crore)

LSA	Auction Determined Price-March 2021 (duly indexed) of 2100 MHz	0.83 times of average valuation of 1800 MHz band	Average (mean) Value
Delhi		319.67	**319.67**
Kolkata		114.66	**114.66**
Mumbai		280.02	**280.02**
Andhra Pradesh		203.43	**203.43**
Gujarat		178.37	**178.37**
Karnataka		143.32	**143.32**
Maharashtra		225.67	**225.67**
Haryana		48.11	**48.11**
Kerala		68.89	**68.89**
Madhya Pradesh		104.27	**104.27**
Punjab		72.52	**72.52**
U.P. (West)		103.01	**103.01**
West Bengal	37.45	68.27	**52.86**
Assam	32.10	37.65	**34.88**
Bihar		96.94	**96.94**
Himachal Pradesh		17.13	**17.13**
Jammu & Kashmir		21.59	**21.59**
North East	6.42	20.13	**13.27**
Orissa		41.64	**41.64**

Annexure 3.11

VALUATION (PER MHz) USING DIFFERENT APPROACHES – 2300 MHz BAND (20 YEARS)

(Rs. in crore)

LSA	Technical efficiency of 2300 MHz band (TDD) with respect to the spectrum in 1800 MHz band (FDD)	Auction Determined Price-March 2021 (duly indexed) of 2300 MHz	Multiple Regression Model	Trend line Model	Average (mean) Value
Delhi	96.29	175.48	164.42	160.06	**149.06**
Kolkata	34.54	40.66	55.89	52.76	**45.96**
Mumbai	84.34	178.69	163.00	162.92	**147.24**
Andhra Pradesh	61.28	83.46	103.17	86.81	**83.68**
Gujarat	53.73	74.90	86.44	74.33	**72.35**
Karnataka	43.17	119.84	84.01	116.09	**90.78**
Maharashtra	67.97	77.04	112.64	80.65	**84.58**
Tamilnadu	50.21	161.57	102.22	149.20	**115.80**
Punjab	21.84	22.47	7.14	20.63	**18.02**
Bihar	29.20	7.49	12.34	6.42	**13.86**
Himachal Pradesh	5.16	1.07	2.03	1.39	**2.41**
Jammu & Kashmir	6.50	1.07	2.00	1.43	**2.75**

* Spectrum in 2300 MHz band is not available in Gujarat, Maharashtra, Punjab, Bihar, Himachal Pradesh and Jammu & Kashmir. However, average value per MHz for these LSAs have been included in the table since there is linkage with 2500 MHz spectrum band.

Annexure 3.12

VALUATION (PER MHz) USING DIFFERENT APPROACHES – 2500 MHz BAND (20 YEARS)

(Rs. in crore)

LSA	Technical efficiency of 2500 MHz band (TDD) with respect to the spectrum in 1800 MHz band (FDD)	Technical Efficiency with respect to 2300 MHz band (Equal to average valuation of 2300 MHz band)	Average (mean) Value
Delhi	96.29	149.06	**122.67**
Kolkata	34.54	45.96	**40.25**
Mumbai	84.34	147.24	**115.79**
Andhra Pradesh	61.28	83.68	**72.48**
Gujarat	53.73	72.35	**63.04**
Karnataka	43.17	90.78	**66.97**
Maharashtra	67.97	84.58	**76.28**
Tamilnadu	50.21	115.80	**83.00**
Punjab	21.84	18.02	**19.93**
Bihar	29.20	13.86	**21.53**
Himachal Pradesh	5.16	2.41	**3.79**
Jammu & Kashmir	6.50	2.75	**4.63**

Annexure 3.13

VALUATION (PER MHz) USING DIFFERENT APPROACHES – 700 MHz BAND (20 YEARS)

(Rs. in crore)

LSA	Two times of average valuation of 1800 MHz band	Equal to average valuation of 800 MHz band	Average (mean) Value
Delhi	770.28	683.99	**727.14**
Kolkata	276.28	218.01	**247.15**
Mumbai	674.74	668.15	**671.44**
Andhra Pradesh	490.20	417.32	**453.76**
Gujarat	429.81	374.53	**402.17**
Karnataka	345.34	283.49	**314.42**
Maharashtra	543.79	482.47	**513.13**
Tamilnadu	401.68	321.10	**361.39**
Haryana	115.93	87.96	**101.95**
Kerala	165.99	147.36	**156.68**
Madhya Pradesh	251.27	194.33	**222.80**
Punjab	174.74	144.90	**159.82**
Rajasthan	213.94	202.74	**208.34**
U. P. (East)	260.18	229.01	**244.59**
U.P. (West)	248.22	190.36	**219.29**
West Bengal	164.50	127.02	**145.76**
Assam	90.73	71.67	**81.20**
Bihar	233.59	180.47	**207.03**
Himachal Pradesh	41.28	31.81	**36.54**
Jammu & Kashmir	52.03	39.49	**45.76**
North East	48.50	38.24	**43.37**
Orissa	100.34	76.60	**88.47**

Annexure 3.14

VALUATION (PER MHz) OF 600 MHz BAND (20 YEARS)

(Rs. in crore)

LSA	**Value per MHz of 600 MHz Band** **(Equal to the average value of 700 MHz band)**
Delhi	**727.14**
Kolkata	**247.15**
Mumbai	**671.44**
Andhra Pradesh	**453.76**
Gujarat	**402.17**
Karnataka	**314.42**
Maharashtra	**513.13**
Tamilnadu	**361.39**
Haryana	**101.95**
Kerala	**156.68**
Madhya Pradesh	**222.80**
Punjab	**159.82**
Rajasthan	**208.34**
U. P. (East)	**244.59**
U.P. (West)	**219.29**
West Bengal	**145.76**
Assam	**81.20**
Bihar	**207.03**
Himachal Pradesh	**36.54**
Jammu & Kashmir	**45.76**
North East	**43.37**
Orissa	**88.47**

Annexure 3.15

VALUATION PER MHz

IN THE 3300-3670 MHz BAND (TDD) (20 years)

(Rs. in crore)

LSA	Value per MHz of 3300-3670 MHz band TDD (Using technical efficiency of 3300-3670 MHz band TDD w.r.t. 1800 MHz band FDD)
Delhi	57.77
Kolkata	20.72
Mumbai	50.61
Andhra Pradesh	36.77
Gujarat	32.24
Karnataka	25.90
Maharashtra	40.78
Tamilnadu	30.13
Haryana	8.70
Kerala	12.45
Madhya Pradesh	18.84
Punjab	13.11
Rajasthan	16.05
U. P. (East)	19.51
U.P. (West)	18.62
West Bengal	12.34
Assam	6.80
Bihar	17.52
Himachal Pradesh	3.10
Jammu & Kashmir	3.90
North East	3.64
Orissa	7.53

Annexure 3.16

VALUATION PER MHz

IN THE 24.25 GHz – 28.5 GHz Band (TDD) (20 years)

(in Rs.)

LSA	Value per MHz of 24.25 GHz – 28.5 GHz Band (2.20% of the value of 3300 - 3670 MHz band)
Delhi	**127.10 lakh**
Kolkata	**45.59 lakh**
Mumbai	**111.33 lakh**
Andhra Pradesh	**80.88 lakh**
Gujarat	**70.92 lakh**
Karnataka	**56.98 lakh**
Maharashtra	**89.73 lakh**
Tamilnadu	**66.28 lakh**
Haryana	**19.13 lakh**
Kerala	**27.39 lakh**
Madhya Pradesh	**41.46 lakh**
Punjab	**28.83 lakh**
Rajasthan	**35.30 lakh**
U. P. (East)	**42.93 lakh**
U.P. (West)	**40.96 lakh**
West Bengal	**27.14 lakh**
Assam	**14.97 lakh**
Bihar	**38.54 lakh**
Himachal Pradesh	**6.81 lakh**
Jammu & Kashmir	**8.58 lakh**
North East	**8.00 lakh**
Orissa	**16.56 lakh**