भारतीय दूरसंचार विनियामक प्राधिकरण

Telecom Regulatory Authority of India

Recommendations on Assignment of Additional Spectrum to Indian Railways for its Safety and Security Applications

New Delhi, India

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CHAPTER I: INTRODUCTION

A. DoT's Reference Dated 26.07.2023

1.1 The Department of Telecommunications (DoT), Ministry of Communications, Government of India, through its letter No. L-14001/13/2023-IMT dated 26.07.2023 **(Annexure-I)**, sent a reference to Telecom Regulatory Authority of India (hereinafter also referred to as "TRAI", or "the Authority") for seeking recommendations on allotment of additional spectrum to Indian Railways for its safety and security applications in the 700 MHz band. The relevant extract of afore-mentioned letter dated 26.07.2023 is reproduced below:

"This is to inform that Indian Railways has requested for additional 5 MHz of paired spectrum in the 700 MHz band to be allocated free of cost for enhancing its safety and security systems (Annexure - I).

2. Based on an earlier request from Indian Railways, the recommendations of TRAI were sought in the matter and TRAI provided its recommendations on this subject on 25-10-2019.

2.1. Later, based on the approval of Cabinet, Indian Railways was assigned 5 MHz of paired spectrum in the 700 MHz band on 22-10-2021 (Annexure - II). IR was also intimated about the withdrawal of its GSM-R spectrum holding in the 900 MHz band in 14 LSAs, upon migration to LTE based network. The Indian Railways is yet to confirm the migration to the LTE based network.

3. Meanwhile, the request of National Capital Region Transport Corporation (NCRTC) for 5 MHz of paired spectrum in the 700 MHz was also considered in the Department. Subsequently, the TRAI recommendations were sought and based on the recommendations dated 28-12-2022, DoT provisionally assigned 5 MHz of paired spectrum to NCRTC and the roll out of the LTE network is under

process. The assignment of spectrum to NCRTC shall be regularized after the approval of the Union Cabinet.

4. Recently, based on the request from BSNL, the Cabinet has approved the reserving of paired spectrum in 700 MHz band in lieu of the 10 MHz of paired spectrum already reserved in the 600 MHz band. After considering this request of BSNL, only 5 MHz of paired spectrum is presently available as vacant spectrum in the 700 MHz band. The present spectrum holding of the various TSPs/ users in the 700 MHz band is placed at Annexure-III.

5. Recently, the Indian Railways has sought additional 5 MHz of paired spectrum, free of cost, in the 700 MHz band citing the following points –

(i) IR's indigenous development of Radio based Train Collision Avoidance System (TCAS) Kavach became successful. Radio based TCAS shall be the IR's ATP instead of ETCS level 2. Hence It is requested that Railways be allotted additional 5 MHz spectrum for design optimization of the network, when IR implements LTE network in 700 MHz band for safety & security applications.

(ii) The recent Balasore incident has shown that for the purpose of safety, it is important to capture large scale data & videos from moving trains on a real time basis. Dumping at a stopping station, which has high-capacity WiFi, shall not serve the objective. Further, during exigencies, the TSP's network gets choked thereby adversely affecting the relief and restoration operations.

(iii) When Railways implements its LTE network & Kavach over LTE, it shall surrender frequencies in the 146-174 MHz presently being used for driver-guard & driver/ guard to station communication as well as in the 400 MHz band being used for Kavach and consolidate all its requirements in 700 MHz band provided adequate bandwidth is available.

(iv) Utilization of this spectrum by other users can be done provided the same does not cause any interference to the network of IR.

6. Further, as per the TRAI recommendations on assignment of spectrum to Indian Railways, 5 MHz of paired spectrum has been assigned to Indian Railways on administrative basis and spectrum charges are to be paid annually on the formula basis similar to other captive users. However, for NCRTC, TRAI has recommended to levy .5 times the Auction Determined Price based on the area of LSA and on pro rata basis for the assignment of spectrum for a period of 10 years. Thus, the per km spectrum charges for NCRTC shall vary from LSA to LSA based on the Auction Determined Price (ADP), whereas for IR charges are fixed irrespective of the LSA. An indicative calculation sheet highlighting the difference in spectrum charging across each LSA is attached herewith (Annexure -IV).

6.1 From the above it is evident that spectrum charges for NCRTC is many fold greater than that of IR in the LSAs having more ADP, whereas in some LSAs where ADP is less and LSA area is more, spectrum charges for IR is many fold greater than that of NCRTC. Hence TRAI may be requested to recommend a uniform spectrum valuation and charging methodology considering similar usages in the same spectrum band.

7. In view of the above, TRAI is requested to examine and provide its recommendations on –

(i) the assignment of 5 MHz of additional spectrum to Indian Railways in view of its earlier recommendations dated 25-10-2019 and also in the context of its earlier recommendations with respect to NCRTC dated 28-12-2022 and auction of spectrum dated 11-04-2022.

(ii) While providing the recommendations, TRAI may also consider the possibility of sharing of the spectrum between IR/ NCRTC/ RRTS/ Metro and other similar networks to ensure the efficient utilization of spectrum.

(iii) Considering the different spectrum valuation methodology as recommended by TRAI for the 5 MHz of paired spectrum in the 700 MHz band, assigned to Indian Railways and for NCRTC, TRAI may examine and if found necessary recommend a uniform spectrum valuation and

charging methodology considering similar usages in the same spectrum band.

(iv) Any other recommendations deemed fit for the purpose.

B. Background

(1) Allotment of Spectrum to Indian Railways Based on the TRAI's Recommendations Dated 25.10.2019

1.2 In the year 2019, through the reference letter No. L-14001/01/2019-NTG dated 27.02.2019, DoT requested TRAI to provide recommendations on administrative allotment of spectrum to Indian Railways for public safety and security services at stations and in the trains and the quantum, price, appropriate frequency band (including 450-470 MHz band) and any other related issue. Through the said reference letter dated 27.02.2019, DoT informed, *inter-alia*, as below:

(a) Indian Railways uses a GSM-R based network like various railway networks deployed around the world. 1.6 MHz (paired) spectrum in 900 MHz band has been assigned to Indian Railways on an administrative basis for captive usage of their GSM-R based network.

(b) Indian Railways has proposed to install an ultra-high-speed Long Term Evolution (LTE) based communication corridor along its rail network for train-ground and train-train communication. The Ministry of Railways had requested DoT to reserve 15 MHz of spectrum in 700 MHz band for this purpose and to begin with, 10 MHz to be allocated, free of cost, as the proposal is devoid of any commercial gain, but only for enhancing security and passenger amenities.

1.3 After consultation with stakeholders on the subject, TRAI, on 25.10.2019[1], sent the following recommendations to DoT on 'allotment of spectrum to Indian Railways for public safety and security services':

Para 3.1:

(a) Out of the 35 MHz (paired) spectrum available in 700 MHz band, 5 MHz (paired) spectrum may be allocated to Indian Railways for implementing ETCS Level-2, MC PTT + Voice, IoT based asset monitoring services, passenger information display system and live feed of Video Surveillance of few coaches at a time. The remaining 30 MHz (paired) in 700 MHz band may be put to auction in the forthcoming auction.

(b) To implement the Video Surveillance System for all coaches of the Train (Security services), Indian Railways may explore other communications means such as-

(i) Dumping the Video Surveillance data to the system using high capacity WiFi when the train reaches a station.

(ii) Using Public Telecommunication Network (TSPs network) for sending continuous video surveillance data streams to its control center.

(c) Efficient and timely utilization of spectrum be ensured through a process of periodical monitoring. Further, the 1.6 MHz spectrum already assigned to IR in 900 MHz band may be taken back from IR upon migration to LTE based network.

(d) As Indian Railways would be using the assigned spectrum along its railway track network and stations only, DoT may explore the possibility of assigning the same spectrum in other areas for area-specific limited use to other entities for captive use. However, it should be ensured that there is no interference to the Railways' network from such use."

[1] TRAI's recommendations dated 25.10.2019 are available at the following URL: https://www.trai.gov.in/sites/default/files/Recommendations_25102019.pdf

Para 3.2:

"(a) Spectrum may be assigned to Indian Railways on administrative basis for captive use only and not to offer any commercial services such as Wi-Fi onboard.

(b) Spectrum charges may be levied based on formula basis as prescribed by DoT for Royalty Charges and License Fee for captive use."

1.4 After considering the afore-mentioned recommendations dated 25.12.2019, DoT, through a letter dated 22.10.2021, assigned 5 MHz (paired) spectrum in 700 MHz band to Indian Railways for Public Safety and Security Services for captive use, with the following conditions:

"(i) This spectrum assignment is being made for captive use along the Railway track only and not to offer any Commercial Services such as Internet/Wi-Fi onboard.

(ii) Annual spectrum charges for this assignment will be levied based on formula as prescribed by WPC Wing, DoT, from time to time for Royalty Charges and License Fee for Captive usages. Addition of new base stations and mobile terminals shall be intimated by Indian Railways without any delay.

(iii) Efficient and timely utilization of spectrum will be ensured by Railways through a process of periodical monitoring.

(iv) The 1.6 MHz (paired) spectrum already assigned to Indian Railways in 900 MHz band will be taken back from Indian Railways upon migration to LTE based network.

(v) As Indian Railways would be using the assigned spectrum along its railway track network and stations only, DoT may consider assigning the same spectrum in other areas for area-specific limited use to other entities for captive use. However, it will be ensured that there is no interference to the Railways' network from such use.

(vi) Applicable procedures for Letter of Intent (LoI), Decision Letter (DL), SACFA clearance and Wireless Operating License (WOL), as being followed for

GSM-R network, shall be followed by Indian Railways for all the base/mobile stations.

(vii)Operations should not commence without obtaining Wireless Operating License (WOL) for the network as per applicable procedure.

(viii) Connection of this network to Public Switched Telecom Network (PSTN) shall not be allowed."

1.5 Subsequently, through the letter No. 2020/Tele/WL/2 Misc. dated 03.11.2021 Indian Railways informed DoT that it was utilizing 1.6 MHz (paired) spectrum in 900 MHz band for Mobile Train Radio Communication (MTRC) for operational, safety and maintenance requirements which was rolled out in six railway zones only. Through the said letter dated 03.11.2021, Indian Railways also surrendered 1.6 MHz paired spectrum in 900 MHz band in States/ Union Territories where GSM-R based MTRC was not rolled out. The surrender of spectrum resulted in the availability of an additional 1.6 MHz (paired) spectrum for commercial use in seven LSAs namely Andhra Pradesh, Himachal Pradesh, Karnataka, Kerala, North East, Orissa, Tamil Nadu LSAs.

(2) Allotment of Spectrum to NCRTC Based on TRAI's Recommendations Dated 28.12.2022

1.6 In the year 2021, DoT sent the reference letter No. L-14001/01/2019-NTG (Pt.) dated 29.11.2021 to TRAI, and informed, *inter-alia*, as below:

"2. …, NCRTC has requested DoT for allotment of spectrum for Regional Rapid Transit System (RRTS) being implemented by them in 8 corridors including 3 rail corridors of approximate length of 350 km along Delhi-Ghaziabad-Meerut, Delhi-Gurugram-Alwar, Delhi-Panipat in Phase-I.

…

4. As in the case of Indian Railways, NCRTC also carries passengers and spectrum will be used for mission critical safety applications of signaling

and train control. Separate spectrum is required since the services involve safety of life."

1.7 Through the afore-mentioned reference letter dated 29.11.2021, DoT requested TRAI to provide recommendations on administrative assignment of spectrum to NCRTC and the quantum, pricing/ charging thereof and any other terms and conditions, for separate spectrum requirements of NCRTC in 700 MHz band; and any other recommendations deemed fit for the purpose, including assignment of the same spectrum for other RRTS/ Metro rail network pan-India.

1.8 In this regard, after consultation with stakeholders, TRAI sent the Recommendations on 'Spectrum Requirements of National Capital Region Transport Corporation (NCRTC) for Train Control System for RRTS corridors' on 28.12.2022[2] to DoT. TRAI made, *inter-alia*, the following recommendations:

Para 3.1:

"5 MHz (paired) spectrum in 700 MHz band be assigned to NCRTC for use in RRTS corridors along the railway tracks. The frequency spectrum to be assigned to NCRTC, shall be adjacent to the frequency spectrum assigned to Indian Railways in 700 MHz band."

Para 3.2:

"(a) The frequency spectrum assigned to NCRTC may also be assigned to other RRTS/ Metro rail networks, which are geographically separated and not likely to cause any interference to one another.

(b) While assigning frequency spectrum to NCRTC and other RRTS/ Metro rail networks, which are geographically separated, it should be included in the terms and conditions that the same frequency spectrum may be assigned

[2] TRAI's recommendations dated 28.12.2022 are available at the following URL: https://www.trai.gov.in/sites/default/files/Recommendation_28122022.pdf

to other RRTS/ Metro rail networks or any other users on non-interference basis.

(c) To ascertain the feasibility of assigning the same frequency spectrum (assigned to NCRTC and other RRTS/ Metro rail network) to the telecom service providers on non-interference basis, a field trial may be conducted involving the Ministry of Railways and the telecom service providers, under the supervision of DoT. Based on the outcome of the field trial, further modalities of assignment of the same frequency spectrum to the telecom service providers on non-interference basis may be worked out.

(d) Efficient and timely utilization of frequency spectrum should be ensured through a process of periodical monitoring."

Para 3.3:

"(a) For an upcoming RRTS/ Metro rail network, a part of which overlaps with NCRTC, or any other RRTS/ Metro rail networks to whom the same frequency spectrum has already been assigned, the same frequency spectrum may be assigned to such RRTS/ Metro rail network in the non-overlapping part of the network. For the overlapping part of the network, the frequency spectrum already assigned to IR may be assigned to such RRTS/ Metro rail network subject to non-interference to IR.

(b) To ascertain feasibility of RAN sharing, a field trial of RAN sharing through MOCN may be conducted by the Ministry of Railways involving IR and NCRTC, under the supervision of DoT. Based on the outcome of the field trial, a decision on implementation of RAN sharing through MOCN for the overlapping areas, can be taken.

(c) While assigning the frequency spectrum to NCRTC and other RRTS/ Metro rail networks, the terms of frequency spectrum assignment should include a condition that in case it is determined through field trial that RAN sharing is feasible,

(i) the same frequency spectrum may be assigned to other RRTS/ Metro rail networks in the same geographic area on a sharing basis.

(ii) The RRTS/ Metro rail networks shall implement RAN sharing through MOCN in the overlapping areas and the same shall be governed through the guidelines issued by DoT. The guidelines for RAN sharing through MOCN should include the process and timelines for entering into the RAN sharing arrangement.

(iii) The commercial arrangement for RAN sharing through MOCN should be left to the RRTS/ Metro rail networks.

(d) As the Ministry of Railway is the nodal Ministry for Rail Networks, the responsibility of creation of SOP and its adherence by the RRTS/ Metro rail networks, should be entrusted with the Ministry of Railways. SOP should be created in consultation with DoT."

Para 3.5:

"(a) The Auction Determined Price for 10 years allocation should be equal to 0.5 times (half times) the Auction Determined Price discovered in the latest 2022 Auction for 700 MHz spectrum band for the respective LSA.

(b) The spectrum charges should be calculated using following formula: -

Total Payment for 5MHz = $\sum_{i=1}^{n} \left(\frac{Ti*2*P}{ARi}\right) * ADPi$

where n is number of LSAs through which the RRTS/ Metro rail network passes

Ti is track length in LSAi

P is the Minimum Protection Width along one side of the track center. Multiplying it by 2 will give the Total Protection Width along both sides from the RRTS track center

ARi is area of LSAi

ADPi is ADP of 5MHz for 10 years in LSAi

The Minimum Protection Width should be determined by DoT by undertaking a Proof of Concept (PoC) study. However, the spectrum for setting up LTE network may immediately be allotted to NCRTC, considering 2.5 Km Minimum Protection Width on each side of the track. In case of any change in Minimum Protection Width determined by DoT, the difference in amount may be adjusted at a later date.

(c) For other RRTS/ Metro rail networks, a similar methodology should be adopted, as in the case of NCRTC. The latest Auction Determined Price (less than one year old) of 700 MHz spectrum band may be used as a base for calculating spectrum charges. In case ADP is not available for the current year, the last discovered ADP (in case the ADP is more than a year old) may be duly indexed using applicable MCLR. For existing RRTS/ Metro rail network, in case of future spectrum requirement in other LSAs and/or in case of change in track length in existing LSAs, the ADP may be adjusted in a similar manner as discussed above in para 2.78. Moreover, it must be noted that the permission/ license for CNPN will be granted for a period of 10 years, accordingly, the validity of the spectrum assigned to NCRTC will be 10 years from the date of initial assignment. Thus, the validity for spectrum assigned in new LSAs, or the same assigned to the new track lengths in existing LSAs, will be co-terminus with the validity of the initial spectrum assignment. However, the base ADP in this case will be adjusted for the remaining time period/ validity."

Para 3.6:

"

(a) NCRTC shall make the payment in accordance with any of the following two options:

Option 1: Full or part upfront payment of the final amount for 10 years within 10 days of declaration of assignment price.

Where part upfront payment has been made, NCRTC shall have the option of availing moratorium for the corresponding 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, payable in advance at the beginning of each year, after the period of moratorium if any, duly protecting the Net Present Value (NPV) of the total amount at the applicable rate of interest. The annual instalments shall become due and payable on the same date of each following year.

Option 2: Payment of 10 equal annual instalments of the total amount, duly protecting the NPV of the total 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 assignment price. The balance 9 instalments shall become due and payable on the same date of each following year.

(b) For other RRTS/ Metro Rail Networks, similar payment terms should be adopted."

1.9 Through the instant reference letter dated 26.07.2023, DoT has conveyed that "*based on the recommendations dated 28-12-2022, DoT provisionally assigned 5 MHz of paired spectrum to NCRTC and the roll out of the LTE network is under process. The assignment of spectrum to NCRTC will be regularized after the approval of the Union Cabinet.*"

1.10 As per the information available in the public domain, NCTRC commenced commercial operations[3] in the priority section of the Delhi-Ghaziabad-Meerut RRTS corridor on 21.10.2023.

C. Instant Reference

1.11 Through the DoT's reference dated 26.07.2023, TRAI has been requested to provide its recommendations on -

(a) Assignment of 5 MHz of additional spectrum to Indian Railways

(b) TRAI may also consider the possibility of sharing of the spectrum between Indian Railways/ NCRTC/ RRTS/ Metro and other similar networks to ensure the efficient utilization of spectrum.

(c) Considering the different spectrum valuation methodology as recommended by TRAI for the 5 MHz of paired spectrum in the 700 MHz band, assigned to Indian Railways and for NCRTC, TRAI may examine and

[3] Source: https://ncrtc.in/commercial-operations-of-indias-first-namo-bharat-train-kickstarts/

if found necessary recommend uniform spectrum valuation and charging methodology considering similar usage in the same spectrum band.

(d) Any other recommendations deemed fit for the purpose.

D. Consultation Process

1.12 In this regard, the Authority issued 'Consultation Paper on Assignment of Additional Spectrum to Indian Railways for its Safety and Security Applications' dated 07.02.2024[4] (hereinafter, also referred to as, "the CP dated 07.02.2024") for soliciting comments of stakeholders on the issues related to assignment of additional 5 MHz (paired) spectrum in the 700 MHz band to Indian Railways, aspects related to sharing of spectrum among Indian Railways/ NCRTC/ RRTS/ Metro and other similar networks, and spectrum valuation and charging methodology. The last date for submission of comments and counter comments was 06.03.2024 and 20.03.2024, respectively. In response to the CP dated 07.02.2024, the Authority received comments from eight stakeholders and counter comments from three stakeholders. The comments and counter comments received from stakeholders are available on TRAI's website. As a part of the consultation process, an open house discussion (OHD) was conducted on 03.05.2024 through online mode.

1.13 Based on the inputs received from stakeholders and its internal analysis, the Authority has finalized these recommendations. The recommendations comprise three chapters. This chapter provides an introduction and background to the subject. Chapter II discusses the issues, comments received from stakeholders, and presents an analysis based on which the recommendations have been framed. Chapter III provides a summary of the recommendations.

[4] https://www.trai.gov.in/sites/default/files/CP_07022024.pdf

CHAPTER II: EXAMINATION OF ISSUES

2.1 Through the CP dated 07.02.2024, the Authority solicited comments of stakeholders on the issues related to assignment of additional 5 MHz (paired) spectrum in the 700 MHz band to Indian Railways, aspects related to sharing of spectrum among Indian Railways/ NCRTC/ RRTS/ Metro and other similar networks, and spectrum valuation and charging methodology. Considering the comments received from stakeholders in the consultation process, an analysis of the issues is presented below.

A. The Request of Indian Railways for the Assignment of Additional 5 MHz (Paired) Spectrum in 700 MHz Band

2.2 Indian Railways (IR) is India's national railway system operated by the Ministry of Railways. The rail network of Indian Railways is spread over 68,000 route Kilometers. Radiocommunication for railway operations is considered as 'mission critical' for train operations and management of train emergency situations. The Railway Radiocommunication System between Train and Trackside (RSTT) provides improved railway traffic control, passenger safety and improved security for train operations.

2.3 In the year 2019, DoT sent a reference dated 27.02.2019 seeking recommendations of TRAI on administrative allotment of spectrum to Indian Railways for public safety and security services at stations and in trains, and the quantum, price, and appropriate frequency band (including 450-470 MHz band). After consultation with stakeholders on the subject, TRAI sent its recommendations on 'Allotment of spectrum to Indian Railways for public safety and security services' dated 25.10.2019[5]. After considering the above recommendations, DoT, on 22.10.2021, assigned 5 MHz (paired) spectrum in

[5] TRAI's recommendations dated 25.10.2019 are available at the following URL: https://www.trai.gov.in/sites/default/files/Recommendations_25102019.pdf

the 700 MHz band to Indian Railways for public safety and security services for captive use.

2.4 Thereafter, in the year 2021, DoT sent a reference letter dated 29.11.2021 for seeking TRAI's recommendations on the spectrum requirement of National Capital Region Transport Corporation (NCRTC) for their LTE technology based RRTS network. After consultation with stakeholders on the subject, TRAI sent its recommendations on 'spectrum requirements of National Capital Region Transport Corporation (NCRTC) for train control system for RRTS corridors' dated 28.12.2022[6]. Through the instant reference letter dated 26.07.2023, DoT has conveyed that DoT has provisionally assigned 5 MHz of paired spectrum to NCRTC. Subsequently, NCTRC commenced commercial operations[7] in the priority section of the Delhi-Ghaziabad-Meerut RRTS corridor on 21.10.2023.

2.5 Through the instant reference letter dated 26.07.2023, DoT informed that Indian Railways has sought an additional 5 MHz of paired spectrum in the 700 MHz band citing the following points:

(i) IR's indigenous development of Radio based Train Collision Avoidance System (TCAS) Kavach became successful. Radio based TCAS shall be the IR's ATP instead of ETCS level 2.

(ii) The recent Balasore incident has shown that for the purpose of safety, it is important to capture large scale data & videos from moving trains on a real time basis. Dumping at a stopping station, which has high-capacity Wi-Fi, shall not serve the objective. Further, during exigencies, the TSP's network gets choked thereby adversely affecting the relief and restoration operations.

(iii) When Railways implements its LTE network & Kavach over LTE, it shall surrender frequencies in the 146-174 MHz as well as in the 400 MHz band

[6] Source: https://www.trai.gov.in/sites/default/files/Recommendation_28122022.pdf
[7] Source: https://ncrtc.in/commercial-operations-of-indias-first-namo-bharat-train-kickstarts/

and consolidate all its requirements in 700 MHz band provided adequate bandwidth is available.

(iv) Utilization of this spectrum by other users can be done provided the same does not cause any interference to the network of IR."

2.6 In the earlier recommendations on 'allotment of spectrum to Indian Railways for public safety and security services' dated 25.10.2019, TRAI had made the following observations:

"2.46 Indian Railways envisages to use the spectrum for the following services:

(a) Safety Services: Signalling (ETCS Level-2) [consist of communication between On-Board Equipment and Trackside Equipment]

(b) Voice Communication: MCPTT communication and voice calling on-board train

(c) IoT Based Asset Reliability Monitoring

(d) Security Services: Video Surveillance (Live Feed) through CCTV Cameras in trains

…

2.50 In view of the above, 5 MHz (paired) spectrum in 700/ 800/ 900 MHz bands will be sufficient for Indian Railways for all its requirements other than continuous Video surveillance system, namely, ETCS level-2 (train control, Safety, signaling etc.), MCPTT + Voice & IoT based asset monitoring. Though, 5 MHz spectrum may not be sufficient for continuous live feed of CCTV for video surveillance system, it will provide an uplink capability of 12 Mbps to 18 Mbps. Therefore, the Indian railways will be able to send live feed of CCTV Surveillance Cameras for two to three coaches at a time using the same 5 MHz (paired) spectrum, as the upload data rate requirement for video surveillance for a single coach is around 6 Mbps. The Video Surveillances data can be stored on-board and can be sent periodically/sequentially as per need. Further, the data rate can be further enhanced by increasing the number of BTSs, using MIMO and

higher order modulation techniques [64 QAM]. It is further noted that 5 MHz (paired) spectrum is not available either in 800 MHz band or 900 MHz band on pan-India basis.

…

2.58 In view of the foregoing discussion, the Authority is of the view that 5 MHz (paired) spectrum in 700 MHz band may be allocated to Indian Railways for implementing ETCS Level-2, MC PTT + Voice, IoT based asset monitoring services, passenger information display system and live feed of Video Surveillance of few coaches at a time. To implement video surveillance of all coaches in the train, Indian Railways may explore other communications means such as:

(i) when the train reaches a station, high capacity WiFi system at Railway Stations can be used to transfer the video data dump to the system.

(ii) Use of public telecommunication network (TSP's network) for sending continuous video surveillance data streams to the Control Center."

2.7 With respect to the instant reference letter dated 26.07.2023, TRAI held discussions with the Indian Railways on 20.11.2023. During the discussions and through a subsequent email, the Indian Railways informed TRAI that it requires 10 MHz of paired spectrum in the 700 MHz band to cater to the updated data rate requirement as given below:

Table 2.1: Updated data rate requirement, as conveyed by Indian Railways

S. No.	Application	Bandwidth requirement in download	Bandwidth requirement in upload
1	KAVACH	100 Kbps	100 Kbps
2	MC PTT + Voice	660 + 1000 Kbps	660 + 1000 Kbps
3	IoT Services	2 Mbps	2 Mbps
4	Video Streaming	4 Mbps	50 Kbps
5	On Board Video Surveillance (minimum per Train) CCTV	200 Kbps	40 Mbps (8 x 25 = 200 x 200 = 40 Mbps)
6	Passenger information display system	100 Kbps	10 Kbps
7	EoTT & DPWCS	300 Kbps	300 Kbps
8	Data uses for other safety, security & train operations applications	4.7 Mbps	1.7 Mbps
	Total Requirement	**13.060 Mbps**	**45.820 Mbps**

2.8 During the discussions, Indian Railways informed that for the purpose of safety, it is important to capture large scale data and videos from moving trains on a real time basis, for which, (a) dumping at a stopping station, which has high-capacity Wi-Fi, does not serve the objective and (b) during exigencies, networks of telecom service providers get choked thereby adversely affecting the relief and restoration operations. Indian Railways asserted that it needs an additional 5 MHz spectrum in the 700 MHz band to serve the updated data rate requirement.

2.9 Further, through the reference letter dated 26.07.2023, DoT has mentioned that *"[w]hile providing the recommendations, TRAI may also consider the possibility of sharing of the spectrum between IR/ NCRTC/ RRTS/ Metro and other similar networks to ensure the efficient utilization of spectrum"*.

2.10 Earlier, while examining the issue relating to spectrum assignment to NCRTC and other RRTS/ Metro rail networks in the year 2021, TRAI, through a letter dated 28.12.2021, had, *inter-alia*, requested DoT to share reasons for not exploring spectrum sharing between Indian Railways and NCRTC and instead seeking recommendations on separate spectrum requirement of NCRTC in 700 MHz band. In response, DoT, through its letter dated 04.05.2022, had informed, *inter-alia*, that *"[w]ith regard to NCRTC's request for assignment of spectrum in 700 MHz band, DoT has decided that as in the case of Indian Railways, NCRTC also carries passengers and spectrum will be used for mission critical safety applications of signaling and train control, therefore, separate spectrum may be required since the services involve safety of life".* After consultation with stakeholders, the Authority, through its recommendations on 'Spectrum requirements of National Capital Region Transport Corporation (NCRTC) for train control system for RRTS corridors' dated 28.12.2022 recommended, *inter-alia*, as below with respect to the reuse and sharing of spectrum between Indian Railways, NCRTC, RRTS and Metro:

"3.2 The Authority recommends that:

(a) The frequency spectrum assigned to NCRTC may also be assigned to other RRTS/ Metro rail networks, which are geographically separated and not likely to cause any interference to one another.

(b) While assigning frequency spectrum to NCRTC and other RRTS/ Metro rail networks, which are geographically separated, it should be included in the terms and conditions that the same frequency spectrum may be assigned to other RRTS/ Metro rail networks or any other users on non-interference basis.

(c) To ascertain the feasibility of assigning the same frequency spectrum (assigned to NCRTC and other RRTS/ Metro rail network) to the telecom service providers on non-interference basis, a field trial may be conducted involving the Ministry of Railways and the telecom service providers, under the supervision of DoT. Based on the

outcome of the field trial, further modalities of assignment of the same frequency spectrum to the telecom service providers on non-interference basis may be worked out.

(d) Efficient and timely utilization of frequency spectrum should be ensured through a process of periodical monitoring.

3.3 In case of overlapping RRTS/ Metro rails networks, the Authority recommends that:

(a) For an upcoming RRTS/ Metro rail network, a part of which overlaps with NCRTC, or any other RRTS/ Metro rail networks to whom the same frequency spectrum has already been assigned, the same frequency spectrum may be assigned to such RRTS/ Metro rail network in the non-overlapping part of the network. For the overlapping part of the network, the frequency spectrum already assigned to IR may be assigned to such RRTS/ Metro rail network subject to non-interference to IR.

(b) To ascertain feasibility of RAN sharing, a field trial of RAN sharing through MOCN may be conducted by the Ministry of Railways involving IR and NCRTC, under the supervision of DoT. Based on the outcome of the field trial, a decision on implementation of RAN sharing through MOCN for the overlapping areas, can be taken.

(c) While assigning the frequency spectrum to NCRTC and other RRTS/ Metro rail networks, the terms of frequency spectrum assignment should include a condition that in case it is determined through field trial that RAN sharing is feasible,

(i) the same frequency spectrum may be assigned to other RRTS/ Metro rail networks in the same geographic area on a sharing basis.

(ii) The RRTS/ Metro rail networks shall implement RAN sharing through MOCN in the overlapping areas and the same shall be governed through the guidelines issued by DoT. The guidelines

for RAN sharing through MOCN should include the process and timelines for entering into the RAN sharing arrangement.

(iii) The commercial arrangement for RAN sharing through MOCN should be left to the RRTS/ Metro rail networks.

(d) As the Ministry of Railway is the nodal Ministry for Rail Networks, the responsibility of creation of SOP and its adherence by the RRTS/ Metro rail networks, should be entrusted with the Ministry of Railways. SOP should be created in consultation with DoT."

2.11 In the above background, stakeholders were requested to furnish their comments on the following questions:

Q1. Whether an additional 5 MHz (paired) spectrum in the 700 MHz band should be assigned to Indian Railways (IR) in order to meet its requirement for safety and security applications? Kindly provide a detailed response with justification.

Q2. In case your response to Q1 is negative, -

(a) In what manner, the requirement of the IR for safety and security applications may be fulfilled?

(i) Specifically, whether it would be appropriate to devise a framework under which the 10 MHz (paired) spectrum [5 MHz (paired) assigned to IR, and 5 MHz (paired) reserved for NCRTC and other RRTS/ Metro rail network] in the 700 MHz band may be used by all types of rail networks on shared basis, subject to the outcome of the field trial recommended by the Authority in its recommendations on 'Spectrum Requirements of National Capital Region Transport Corporation (NCRTC) for Train Control System for RRTS Corridors' dated 28.12.2022? If yes, please suggest the key features which should be included in such a framework?

(ii) Any other suggestion may be provided with detailed justification.

(b) In case your response to Q(2)(a)(i) is affirmative, whether a frequency spectrum of 10 MHz (paired) in the 700 MHz band would be sufficient to meet the requirement of different rail networks in India particularly in the overlapping zones? Kindly provide a detailed response with justification.

Comments Received from Stakeholders on the Q1

2.12 In response to the Q1, many stakeholders were of the view that Indian Railways should be assigned an additional 5 MHz (paired) spectrum in 700 MHz band for safety and security applications. A few stakeholders were not in favour of assignment of additional spectrum to Indian Railways. A couple of stakeholders mentioned that as the Government, via a Cabinet decision, has already decided to reserve an additional 5 MHz (paired) spectrum in the 700 MHz band for Indian Railways, the deliberation over the issue of assignment of additional spectrum to Indian Railways may no longer be relevant.

2.13 A broad summary of comments received from stakeholders who were in favour of the assignment of an additional 5 MHz (paired) spectrum in the 700 MHz band assignment to Indian Railways, is given below:

(a) To provide a reliable optimum communication network with a high level of operational availability, Indian Railways needs at least 10 MHz spectrum. The challenges of Indian Railways' LTE requirements are different from public telecom operators and from highly structured train operations by Metro railways.

(b) Indian railways safety and security applications are uplink centric which requires cumulative uplink capacity ~40 Mbps. To achieve this throughput, minimum spectrum would be 10 MHz.

(c) An additional spectrum would be required for design optimization of the network for safety & security applications and will enable Indian Railways to consolidate all spectrum requirements in the 700 MHz band.

2.14 In its comments, Indian Railways mentioned that it needs at least 10 MHz spectrum in the 700 MHz frequency band to provide a reliable optimum communication network with a high level of operational availability on its rail network for safety and security applications. Indian Railways also mentioned that -

(i) Indian Railways is a 24 x 7 x 365 operation spread across India.

(ii) Railway operation teams are always on the ground supervising track, rolling stock, electrical and signaling assets.

(iii) The proposed LTE network will become the communication backbone. Any performance degradation will have an impact on train operations.

2.15 In its comments, Indian Railways also provided the following details:

"Indian Railways was allotted a bandwidth of 5 MHz in band 28[8] against the requested requirement of 10 MHz suggesting that an alternative technology/ spectrum can be utilized for backhauling the CCTV video use cases & other applications.

Accordingly, Indian Railways created a traffic model for typical LTE sector for 5 MHz Bandwidth to cater Mission Critical Services as well as limited CCTV video use cases.

In Indian Railways' scenario, where UE is in mobility mode, Cell capacity, UL/ DL throughput availability, requirement, catered and shortfall, is depicted as:

[8] Band 28: Uplink frequencies: 703-748 MHz, Downlink frequencies: 758-803 MHz

(i) Scenario when Railway has 5 MHz spectrum

Mission Critical Services (in Kbps)

Application	***Availability***	***Requirement***		***Catered***	***Shortfall***
	DL/ UL	*DL*	*UL*	*DL/ UL*	*DL/ UL*
KAVACH	*Average throughput* *7000 Kbps in D/L and 3000 Kbps in U/L*	*100*	*100*	*100/ 100*	
MC PTT + Voice		*1600*	*1600*	*1600/ 1600*	
EoTT & DPCS		*300*	*300*	*300/ 300*	
IoT Services		*2000*	*2000*	*2000/ 500*	*-/ 1500*
On Board Video Surveillance		*200*	*40000*	*200/ 500*	*-/ 39500*
Total	*7000/ 3000*	*4200*	*44000*	*4200/ 3000*	*-/ 41000*

(ii) Scenario when Railway has 10 MHz spectrum

Mission Critical Services (in Kbps)

Application	***Availability***	***Requirement***		***Catered***	***Shortfall***
	DL/UL	*D/L*	*U/L*		
KAVACH	*Average throughput* *18000 Kbps in D/L and 6500 Kbps in U/L*	*100*	*100*	*100/ 100*	
MC PTT + Voice		*1600*	*1600*	*1600/ 1600*	
EoTT & DPCS		*300*	*300*	*300/ 300*	
IoT Services		*2000*	*2000*	*2000/ 1000*	*-/1000*
On Board Video Surveillance & Video Streaming for disaster incidences		*4200*	*40000*	*4200/ 3000*	*-/37000*

Application	***Availability***	***Requirement***		***Catered***	***Shortfall***
	DL/UL	*D/L*	*U/L*		
Passenger information display system		*100*	*10*	*100/ 10*	
Data uses for other safety, security & train operations applications		*4700*	*1700*	*4700/ 490*	*-/1210*
Total	*18000/6500*	*13000*	*45710*	*13000/ 6500*	*-/39210*

Note: The above Railway's requirement even does not meet with throughput given by 10 MHz. Hence, it is imperative to request for at least 10 MHz spectrum to Indian Railways on its need basis."

2.16 A broad summary of comments received from stakeholders, who were not in favour for assignment of an additional 5 MHz (paired) spectrum in the 700 MHz band assignment to Indian Railways, is given below:

(a) 700 MHz is a commercially important spectrum band for 5G standalone network, especially in rural areas.

(b) Only 5 MHz is left in 700 MHz band and any further assignment to any Government user will leave no further spectrum for TSPs in future. In such a case, it will disentitle some private TSPs from this band entirely.

(c) Considering length and breadth of Indian Railways, any spectrum assigned to Indian Railways will become unusable for commercial networks. Therefore, spectrum assignment must not be from a commercially viable spectrum pool.

Comments of Stakeholders on the Q2

2.17 A summary of views expressed by stakeholders, in support of spectrum sharing among rail networks using multi-operator core networks (MOCN)[9] technique, is given below:

(a) In overlapping zone, MOCN based sharing model is recommended for ensuring best utilization of spectrum resources, that is, single RAN network connecting multiple core networks of respective rail networks.

(b) A field trial recommended by TRAI for sharing of 10 MHz (paired) spectrum between three claimants viz. Indian Railways, NCRTC & RRTS/ Metro networks should be conducted. If successful, a shared spectrum between Indian Railways, NCRTC, and RRTS would lead to optimal use of the scarce spectrum.

(c) A common shared network based on MOCN is helpful. RAN slicing can also be used to enable Indian Railways and NCRTC to guarantee a defined radio network resource share.

(d) In case of a hypothetical scenario of capacity crunch, the possibility of spectrum leasing and/or sharing by telecom service providers can also be explored. This will help optimal utilization of the spectrum already allocated to Indian Railways.

2.18 NCRTC, not in support of MOCN, mentioned that the sharing of spectrum between NCRTC and Railways is a settled issue which does not require reconsideration. A considered view was reached in 2021 wherein Indian Railway insisted that sharing of spectrum is not possible for passenger safety reasons. In view of this, separate 5 MHz spectrum has been allotted to NCRTC and has been approved by cabinet.

2.19 A broad summary of other proposals received from stakeholders, are given below:

[9] MOCN functionality allows a network operator to provide access to a single radio access network by other operators. Each operator operates its own core network.

(a) Accommodate spectrum requirements of Indian Railways and other undertakings and entities like NCRTC in non-commercial spectrum bands.

(b) An unutilized spectrum in 900 MHz band be asked to be returned in a time-bound manner to the DoT and it be made available for IMT purposes.

(c) The use of additional spectrum must also be restricted to captive use, as in the case of the original assignment of 5 MHz of spectrum in the 700 MHz band to Indian Railways in 2021. Indian Railways should not be allowed to offer any commercial services like Internet/ Wi-Fi onboard.

(d) In case it is decided that spectrum in 700 MHz band should be used, consider a common service provider (CSP) for meeting the requirements of Indian Railways, other associated bodies and public protection and disaster recovery (PPDR) services. The CSP will be able to build a network using the same spectrum having its own core and interconnection with legacy networks. This common network will be available to Indian Railways and agencies like NCRTC and will simultaneously be available to all other First Responders and PPDR bodies. The network will be designed to give preference to the extent of complete bandwidth to the first responders/designated person during disasters. The CSP network can also be utilized by the Defence services, if required and the CSP will be free to monetize the free available bandwidth. Like FirstNet in the United States, this service provider will deliver an exclusive communication network for use of Indian Railways and other First responders using the spectrum in 700 MHz band already assigned to Indian Railways and entities like NCRTC. This will ensure the objective of efficient utilized without any fragmentation of IMT spectrum.

Analysis of the Issues Raised Through Q1 and Q2

2.20 The Authority noted that many stakeholders were in favour of assignment of additional 5 MHz (paired) spectrum to Indian Railways in order to meet its requirement for safety and security applications, whereas a few stakeholders opposed it.

2.21 As mentioned above, the updated uplink data rate requirement of Indian Railways is about 45 Mbps. It is noted that Indian Railways, in its comments, has mentioned that out of the total uplink data rate requirement of about 45 Mbps, only 3 Mbps will be served with the existing 5 MHz (paired) frequency spectrum, which will increase to 6.5 Mbps with 10 MHz (paired) frequency spectrum. Also, one of the stakeholders expressed the view that the throughput requirement of Indian Railways is significantly high for a 10 MHz network to deliver in practical.

2.22 The Authority examined the comments of stakeholders and is of the considered view that with assignment of additional 5 MHz (paired) frequency spectrum in 700 MHz band to Indian Railways, it will have a total of 10 MHz (paired) frequency spectrum in 700 MHz band, which may not be sufficient to fulfil the entire throughput requirement of Indian Railways, but will provide enough bandwidth such that the Indian Railways will be able to meet the entire critical data throughput requirement i.e. signalling system operation, MC PTT, safety and security features other than on-board video surveillance. As regards on-board video surveillance, Indian Railways may not be able to stream the live feed of all the coaches at all times but would be able to stream live feed of a limited number of coaches having security concerns or could send intermittent live feed on a coach-by-coach basis. In addition, Indian Railways could use other means such as using telecom service provider's mobile network to transmit residual on-board video surveillance data.

2.23 It is noteworthy that through the instant reference dated 26.07.2023, DoT has requested TRAI to provide recommendations on the assignment of additional 5 MHz of spectrum to Indian Railways. Therefore, the Authority has considered assignment of only 5 MHz of additional spectrum to Indian Railways. The Authority is of the view that Indian Railways may consider implementing AI-based solution to optimize their requirement as the availability of spectrum in 700 MHz band is limited.

2.24 The Authority notes that the DoT in its reference dated 26.07.2023 has mentioned, *inter-alia*, that the Indian Railways has sought additional 5 MHz of paired spectrum in the 700 MHz band and has citied that –

"When Railways implements its LTE network & Kavach over LTE, it shall surrender frequencies in the 146-174 MHz presently being used for driver-guard & driver/ guard to station communication as well as in the 400 MHz band being used for Kavach and consolidate all its requirements in 700 MHz band provided adequate bandwidth is available."

2.25 The Authority has had a consistent view that it is important to ensure that the assigned spectrum, particularly the administratively assigned, is put to use at the earliest by the assignee. Therefore, the Authority is of the opinion that the efficient and timely utilization of frequency spectrum be ensured through a process of periodical monitoring. Further, upon implementation of the LTE-based safety and security applications in 700 MHz band by the Indian Railways; for the frequency spectrum held by Indian Railways in other bands viz. 146-174 MHz, 400 MHz band, and 900 MHz band, DoT should take up the matter with Indian Railways for taking these assigned frequency spectrum back in a time-bound manner.

2.26 In view of the above, **the Authority recommends that-**

(a) In addition to the already assigned 5 MHz (paired) frequency spectrum in the 700 MHz frequency band, an additional 5 MHz (paired) frequency spectrum in the 700 MHz frequency band should be assigned to Indian Railways for its safety and security applications along the railway tracks for captive use.

(b) The efficient and timely utilization of the frequency spectrum should be ensured through a process of periodic monitoring.

(c) Upon implementation of LTE-based network for safety and security applications in the 700 MHz frequency band by the Indian Railways, DoT should take up the matter with Indian Railways for taking back the frequency spectrum assigned to

Indian Railways in other frequency bands viz. 146-174 MHz, 400 MHz band, and 900 MHz band in a time-bound manner.

2.27 Further, with respect to the reuse and sharing of spectrum between Indian Railways, NCRTC, RRTS and Metro, it is noted that the Authority in its earlier recommendations on 'Spectrum requirements of National Capital Region Transport Corporation (NCRTC) for train control system for RRTS corridors' dated 28.12.2022 recommended, *inter-alia*, as below:

"3.2 The Authority recommends that:

(a) The frequency spectrum assigned to NCRTC may also be assigned to other RRTS/ Metro rail networks, which are geographically separated and not likely to cause any interference to one another.

(b) While assigning frequency spectrum to NCRTC and other RRTS/ Metro rail networks, which are geographically separated, it should be included in the terms and conditions that the same frequency spectrum may be assigned to other RRTS/ Metro rail networks or any other users on non-interference basis.

(c) To ascertain the feasibility of assigning the same frequency spectrum (assigned to NCRTC and other RRTS/ Metro rail network) to the telecom service providers on non-interference basis, a field trial may be conducted involving the Ministry of Railways and the telecom service providers, under the supervision of DoT. Based on the outcome of the field trial, further modalities of assignment of the same frequency spectrum to the telecom service providers on non-interference basis may be worked out.

(d) Efficient and timely utilization of frequency spectrum should be ensured through a process of periodical monitoring.

3.3 In case of overlapping RRTS/ Metro rails networks, the Authority recommends that:

(a) For an upcoming RRTS/ Metro rail network, a part of which overlaps with NCRTC, or any other RRTS/ Metro rail networks to whom the same frequency spectrum has already been assigned, the same frequency spectrum may be assigned to such RRTS/ Metro rail network in the non-overlapping part of the network. For the overlapping part of the network, the frequency spectrum already assigned to IR may be assigned to such RRTS/ Metro rail network subject to non-interference to IR.

(b) To ascertain feasibility of RAN sharing, a field trial of RAN sharing through MOCN may be conducted by the Ministry of Railways involving IR and NCRTC, under the supervision of DoT. Based on the outcome of the field trial, a decision on implementation of RAN sharing through MOCN for the overlapping areas, can be taken.

(c) While assigning the frequency spectrum to NCRTC and other RRTS/ Metro rail networks, the terms of frequency spectrum assignment should include a condition that in case it is determined through field trial that RAN sharing is feasible,

(i) the same frequency spectrum may be assigned to other RRTS/ Metro rail networks in the same geographic area on a sharing basis.

(ii) The RRTS/ Metro rail networks shall implement RAN sharing through MOCN in the overlapping areas and the same shall be governed through the guidelines issued by DoT. The guidelines for RAN sharing through MOCN should include the process and timelines for entering into the RAN sharing arrangement.

(iii) The commercial arrangement for RAN sharing through MOCN should be left to the RRTS/ Metro rail networks.

(d) As the Ministry of Railway is the nodal Ministry for Rail Networks, the responsibility of creation of SOP and its adherence by the RRTS/ Metro rail networks, should be entrusted with the Ministry of Railways. SOP should be created in consultation with DoT."

2.28 As can be seen from the above, the Authority had recommended that to ascertain feasibility of RAN sharing, a field trial of RAN sharing through MOCN may be conducted by the Ministry of Railways involving Indian Railways and NCRTC, under the supervision of DoT, and based on the outcome of the field trial, a decision on the implementation of RAN sharing implemented through MOCN for the overlapping areas, can be taken. The Authority is of the view that ideally there should be a common sharable radio access network implemented through MOCN for the operation of different railway networks in the country. This will result in an efficient utilisation of the network resources including spectrum and reduction of cost by avoiding duplication of network elements. Therefore, the DoT should take an early decision on the Authority's earlier recommendations that to ascertain feasibility of RAN sharing, a field trial of RAN sharing through MOCN may be conducted by the Ministry of Railways involving Indian Railways and NCRTC, under the supervision of DoT as recommended through the TRAI's Recommendations on 'Spectrum requirements of National Capital Region Transport Corporation (NCRTC) for train control system for RRTS corridors' dated 28.12.2022.

2.29 In view of the above, **the Authority recommends that-**

(a) DoT should take an early decision on the Authority's earlier recommendation that to ascertain feasibility of radio access network (RAN) sharing, a field trial of RAN sharing through multi-operator core network (MOCN) may be conducted by the Ministry of Railways involving Indian Railways and NCRTC, under the supervision of DoT, as recommended by TRAI through the Recommendations on 'Spectrum Requirements of National Capital Region Transport Corporation (NCRTC) for Train Control System for RRTS Corridors' dated 28.12.2022. Based on the outcome of the field trial, a decision on the implementation of RAN sharing through MOCN in the overlapping areas among Indian Railways/ NCRTC/ other RRTS/ Metro rail networks can be taken.

(b) While assigning the frequency spectrum to Indian Railways, the terms of frequency spectrum assignment should include a condition that in case it is determined through the field trial that RAN sharing is feasible, Indian Railways shall implement RAN sharing through MOCN in the overlapping areas with NCRTC/ other RRTS/ Metro rail networks and the same shall be governed through the guidelines issued by DoT.

2.30 Further, the Authority is of the view that the 5 MHz (paired) spectrum assigned to NCRTC and also reserved for other RRTS/ Metro rail networks may not be utilized at all places. Keeping any chunk of frequency spectrum idle not only results in a loss to the exchequer but is also a waste of precious scarce resource. Therefore, the Authority is of the view that till the time the field trial of RAN sharing through MOCN is conducted to ascertain feasibility of RAN sharing, in case Indian Railways desires to put to use the 5 MHz assigned to NCRTC and other RRTS/ Metro rail networks in some areas, provided the same is not being used in such areas by NCRTC/ other RRTS/ Metro rail networks, it may be allowed to use this 5 MHz (paired) frequency spectrum in 700 MHz band on a payment basis.

2.31 In view of the above, **the Authority recommends that till the time, the field trial of RAN sharing through MOCN is conducted to ascertain feasibility of RAN sharing, in case Indian Railways intends to put to use the 5 MHz frequency spectrum in the 700 MHz band assigned to NCRTC and other RRTS/ Metro rail networks, in certain areas, it may be permitted to use this 5 MHz (paired) frequency spectrum on a payment basis provided that the same is not being used in such areas by NCRTC/ other RRTS/ Metro rail networks.**

2.32 Further, it is noted that some of the stakeholders have raised their concerns regarding assignment of spectrum in 700 MHz band which is a globally harmonized frequency band for IMT and is also a prime coverage band for 5G.

In this regard, it may be worth noting that deployment of LTE-based railway networks can economize on the cost of deployment if spectrum assignment is made in a globally harmonized frequency band. Having said that, it is also important that such frequency spectrum is utilized efficiently. Keeping this in view, the Authority through its earlier recommendations on 'Spectrum requirements of National Capital Region Transport Corporation (NCRTC) for train control system for RRTS corridors' dated 28.12.2022 had also recommended that "*to ascertain the feasibility of assigning the same frequency spectrum (assigned to NCRTC and other RRTS/ Metro rail network) to the telecom service providers on non-interference basis, a field trial may be conducted involving the Ministry of Railways and the telecom service providers, under the supervision of DoT. Based on the outcome of the field trial, further modalities of assignment of the same frequency spectrum to the telecom service providers on non-interference basis may be worked out*".

2.33 It is also noted that one of the stakeholders has suggested that a common network may be built by a telecom service provider for rail networks (Indian Railways, NCRTC, other RRTS/ Metro rail networks) and public land mobile network (PLMN) [commercial network] in line with the FirstNet in the USA; however, the priority will always be railway usage.

2.34 In this regard, the Authority notes that FirstNet is exclusively for first responders and those who support their vital efforts. This includes law enforcement, emergency medical services and fire protection services, and important supporting services such as emergency (9-1-1) call dispatching, government public safety answering points and emergency planning and management offices. In 2017, the FirstNet Authority selected AT&T to build and manage the FirstNet network for a period of 25 years. As per a report published by Ericsson, FirstNet is an entire communications ecosystem dedicated to public safety and characterized by:

(a) a shared radio network utilizing all AT&T LTE commercial spectrum bands, as well as 20 MHz (2 x 10 MHz) of nationwide coverage in the

700 MHz band, dedicated to first responders, and available to commercial users when not in use by public safety.

(b) a highly secure, dedicated network core designed to serve the public safety community.

(c) a network launched with 4G LTE and being upgraded to provide 5G capabilities.

(d) always-on, 24/7 priority and preemption across voice and data, with multiple priority levels that first responder users can allocate as needed to protect communications against commercial traffic congestion.

(e) a nationwide, dedicated fleet of land-based and airborne portable cell sites to help provide coverage in remote locations or immediately following a disaster.

2.35 The following figure depicts the network architecture of FirstNet:

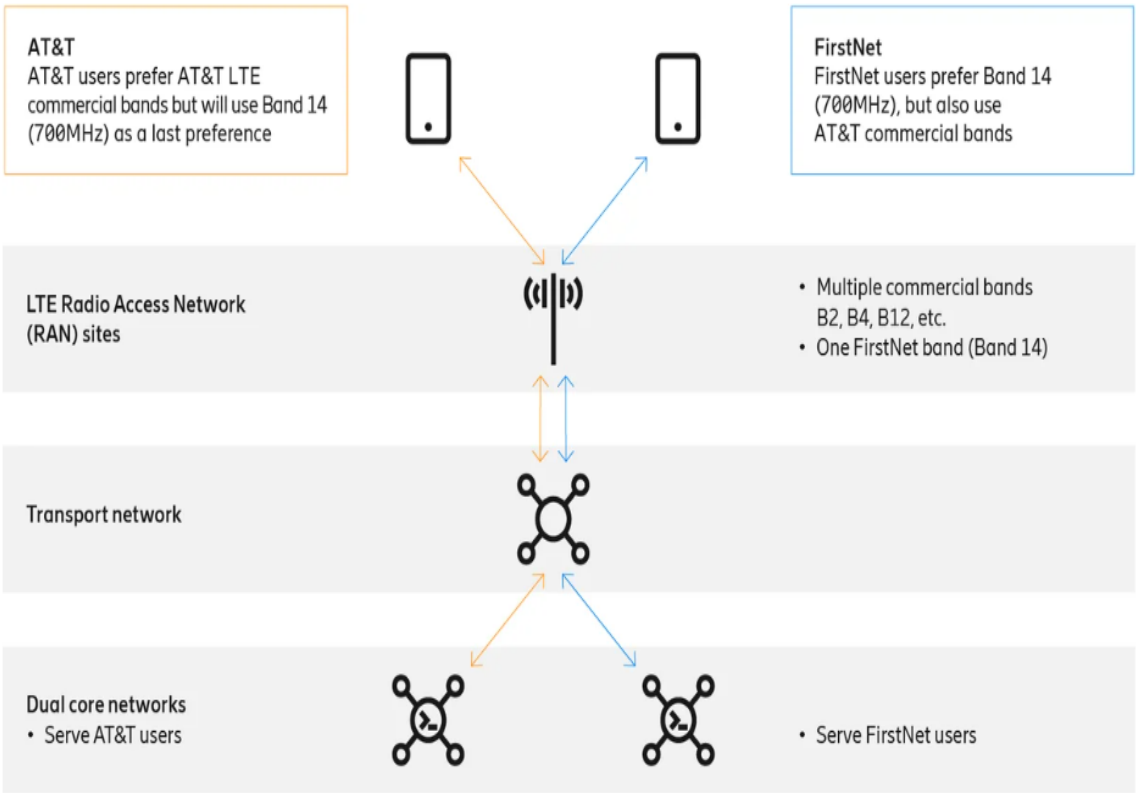

Figure 2.1: Network architecture of FirstNet (Source: Report by Ericsson[10])

[10] Source: https://www.ericsson.com/en/reports-and-papers/mobility-report/articles/stress-test-for-firstnet

2.36 In case the CSP model as suggested by one of the stakeholders is implemented, the telecom service provider(s) will be able to use the network for PLMN services - (a) in areas having no railway track and (b) in the areas having railway tracks, when no train is scheduled. This can be implemented using MOCN technique. Implementation of PPDR services through the same network can also be explored. Implementation of a common network through one or more TSP(s) will result in optimal utilization of spectrum. However, modalities will need to the worked out.

2.37 In view of the above, **the Authority recommends that the DoT should explore the possibility of implementing a common network built by one or more telecom service provider(s) for rail networks (Indian Railways, NCRTC, other RRTS/ Metro rail networks) and public land mobile network (PLMN). However, the priority will always be given to rail networks. In case the Government agrees, in-principle, with this recommendation, DoT may, if deemed fit, seek the recommendations from TRAI on a detailed mechanism and modalities for its implementation.**

B. Need for the Harmonization of Spectrum

2.38 India has adopted frequency division duplex (FDD) configuration-based band 28 for LTE or APT 700 band (Uplink: 703-748 MHz/ Downlink: 758-803 MHz). For the 700 MHz frequency band. DoT, through the reference letter dated 26.07.2023, has provided the spectrum utilization of the 700 MHz frequency band as below:

Table 2.2: The present spectrum utilization of the 700 MHz band

S. No.	Uplink Frequency (MHz)	Downlink Frequency (MHz)	Quantum (MHz)	TSP/ User
1.	703 - 713	758 - 768	10	Government User
2.	713 - 718	768 - 773	5	Indian Railways
3.	718 - 723	773 - 778	5	NCRTC/ RRTS
4.	723 - 733	778 - 788	10	Reliance Jio
5.	733- 738	788 - 793	5	Vacant
6.	738 - 748	793 - 803	10	Reserved for BSNL

2.39 As can be seen from the above table, only 5 MHz (paired) spectrum is vacant in each of the 22 licensed service areas (LSAs) in the 700 MHz band. In case it is decided to assign an additional 5 MHz (paired) spectrum in 700 MHz band to Indian Railways, it may be deemed preferable to assign such spectrum in a frequency block which is contiguous to the existing assignment to Indian Railways. In view of the above, the Authority solicited comments of stakeholders on the following question:

Q3. In case it is decided to assign an additional 5 MHz (paired) spectrum in the 700 MHz band to IR, whether there is a need for harmonization of spectrum in the 700 MHz band to make the spectrum assigned to IR, and NCRTC and other RRTS/ Metro Rail Networks contiguous? Kindly provide a detailed response with justification.

Comments of Stakeholders on the Q3

2.40 In response to Q3, many stakeholders were in favour of harmonization of spectrum. The reasons cited by such stakeholders in support of harmonization are as follows:

(a) For optimum utilization of network, maximum throughput and ease of maintenance of system, contiguous 10 MHz (Paired) spectrum is needed. A contiguous spectrum of 10 MHz will have better interference mitigation

at loading conditions in overlapping areas and will have lesser overhead control channel consumption. In case of non-contiguous deployment, both the user equipment (UE) and base station have to be capable of handling non-contiguous carriers in that band. When carrier aggregation is used, as component carriers (CCs) may experience different path losses, the coverage of the serving cells may differ.

(b) Harmonization of spectrum will make efficient utilization of complete 10 MHz spectrum across different services like Kavach, MC-PPT and on-board video surveillance. In case spectrum is not harmonized, radio optimization for services like Kavach, MC-PTT and video surveillance will increase complexity across various network elements during deployment.

(c) The most important requirement of harmonization is to make the spectrum contiguous. The performance of a contiguous band is always higher. Non-contiguous spectrum can impact end device performance and may not suffice the requirement of Indian Railways.

2.41 One of the stakeholders mentioned that in case more spectrum is assigned to Indian Railways, then any harmonization should not affect operational commercial networks.

Analysis of the Issues Raised Through the Q3

2.42 In the earlier section of these recommendations, assignment of an additional 5 MHz (paired) spectrum in the 700 MHz band to the Indian Railways has been recommended. Accordingly, there may be a requirement for the harmonization of spectrum in the 700 MHz band. The Authority examined the comments received from stakeholders and noted that many stakeholders were in favour of harmonization of spectrum in the 700 MHz frequency band to make the spectrum assigned to Indian Railways contiguous. The Authority concurs with the views of stakeholders that the harmonization of spectrum will enable efficient utilization of spectrum across different services. The non-contiguous spectrum can impact performance as the contiguous frequency spectrum has lesser overhead control channel consumption and thereby better performance.

2.43 As can be seen from Table 2.2 given above, the only vacant frequency block of 5 MHz (paired) spectrum in the 700 MHz band, is not adjacent either to the frequency block already assigned to Indian Railways or the block assigned/ reserved for NCRTC and other RRTS/ Metro rail networks. Thus, harmonization of spectrum in this band is required. The Authority is also of the view that the frequency spectrum assignment to Indian Railways and NCRTC should be contiguous to enable Indian Railways to get 15 MHz contiguous spectrum based on its spectrum requirement.

2.44 It is noteworthy that some of the spectrum assignees have already deployed their network using the spectrum in 700 MHz frequency band while some other stakeholders may be in the process of deploying. While spectrum harmonisation is required to be carried out to assign a contiguous 10 MHz to Indian Railways and an adjacent 5 MHz block to NCRTC/ other RRTS/ Metro rail networks, at the same time, it should be ensured that minimum disturbance occurs to the running networks. Further, scheduled downtime in some of the networks could be used to perform the spectrum harmonization exercise.

2.45 In view of the above, **the Authority recommends that spectrum harmonization should be carried out to assign a contiguous block of 10 MHz of frequency spectrum in the 700 MHz band to Indian Railways and an adjacent 5 MHz block to NCRTC/ other RRTS/ Metro rail networks. At the same time, it should be ensured that minimum disturbance occurs to the running networks.**

C. Spectrum Charging Methodology

2.46 Ministry of Railways is responsible for rail transport in India through Indian Railways, which is owned and operated by the ministry through Railway Board.

It manages the fourth largest national railway system in the world by size.[11] The rail network of Indian Railways is spread over 68,000 route kilometers, covering the length and breadth of the country.

2.47 NCRTC is a joint venture company of the Government of India and states of Haryana, Rajasthan, Uttar Pradesh and Delhi. NCRTC was formally incorporated on 21.08.2013, under the Companies Act. As a partnership project between the Center and the States, NCRTC has one nominated Director each from the participating States, and four nominee Directors from the Government of India. NCRTC also has the flexibility of forming separate subsidiary companies for implementing specific projects.[12]

2.48 DoT vide its reference dated 26.07.2023 has, *inter-alia*, stated that:

"-------Further, as per TRAI recommendations on assignment of spectrum to Indian Railways, 5 MHz of paired spectrum has been assigned to Indian Railways on administrative basis and spectrum charges are to be paid annually on the formula basis similar to other captive users. However, for NCRTC, TRAI has recommended to levy 0.5 times the Auction determined price (ADP) based on the area of LSA and on pro rata basis for assignment of spectrum for a period of 10 years. Thus, the per km spectrum charges for NCRTC shall vary from LSA to LSA based on the Auction Determined Price (ADP), whereas for IR charges are fixed irrespective of the LSA.

From the above it is evident that spectrum charges for NCRTC is many fold greater than that of IR in the LSAs having more ADP, whereas in some LSAs where ADP is less and LSA area is more, spectrum charges for IR is many fold greater than that of NCRTC. Hence, TRAI may be requested to recommend a uniform spectrum valuation and charging methodology considering similar usages in the same spectrum band.

[11] https://in.linkedin.com/company/ministry-of-railways-india
[12] https://trai.gov.in/sites/default/files/Recommendation_28122022.pdf

In the view of the above, TRAI is requested to examine and provide recommendations on –

……

(iii) Considering the different spectrum methodology as recommended by TRAI for the 5 MHz of paired spectrum in 700 MHz band, assigned to Indian Railways and for NCRTC, TRAI may examine and if found necessary recommend a uniform spectrum valuation and charging methodology considering similar usages in the same spectrum band."

……."

2.49 With this background, the stakeholders were asked to give their inputs on the following issues: -

Q4. Should a uniform spectrum charging methodology be adopted for Indian Railways as well as for NCRTC and other RRTS/ Metro rail networks? If yes, which of the following spectrum charging methodology be adopted in this regard:

(i) Spectrum charging methodology based on Auction Determined price (ADP) as recommended in the TRAI's recommendations on 'Spectrum requirements of National Capital Region Transport Corporation (NCRTC) for train control system for RRTS corridors' dated 28.12.2022.

(ii) Spectrum charges as levied for Indian Railways as per DoT's Order No. P-11014/34/2009-PP (II) and P- 11014/34/2009- PP(IV) dated 22nd March 2012 (revised vide DoT's order dated 11.12.2023).

(iii) Apart from the methodologies highlighted in (i) and (ii) above, any other uniform spectrum charging methodology that may be adopted in this regard? Details with justification may kindly be provided.

Q5. If answer to Q4 above is no, whether the existing charging methodology as per DoT's Order No. P-11014/34/2009-PP (II) and P- 11014/34/2009-

PP(IV) dated 22nd March 2012 (revised vide DoT's Order dated 11.12.2023) be continued for Indian Railways or some other spectrum charging methodology may be adopted specifically for Indian Railways? Please provide detailed response with justification.

Q6. If a spectrum charging methodology similar to NCRTC and other RRTS/Metro rail networks, is adopted for Indian Railways, what should be the payment terms and associated conditions relating to:
i. Upfront payment
ii. Moratorium period
iii. Total number of installments to recover deferred payments
iv. Rate of interest in respect of deferred payment and prepayment
Please support your answer with detailed justification.

Comments of Stakeholders on the Q4 to Q6

2.50 A stakeholder has stated that spectrum should be assigned to Indian railways, free of cost as it is required for safety and security of passengers & train operations & has no commercial utilization.

2.51 The stakeholder has further stated that since Indian Railway is being operated by Ministry of Railways, Government of India and the amount paid by Railways will also be charged to Consolidated Fund of India, therefore, allotment of 10 MHz (paired) spectrum (5 MHz additional as demanded as well as 5 MHz already allotted to Indian Railways) in 700 MHz frequency band is sought free of cost. Moreover, it added that Finance Ministry vide its letter no. 14/6/2018-IPP dated 08.10.2018 had also recommended the same.

2.52 Another stakeholder has stated that the spectrum charging methodology cannot be same for Indian Railways and other RRTS/Metro Rails for the following reasons:

- Indian Railways is supported through government budget for significant part of its capital investment while Metros have to repay their debt.
- Passenger journeys are supported by cross-subsidy in Indian Railways, but this is not the case with NCRTC.
- In case of Indian Railways, Railway Stations come first and cities develop around the stations later. Indian Railways for this reason, owns large land banks and doesn't have to pay for acquiring land whereas, NCRTC has to pay three to four times the market rate for acquiring land.

2.53 Considering the above, the stakeholder has requested that NCRTC should be given the spectrum free of cost and if it is not possible to assign spectrum free of cost, then the spectrum should be assigned at a price that is at least one tenth of the price given by Indian Railways.

2.54 Another stakeholder has favored uniform charging methodology based on DoT's order of 2012 (revised vide order dated 11.12.2023). stating that Auction Determined Price (ADP) is different for each LSA and has wide variance, which subsequently gives irrational charges. Since Royalty fee formula of DoT order is independent of ADP, it is more uniform.

2.55 Some stakeholders have favored a uniform charging methodology stating that spectrum-charging mechanism for IR, NCRTC and other RRTS/Metro rail networks must account for the opportunity cost of (auctioning) this spectrum, in terms of both the higher revenues that may accrue to the exchequer as well as the larger public good that may be served through its usage by TSPs.

2.56 Another stakeholder has stated that spectrum assignment to Government Agencies like Indian Railways should be at market price/ADP. It added that ADP based formula for NCRTC does not consider the fact that while the Railway Authority is using the spectrum in limited geographical area, but the spectrum is rendered useless in entire LSA. Therefore, the distance-based criteria should be removed, and spectrum charging should be for entire LSA and accordingly,

the charging from Indian Railways should be the indexed market price for the complete 22 LSAs.

2.57 Regarding the payment terms, this stakeholder stated that the payment terms for Indian Railways should be same as for all other users of this spectrum as per the Notice Inviting Application.

2.58 The stakeholder was also of the view, that if Indian Railways desires free of cost spectrum on the grounds of safety and security related applications, then it should be accommodated from the spectrum bands reserved for PPDR services.

Analysis of the Issues Raised Through the Q4 to Q6

2.59 In December 2023, the Parliament enacted a new statute namely, 'the Telecommunication Act, 2023'[13]. The sub-section 4 of Section 4 of the Telecommunications Act, 2023 is reproduced below:

"*The Central Government shall assign spectrum for telecommunication through auction except for entries listed in the First Schedule for which assignment shall be done by administrative process.*

Explanation. - For the purposes of this sub-section, -

(a) *"administrative process" means assignment of spectrum without holding an auction;"*

2.60 The First Schedule of the Telecommunications Act, 2023 lists 19 items for assignment of spectrum through the administrative process. The relevant items of the First Schedule are reproduced below:

"*.....*

4. Disaster management, safeguarding life and property.

.....

[13] https://egazette.gov.in/WriteReadData/2023/250880.pdf

6. Safety and operation of roads, railways, metro, regional rail, inland waterways, airports, ports, pipelines, shipping, and other transport systems.

….."

2.61 Presently, the spectrum charges for Indian railways are being levied on annual basis, as per DoT's order issued vide letter no. P-11014/34/2009-PP dated 11th December 2023 (erstwhile DoT's order dated 22nd March 2012) **(Annexure-II)**

2.62 Regarding the spectrum charging methodology for Indian Railways, vide Recommendations on 'Allotment of spectrum to Indian Railways for Public Safety and Security services' dated 25th October 2019, the Authority recommended the following:

a) *Spectrum may be assigned to Indian Railways on administrative basis for captive use only and not to offer any commercial services such as Wi-Fi onboard.*
b) *Spectrum charges may be levied based on formula basis as prescribed by DoT for Royalty Charges and License Fee for captive use.*

2.63 While recommending the above, the Authority took a view that spectrum is required by Indian Railways along its track network only, to meet its signalling requirement and not for the services consumed by the passengers/users; thus, the spectrum requirement is captive requirement rather than commercial requirement. Therefore, it would not be rational to ask IR to pay the auction determined price i.e. equivalent to that paid/payable by the TSPs.

2.64 Further, the Authority in its Recommendation on 'Spectrum Requirements of National Capital Region Transport Corporation (NCRTC) for Train Control System for RRTS Corridors' dated 28.12.2022, recommended spectrum charging methodology based on Licensed Service Area (LSA)-wise Auction Determined Price (ADP) of 700 MHz band for 10 years adjusted on pro-rata basis based on corridor area relative to total geographical area of LSA. This

adjustment was made considering that the auction prices that were based on financial, economic & technical parameters pertaining to 5G|IMT access services. Since NCRTC required spectrum for safety applications and not for offering services similar to access service providers, therefore, the same ADP was adjusted proportionally by comparing the corridor area to the total geographical area of the LSA.

2.65 The Authority is cognizant of the fact that Indian Railways (IR) and Mass Rapid Transit Systems (MRTS), such as the National Capital Region Transport Corporation (NCRTC), play a pivotal role in delivering a wide range of financial, economic, and social benefits to the nation. Indian Railways and MRTS serve as indispensable components in public and national interests, reinforcing their strategic importance in the country's progress.

2.66 As per Asian Development Bank[14], Indian railways has been and continues to be the "lifeline for the socioeconomic growth of India," by connecting human settlements across the country and simultaneously transporting various resources to centers of production and markets. Indian Railways has always aimed to provide safety during travel and it has been unwavering in providing sustenance for economic growth.

2.67 As per World Bank[15], Railways are a climate-smart and efficient way to move people and freight. Railways promote economic growth while cutting greenhouse gas emissions. They are a clean and compact way to move millions of passengers and millions of tons of goods across countries and continents.

2.68 As per the policy document available on the website of Ministry of Housing and Urban Affairs (MOHUA)[16], Mass Rapid Transit Systems in urban areas not only

[14] https://www.adb.org/publications/speed-and-socioeconomic-development-influence-indian-railways
[15]https://www.worldbank.org/en/topic/transport/brief/railways#:~:text=The%20World%20Bank%20brings%20its,worth%20%246.9%20billion%20U.S.%20dollars
[16] https://www.mohua.gov.in/upload/whatsnew/59a3f7f130eecMetro_Rail_Policy_2017.pdf

facilitate easy and quick movement of people but also have a positive impact on the economic growth and quality of life. This results in increased income and various benefits to the society like reduced external cost due to reduction in traffic congestion, road and parking cost, transport cost and per-capita traffic accidents. Mass Rapid Transit Systems tend to reduce per capita vehicle ownership and usage and encourage more compact & walkable development pattern which provide developmental benefits to the society. Reduction in cost and time of travel lowers the cost of production of goods and services which significantly improves city's competitiveness. One of the significant contributions is substantial reduction in per capita pollution emission bringing down various chronic diseases; hence, results in huge public health benefits.

2.69 Based on the discussions above, it is evident that the services being offered by both Indian Railways and Mass Rapid Transit Systems (MRTS) like NCRTC are of national importance and are integral in public interest. The strategic importance of these systems goes beyond transportation—they are indispensable pillars of national development and public welfare.

2.70 Given these substantial contributions, the Authority is of the view that the spectrum charging methodology for Indian Railways and NCRTC should be such it acknowledges the nature of service and the broad benefits railway systems deliver. Such an approach will not only safeguard their sustainability but also amplify their role in advancing national priorities and public welfare. Accordingly, the Authority is of the opinion that the spectrum charging should ensure that financial burdens, such as high spectrum charges, do not undermine this vital objective.

2.71 For the purpose of calculating the spectrum charges for NCRTC, the Authority in 2022 recommended that the minimum protection width should be determined by DoT by undertaking a proof of concept (PoC) study. However, for the purpose of immediate spectrum allotment for setting up LTE network by NCRTC, it was mentioned that the minimum protection width along one side

of the track center for calculating the corridor area be taken as 2.5 Km. This minimum protection width was based on the information provided by NCRTC and was not substantiated by any technical studies/reports etc. However, in the present exercise, Indian Railways has mentioned stated that for no interference, frequency reuse may be permitted beyond 26 Km of the railway track based on the report on feasibility of co-existence of two separate LTE networks done by Centre of Excellence in Wireless Technology, IIT Madras (CEWiT).

2.72 Therefore, the Authority observed that if the NCRTC formula is applied to Indian Railways (IR) for determining spectrum with minimum protection width as 26 Km, the spectrum charges for Indian Railways will be significantly higher than that of NCRTC, even though both NCRTC and Indian Railways are utilizing the spectrum for similar purposes i.e. for safety and security and not to offer any commercial services. In case the studies conducted for NCRTC find out that the requirement of a protection width for NCRTC is larger than 2.5 Km or if the protection width as ascertained by Indian Railway is applied to NCRTC, the spectrum charges for NCRTC may also go up. This will in turn increase the operational cost of these entities.

2.73 Further, DOT vide its reference dated 26.07.2023 has also pointed out that the per km spectrum charges for NCRTC shall vary from LSA to LSA based on the ADP, whereas for IR charges are fixed irrespective of the LSA and the spectrum charges for NCRTC is many fold greater than that of IR in the LSAs having more ADP, whereas in some LSAs where ADP is less and LSA area is more, spectrum charges for IR is many fold greater than that of NCRTC.

2.74 The Authority notes that the auction determined prices of spectrum used for access services are linked to a wide range of offerings, including internet, data, voice calls, SMS, and other related services. As detailed at Chapter I of these recommendations, Indian Railways (IR) and NCRTC require spectrum in the 700 MHz band for enhancing its safety, and security. Since both entities require

spectrum only for captive use and not for providing any commercial services, using the market determined prices of access spectrum bands for determining spectrum charges for IR and NCRTC may not accurately reflect the economic value of spectrum for these entities.

2.75 In the light of the above considerations, the Authority feels that Recommendations on 'Spectrum Requirements of National Capital Region Transport Corporation (NCRTC) for Train Control System for RRTS Corridors' dated 28.12.2022 merits reconsideration.

2.76 Besides**,** DoT vide its reference dated 26.07.2023 has requested TRAI to examine, and if found necessary, recommend a uniform spectrum valuation and charging methodology for both IR and NCRTC, considering similar usages in the same spectrum band.

2.77 As per Economic Theory, price discrimination[17] is a strategy by which suppliers segment the market by differentiating consumer groups and charging different prices in accordance with perceived or assumed consumers' price elasticity and willingness-to-pay.

2.78 Differential pricing or Ramsey Pricing may enhance efficiency only when two consumers or consumer segments exhibit distinct willingness to pay and differing demand elasticities. As stated above in para 2.74, the Indian Railways and NCRTC will be utilizing this spectrum in 700 MHz frequency band for similar purpose, hence it is reasonable to assume that the economic value of the spectrum for these entities and consequently their willingness to pay for the spectrum will also be similar. This could support the argument for adopting a uniform spectrum charging methodology for both Indian Railways and NCRTC.

[17] Assessment of External Price Referencing and Alternative Policies :Sabine Vogler, in Medicine Price Surveys, Analyses and Comparisons, 2019

2.79 For both Indian Railways (IR) as well as for NCRTC, spectrum is critical for executing mission critical safety applications and ensuring efficient train operations and security. Consequently, spectrum assumes the characteristics of a 'necessity' or a necessary good in case of both IR as well as NCRTC. It is well-established that necessary goods typically have inelastic demand, with a price elasticity of demand[18] less than one. Therefore, the low price elasticity of demand for spectrum in the context of both IR and NCRTC further supports the adoption of a uniform spectrum charging methodology for these entities.

2.80 In the light of above, since the conditions of differential pricing are not satisfied, the Authority is of the view that in the present scenario uniform spectrum charging mechanism may prove to be the most appropriate methodology for Indian Railways and for NCRTC and other RRTS/ Metro rail networks.

2.81 Considering the critical role played by Indian Railways (IR) and NCRTC in serving public and national interests, it may not be appropriate to levy spectrum charges for these entities based on Auction Determined Prices (ADP) derived from commercial spectrum usage. The economic value of spectrum for these entities is fundamentally different from that of commercial service providers, as it does not include revenue-generating activities like commercial use of internet, voice, or data services. Thus, applying ADP, which reflects market-driven prices for commercial usage, would not appropriately account for the public service nature and critical safety applications of IR and NCRTC.

2.82 Moreover, the spectrum being demanded by Indian Railways as well as by NCRTC is for captive use. For assignment of spectrum for captive use, DOT has been following the policy of formula-based pricing. Hence, the Authority is of the view that in the public and national interest, it would be appropriate that

[18] **Price Elasticity of Demand: Meaning, Types, Calculation and Factors Affecting Price Elasticity**
https://www.geeksforgeeks.org/price-elasticity-of-demand/
Elasticity of demand = (% change in qty demanded/% change in price)
https://socialsci.libretexts.org/Bookshelves/Economics/Principles_of_Microeconomics_(Curtis_and_Irvine)/02%3A_Responsiveness_and_the_Value_of_Markets/04%3A_Measures_of_response-_Elasticities/4.05%3A_The_income_elasticity_of_demand

spectrum charges for NCRTC and Indian Railways may be levied on formula for captive users basis as prescribed by DoT.

2.83 The Authority further takes note of DoT's order for payment of spectrum charges for assignment of frequencies to captive users (being charged on formula basis) for different types of Radiocommunications services and applications, recently revised by DoT vide order no. P-11014/34/2009-PP dated 11th December 2023. The Authority is of the view that the same may be used for levying spectrum charges on an annual basis for Indian Railways/ NCRTC/ other RRTS/ Metro rail networks.

2.84 Accordingly, **the Authority recommends that spectrum charges for Indian Railways /NCRTC/ other RRTS/ Metro rail networks should be levied based on the formula for Royalty Charges and License Fees for captive use, as prescribed by DoT.**

2.85 The following chapter provides a summary of recommendations.

CHAPTER III: SUMMARY OF RECOMMENDATIONS

3.1 The Authority recommends that-

(a) In addition to the already assigned 5 MHz (paired) frequency spectrum in the 700 MHz frequency band, an additional 5 MHz (paired) frequency spectrum in the 700 MHz frequency band should be assigned to Indian Railways for its safety and security applications along the railway tracks for captive use.

(b) The efficient and timely utilization of the frequency spectrum should be ensured through a process of periodic monitoring.

(c) Upon implementation of LTE-based network for safety and security applications in the 700 MHz frequency band by the Indian Railways, DoT should take up the matter with Indian Railways for taking back the frequency spectrum assigned to Indian Railways in other frequency bands viz. 146-174 MHz, 400 MHz band, and 900 MHz band in a time-bound manner.

[Para 2.26]

3.2 The Authority recommends that-

(a) DoT should take an early decision on the Authority's earlier recommendation that to ascertain feasibility of radio access network (RAN) sharing, a field trial of RAN sharing through multi-operator core network (MOCN) may be conducted by the Ministry of Railways involving Indian Railways and NCRTC, under the supervision of DoT, as recommended by TRAI through the Recommendations on 'Spectrum Requirements of National Capital Region Transport Corporation (NCRTC) for Train Control System for RRTS Corridors' dated 28.12.2022. Based on the outcome of the field trial, a decision on the implementation of RAN sharing through MOCN in the overlapping areas among Indian Railways/ NCRTC/ other RRTS/ Metro rail networks can be taken.

(b) While assigning the frequency spectrum to Indian Railways, the terms of frequency spectrum assignment should include a condition that in case it is determined through the field trial that RAN sharing is feasible, Indian Railways shall implement RAN sharing through MOCN in the overlapping areas with NCRTC/ other RRTS/ Metro rail networks and the same shall be governed through the guidelines issued by DoT.

[Para 2.29]

3.3 The Authority recommends that till the time, the field trial of RAN sharing through MOCN is conducted to ascertain feasibility of RAN sharing, in case Indian Railways intends to put to use the 5 MHz frequency spectrum in the 700 MHz band assigned to NCRTC and other RRTS/ Metro rail networks, in certain areas, it may be permitted to use this 5 MHz (paired) frequency spectrum on a payment basis provided that the same is not being used in such areas by NCRTC/ other RRTS/ Metro rail networks.

[Para 2.31]

3.4 The Authority recommends that the DoT should explore the possibility of implementing a common network built by one or more telecom service provider(s) for rail networks (Indian Railways, NCRTC, other RRTS/ Metro rail networks) and public land mobile network (PLMN). However, the priority will always be given to rail networks. In case the Government agrees, in-principle, with this recommendation, DoT may, if deemed fit, seek the recommendations from TRAI on a detailed mechanism and modalities for its implementation.

[Para 2.37]

3.5 The Authority recommends that the spectrum harmonization should be carried out to assign a contiguous block of 10 MHz of frequency

spectrum in the 700 MHz band to Indian Railways and an adjacent 5 MHz block to NCRTC/ other RRTS/ Metro rail networks. At the same time, it should be ensured that minimum disturbance occurs to the running networks.

[Para 2.45]

3.6 The Authority recommends that spectrum charges for Indian Railways /NCRTC/ other RRTS/ Metro rail networks should be levied based on the formula for Royalty Charges and License Fees for captive use, as prescribed by DOT.

[Para 2.84]

ANNEXURES

Annexure-I: DoT's letter dated 26.07.2023 (with Annexure-II and III)

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

No.: L-14001/13/2023-IMT Date: 26.07.2023

To,

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

Subject: Seeking recommendations of TRAI on allotment of additional spectrum to Indian Railways for its safety and security applications in the 700 MHz band - reg.

Sir,

This is to inform that Indian Railways has requested for additional 5 MHz of paired spectrum in the 700 MHz band to be allocated free of cost for enhancing its safety and security systems (Annexure – I).

2. Based on an earlier request from Indian Railways, the recommendations of TRAI were sought in the matter and TRAI provided its recommendations on this subject on 25-10-2019.

2.1. Later, based on the approval of Cabinet, Indian Railways was assigned 5 MHz of paired spectrum in the 700 MHz band on 22-10-2021 (Annexure – II). IR was also intimated about the withdrawal of its GSM-R spectrum holding in the 900 MHz band in 14 LSAs, upon migration to LTE based network. The Indian Railways is yet to confirm the migration to the LTE based network.

3. Meanwhile, the request of National Capital Region Transport Corporation (NCRTC) for 5 MHz of paired spectrum in the 700 MHz was also considered in the Department. Subsequently, the TRAI recommendations were sought and based on the recommendations dated 28-12-2022, DoT provisionally assigned 5 MHz of paired spectrum to NCRTC and the roll out of the LTE network is under process. The assignment of spectrum to NCRTC shall be regularized after the approval of the Union Cabinet.

4. Recently, based on the request from BSNL, the Cabinet has approved the reserving of 10 MHz of paired spectrum in the 700 MHz band in lieu of the 10 MHz of paired spectrum already reserved in the 600 MHz band. After considering this request of BSNL only 5 MHz of paired spectrum is presently available as vacant spectrum in the 700 MHz band. The present spectrum holding of the various TSPs/users in the 700 MHz band is placed at Annexure -III.

5. Recently, the Indian Railways has sought additional 5 MHz of paired spectrum, free of cost, in the 700 MHz band citing the following points –

(i) IR's indigenous development of Radio based Train Collision Avoidance System (TCAS) Kavach became successful. Radio based TCAS shall be the IR's ATP instead of ETCS level 2. Hence It is requested that Railways be allotted additional 5 MHz spectrum for design optimization of the network, when IR implements LTE network in 700 MHz band for safety & security applications.

(ii) The recent Balasore incident has shown that for the purpose of safety, it is important to capture large scale data & videos from moving trains on a real time basis. Dumping at a stopping station, which has high-capacity WiFi, shall not serve the objective. Further, during exigencies, the TSP's network gets choked thereby adversely affecting the relief and restoration operations.

(iii) When Railways implements its LTE network & Kavach over LTE, it shall surrender frequencies in the 146-174 MHz presently being used for driver-guard & driver/guard to station communication as well as in the 400 MHz band being used for Kavach and consolidate all its requirements in 700 MHz band provided adequate bandwidth is available.

(iv) Utilization of this spectrum by other users can be done provided the same does not cause any interference to the network of IR.

6. Further, as per the TRAI recommendations on assignment of spectrum to Indian Railways, 5 MHz of paired spectrum has been assigned to Indian Railways on administrative basis and spectrum charges are to be paid annually on the formula basis similar to other captive users. However, for NCRTC, TRAI has recommended to levy .5 times the Auction Determined Price based on the area of LSA and on pro rata basis for the assignment of spectrum for a period of 10 years. Thus, the per km spectrum charges for NCRTC shall vary from LSA to LSA based on the Auction Determined Price (ADP), whereas for IR charges are fixed irrespective of the LSA. An indicative calculation sheet highlighting the difference in spectrum charging across each LSA is attached herewith (Annexure -IV).

6.1 From the above it is evident that spectrum charges for NCRTC is many fold greater than that of IR in the LSAs having more ADP, whereas in some LSAs where ADP is less and LSA area is more, spectrum charges for IR is many fold greater than that of NCRTC. Hence TRAI may be requested to recommend a uniform spectrum valuation and charging methodology considering similar usages in the same spectrum band.

7. In view of the above, TRAI is requested to examine and provide its recommendations on -

(i) the assignment of 5 MHz of additional spectrum to Indian Railways in view of its earlier recommendations dated 25-10-2019 and also in the context of its earlier recommendations with respect to NCRTC dated 28-12-2022 and auction of spectrum dated 11-04-2022.

(ii) While providing the recommendations, TRAI may also consider the possibility of sharing of the spectrum between IR/NCRTC/RRTS/Metro and other similar networks to ensure the efficient utilization of spectrum.

(iii) Considering the different spectrum valuation methodology as recommended by TRAI for the 5 MHz of paired spectrum in the 700 MHz band, assigned to Indian Railways and for NCRTC, TRAI may examine and if found necessary recommend a uniform spectrum valuation and charging methodology considering similar usages in the same spectrum band.

(iv) Any other recommendations deemed fit for the purpose.

Encl: As above.

26.07.2023

(Gulab Chand)
Joint Wireless Adviser

Annexure - II

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

No.: L-14001/01/2019-NTG (Pt.) Date: 22.10.2021

To,

Executive Director (Tele Div)
Railway Board
Ministry of Railways

Subject: Allotment of 5 MHz (paired) spectrum to Indian Railways in 700 MHz band for Public Safety and Security services at Stations and in the Trains for Captive use.

Reference: Ministry of Railways' O.M. No. 2017-Tele/14(1)/1 Pt. dated 23.06.2021.

Sir,

I am directed to refer to Ministry of Railways' Office Memorandum dated 23.06.2021 on the above subject and to inform that in accordance with the Cabinet decision taken in its meeting held on 09.06.2021, 5 MHz (paired) spectrum in the spectrum block 713-718/768-773 MHz is hereby assigned to Indian Railways for Public Safety and Security services for Captive use, with the following conditions:

(i) This spectrum assignment is being made for captive use along the Railway track only and not to offer any Commercial Services such as Internet/Wi-Fi onboard.

(ii) Annual spectrum charges for this assignment will be levied based on formula as prescribed by WPC Wing, DoT, from time to time for Royalty Charges and License Fee for Captive usages. Addition of new base stations and mobile terminals shall be intimated by Indian Railways without any delay.

(iii) Efficient and timely utilization of spectrum will be ensured by Railways through a process of periodical monitoring.

(iv) The 1.6 MHz (paired) spectrum already assigned to Indian Railways in 900 MHz band will be taken back from Indian Railways upon migration to LTE based network.

(v) As Indian Railways would be using the assigned spectrum along its railway track network and stations only, DoT may consider assigning the same spectrum in other areas for area-specific limited use to other entities for captive use. However, it will be ensured that there is no interference to the Railways' network from such use.

(vi) Applicable procedures for Letter of Intent (LoI), Decision Letter (DL), SACFA clearance and Wireless Operating License (WOL), as being followed for GSM-R network, shall be followed by Indian Railways for all the base/mobile stations.

(vii) Operations should not commence without obtaining Wireless Operating License (WOL) for the network as per applicable procedure.

(viii) Connection of this network to Public Switched Telecom Network (PSTN) shall not be allowed.

22.10.2024

(Neeraj Juyal)
Assistant Wireless Adviser
Phone: 2372 3595

Annexure-III

Spectrum utilisation in the 700 MHz IMT band

SL No	Uplink		Downlink		Quantum (MHz)	TSP/User
	Start (MHz)	Stop(MHz)	Start (MHz)	Stop(MHz)		
1.	703	713	758	768	10	Government User
2.	713	718	768	773	5	Indian Railways
3.	718	723	773	778	5	NCRTC/RRTS
4.	723	733	778	788	10	Reliance Jio
5.	733	738	788	793	5	Vacant
6.	738	748	793	803	10	Reserved for BSNL
7.	748	758			10	Guard band

Annexure-II: DoT's Order No. P-11014/34/2009-PP dated 11.12.2023 (with Schedule VI)

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning and Coordination Wing
20, Ashoka Road, Sanchar Bhawan, New Delhi

No. P-11014/34/2009-PP Dated: 11.12.2023

ORDER

Subject: Spectrum Charges for Assignment of Frequencies to Captive Users (being charged on formula basis) for different types of Radiocommunication Services and applications.

In pursuance of the powers conferred under section 4 of the Indian Telegraph Act, 1885 (13 of 1885) and in supersession of this Ministry's Orders Nos. P-11014/34/2009-PP (I), (II), (III) & (IV) each dated 22.03.2012, the Central Government has decided that assignment of radio frequency spectrum to all users to whom radio frequency assignment is made through administrative process and spectrum charges are calculated based on a formulae, shall be made as per the methodology defined in this order.

2. Upon successful processing of application for assignment of radio frequency, a Letter of Intent (LoI) will be issued to the applicant which include, among others, information about the license fee and royalty charge (collectively called spectrum charges) required to be paid. Spectrum charges shall be informed for the full period of the assignment requested. If the request for assignment is for a period more than one year, the applicant can opt to pay the license fee and royalty annually, in advance for each year.

3. Immediately thereafter, but in any case not later than sixty (60) days from the date of issue of the LoI, the applicant shall pay the spectrum charges for issue of Decision Letter (DL), if otherwise permissible.

3.1 If the payment is not received within 60 days from the date of LoI, the application shall be treated as cancelled and the frequency shall be freed for assignment to other applicants. The applicant will have to submit a fresh application if they still want the frequency assignment.

4. A Construction Period of three months is permitted for the purpose of import of the equipment, site preparedness, deployment, etc. and spectrum charges be levied, after three months' period from the 1st day of the month of date of issue of LoI.

4.1 Three months' construction period shall not be applicable for temporary frequency assignment (assignment issued for the period less than one year). In such cases, spectrum charges shall be applicable from the 1st day of the month of date of issue of LoI.

5. Initially, DL shall be issued with a validity of 15 months (one year plus three months of construction period) from the 1st day of the month of date of issue of LoI that can be further extended for a period of another one year subject to payment of annual spectrum charges, in advance. For example: If date of issue of initial LoI is 20th August 2023, the spectrum charges will be levied from 1st November 2023 and the initial DL will be valid upto 31st October 2024. Further extension of one year will be expired on 31st October 2025.

5.1 In no case DL be renewed further, however, extension of another one year may be considered for Government users under certain circumstances subject to payment of annual spectrum charges, in advance.

6. The spectrum charges, comprises of Royalty and License fee, shall be calculated for following radiocommunication services as per the enclosed schedules:

6.1 All the above services have been defined in the National Frequency Allocation Plan of India (NFAP). The latest NFAP is available in DoT's website (www.dot.gov.in).

6.2 Spectrum charges, mentioned in all the schedules, are annual charges, unless otherwise specified.

6.3 Royalty charge has been made independent of numbers of equipment/set, unless otherwise specified. However, license fee will be applicable on them. Therefore, any increase/ decrease in the number of equipment (Fixed/ Mobile) in the existing frequency assignment shall require prior permission.

6.4 The spectrum charges due for different period shall be determined as follows:

License Period	**License Fee Payable**	**Royalty payable after three months period from the 1st day of the month of date of issue of LOI**	**Method of Payment**
One calendar month or less	At specified rate given in various schedules	Annual Royalty divided by 12	Full License fee and Royalty to be paid in advance at the time of issue of DL/frequency assignment.
More than one calendar month but less than 12 months	At specified rate given in various schedules	On pro-rata basis. However, part of a month shall be taken as one month.	--do--
More than one year	At specified rate given in various schedules	On pro-rata basis. However, part of a month shall be taken as one month.	Pay the License Fee plus Royalty for the entire duration in advance at the time of issue of DL/ frequency assignment or pay it in annual advance instalments.

7. Generally, there shall be no limit on number of frequency(ies) applied for any type of services. However, number of frequency(ies) shall be assigned subject to availability, technical justification, regulatory feasibility etc.

8. **Renewal of Frequency Assignment:**

8.1 The assignee shall be responsible for keeping the frequency assignment current and up to date until its surrender/ cancellation. To this effect, the assignee shall, at least 30 days before the end date of the validity of the frequency assignment, pay through Saral Sanchar Portal, the spectrum charges for the renewal of his/her existing frequency assignment.

9. **Frequency assignment/ authorization Modification Fee:**

9.1. Applicable fees for modification in the frequency authorization/ frequency assignment shall be charged at the rate of Rs. 1000/- per modification.

10. **Cancellation/ Surrender of Frequency Assignment:**

10.1 The assignee shall surrender the frequency assignment, if no longer required. To this effect the assignee shall apply for cancellation through Saral Sanchar Portal in accordance with OM No. L-14027/210/2020-WF dated 27.07.2023. Failure to surrender a frequency assignment within the stipulated time shall result in accrual of spectrum charges and late fee.

10.2 Non-purchase of equipment/ non-utilization of frequency assignment shall not be ground for exemption from payment of spectrum charges.

10.3 On surrender of frequency assignment, after adjustment of due spectrum charges, the balance amount will be either adjusted against other active frequency assignments or refunded to the applicant.

11. **Late fee for delayed payment of Spectrum Charges:**

11.1 Late fee shall be payable by the assignee on the frequency assignment for delay in payment of spectrum charges (Royalty and License fee) or any other dues payable against the frequency assignment. In this regard, any payment reflected in DoT's account after the midnight (2400 Hrs.) of the end date will be considered as a delay in payment irrespective of the date on which such transaction was initiated by the assignee of the frequency assignment.

11.2 The rate at which Late Fee is levied for a Financial Year shall be 2% added to one-year Marginal Cost of Lending Rate (MCLR) of State Bank of India, on the beginning of the Financial Year i.e. 1st April.

11.3 The Late Fee shall be compounded annually, subject to minimum annual Late Fee of Rs. 250/- per Frequency Assignment. A part of the month shall be considered as a full month for the purpose of calculation of Late Fee. A month shall be an English calendar month.

12. The applications for the frequency assignment shall continue to be processed through DoT's online portal (Saral Sanchar portal). Further, all renewals, cancellations, import permission, surrenders will also be issued through online portal (Saral Sanchar) as per prevailing instructions issued from time to time.

13. Any issue either arising due to interpretation of this Order or new uses/ applications not covered in the said Order shall be referred to the Standing Committee constituted vide WPC Wing OM of even No. dated 11.12.2023.

14. This Order issues with the approval of competent authority.

15. This Order shall come into force with effect from 01st April 2024. However, the revised spectrum charges on existing frequency assignments shall be applicable from the date of next renewal cycle.

Enclosure: As above.

11.12.2023

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To,

1. All concerned.
2. Wireless Finance Division
3. Wireless Monitoring Organisation
4. IT cell, DoT - for publication on DoT Website
5. ITPC, BSNL, Pune to send text messages to all licensee informing them about the new orders on frequency assignment.

Schedule-VI: Fixed and Mobile Services having Multiplexed Multi-channels

General:

(i) Charging methodology is based on MxCxW formula (M= Basic Royalty, C=No. Freq. Carriers, W=Bandwidth Factor). It will be used for calculation of royalty charges for the Fixed services and Mobile services having multiplexed multi-channels.

(ii) The rate of M-Factor will be calculated based on the maximum Coverage distance as per Table-1

(iii) The bandwidth factor will be calculated as per Table-2. Any fraction would be rounded up to the next integer.

Part-I (Royalty Charges)

1. Annual royalty Charges for radio stations in Fixed Services and Mobile services having multiplexed multi-channels for Captive use will be multiplication of the M-factor (Basic Royalty), C-factor (No. of frequency carriers) and W-factor (Bandwidth).

Royalty (R) = MxCxW

Table-1: Rate of M-Factor

Distance Category	Maximum Distance (Km)	Value of M Factor
I	<= 2	750
II	> 2= 5	1500
III	> 5 <= 25	3000
IV	> 25 <=60	6000
V	> 60 <=120	11000
VI	> 120 <=500	18750
VII	> 500	25000

Table-2: Rate of bandwidth factor

Slabs of Adjacent Channel Separation (BW), in MHz	Value of W factor
More than 375 kHz and including 2 MHz	30
More than 2 but <= 3.5	40
More than 3.5 but <= 7	60
More than 7 but <= 14	90
More than 14 but <= 28	120
More than 28 but <= 56	150
More than 56 but <= 112	180
More than 112 but <= 256	210
More than 256 but <= 512	240
> 512	240+ 30 x (Excess bandwidth / 256) *

*That is, in steps of 256 MHz or part thereof

Part-II (License fee)

License Fee for wireless stations operating under Fixed and Mobile Services including Standby sets:

S. No.	Type of Wireless station License	Annual License Fee (in Rs.)
i.	Fixed station	1000 per station
ii.	Vehicle Mobile/ Handheld Mobile station	250 per station

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LIST OF ACRONYMS

Acronym	Description
ADP	Auction Determined Price
AI	Artificial Intelligence
APT	Asia-Pacific Telecommunity
ATP	Automatic Train Protection
BSNL	Bharat Sanchar Nigam Limited
BTS	Base Transceiver Station
CC	Component Carrier
CCTV	Closed Circuit Television
CEWiT	Centre of Excellence in Wireless Technology
CNPN	Captive Non-Public Network
CNPN-R	Captive Non-Public Network for Railway Networks
CP	Consultation Paper
CSP	common service provider
DL	Decision Letter
DL	Downlink
DoT	Department of Telecommunications
DPWCS	Distributed Power Wireless Control System
EoTT	End of Train Telemetry
ETCS	European Train Control System
FDD	Frequency-division duplexing
GSM-R	Global System for Mobile Communications-Railway
IMT	International Mobile Telecommunications
IoT	Internet of Things
IR	Indian Railways
LoI	Letter of Intent
LSA	Licensed Service Area
LTE	Long Term Evolution
Mbps	Megabits per second
MC PTT	Mission Critical Push-To-Talk
MCLR	Marginal Cost of Funds based Lending Rate
MHz	Megahertz

MIMO	Multiple Input Multiple Output
MOCN	Multi-Operator Core Networks
MTRC	Mobile Train Radio Communication
NCRTC	National Capital Region Transport Corporation
NPV	Net Present Value
OHD	Open House Discussion
PLMN	Public Land Mobile Network
PoC	Proof of Concept
PPDR	Public Protection & Disaster Relief
PSTN	Public Switched Telecom Network
QAM	Quadrature Amplitude Modulation
RAN	Radio Access Network
RRTS	Regional Rapid Transit System
RSTT	Railway Radiocommunication Systems between Train and Trackside
SACFA	Standing Advisory Committee on Radio Frequency Allocation
SOP	Standard Operating Procedure
TCAS	Train Collision Avoidance System
TRAI	Telecom Regulatory Authority of India
TSP	Telecom Service Provider
UL	Uplink
Wi-Fi	Wireless Fidelity
WOL	Wireless Operating License
WPC	Wireless Planning and Coordination Wing