

**Consultation Paper No. 6/2022**



भारतीय दूरसंचार विनियामक प्राधिकरण  
**Telecom Regulatory Authority of India**

**Consultation Paper**  
**on**  
**Spectrum Requirements of National Capital Region Transport Corporation (NCRTC) for Train Control System for RRTS Corridors**

**9<sup>th</sup> June 2022**

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**Written Comments on the Consultation Paper are invited from the stakeholders by 7<sup>th</sup> July 2022 and counter-comments by 21<sup>st</sup> July 2022. Comments and counter-comments will be posted on TRAI's website [www.trai.gov.in](http://www.trai.gov.in). The comments and counter-comments may be sent, preferably in electronic form, to Shri Syed Tausif Abbas, Advisor (Networks, Spectrum and Licensing), TRAI on the email ID [advmn@traigov.in](mailto:advmn@traigov.in). For any clarification/ information, he may be contacted at Telephone No. +91-11-23210481.**

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## CHAPTER- I: INTRODUCTION

### A. DoT Reference

- 1.1 The Department of Telecommunications (DoT), through its letter No. L-14001/01/2019-NTG (Pt.) dated 29<sup>th</sup> November 2021 (**Annexure-1.1**), while forwarding the NCRTC letters dated 6<sup>th</sup> November 2019 and 10<sup>th</sup> August 2021, has informed the following:
- a. Based on the TRAI recommendations dated 25<sup>th</sup> October 2019 on 'Allotment of spectrum to Indian Railways for Public Safety and Security services', Government has assigned 5 MHz (paired) spectrum in 700 MHz band to Indian Railways (IR) for their LTE technology-based proposed network.
  - b. Subsequently, NCRTC has requested DoT for allotment of spectrum for Regional Rapid Transit System (RRTS) being implemented by them in 8 rail corridors including 3 rail corridors of approximate length of 350 km along Delhi — Ghaziabad — Meerut, Delhi — Gurugram — Alwar, Delhi — Panipat in Phase-I.
  - c. In their request, NCRTC has also informed that delay in sharing of spectrum assigned to Indian Railways is adversely affecting their August-2022 timeline for commissioning of 17 km-priority section of RRTS during 75<sup>th</sup> Anniversary of India's Independence (Azadi ka Amrut Mahotsav) in 2022.
  - d. As in the case of Indian Railways, NCRTC also carries passengers and spectrum will be used for mission critical safety applications of signalling and train control. Separate spectrum is required since the services involve safety of life.
- 1.2 Through the afore-mentioned letter dated 29<sup>th</sup> November 2021, DoT under the terms of clause 11(1)(a) of TRAI Act, 1997 as amended by TRAI Amendment Act 2000, has requested TRAI to provide:

- (i) 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.
- (ii) Any other recommendations deemed fit for the purpose, including assignment of the same spectrum for other RRTS/metro rail networks pan-India.

## **B. Spectrum Assignment to Indian Railways for RSTT**

1.3 DoT vide reference dated 27<sup>th</sup> February 2019 informed that:

- a) Indian Railways (IR) is using GSM-R based network similar to various Railways networks deployed around the world. 1.6 MHz (paired) spectrum in 900 MHz band has been assigned to IR on administrative basis for captive usage of their GSM-R based network.
- b) The Ministry of Railways has proposed to install an Ultra-high-speed LTE based communication corridor along their rail network for Train-Ground and Train-Train communication. Ministry of Railways had requested DoT to reserve 15 MHz of spectrum in 700 MHz band for this purpose and to begin with requested for 10 MHz to be allocated free of cost as their proposal was devoid of any commercial gain and was only for enhancing security and passenger amenities.

1.4 Through the reference dated 27<sup>th</sup> February 2019, DoT requested TRAI to provide recommendations on administrative allotment of spectrum to Indian Railways and the quantum, price, appropriate frequency band (including 450-470 MHz band) and any other related issue.

1.5 After detailed consultation process, TRAI submitted its Recommendations on 'Allotment of spectrum to Indian Railways for Public Safety and Security services' on 25<sup>th</sup> October 2019. Summary of

the recommendations given on 25<sup>th</sup> October 2019 are reproduced below:

- (a) In the 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.*
- (b) To implement Video Surveillance System for all coaches of the Train (Security services), IR may explore other communications means such as:
  - i) Dumping the Video Surveillance data to the system using high-capacity Wi-Fi when the train reaches a station.*
  - ii) Using Public Telecommunication 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.*
- (e) 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.*

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

1.6 The recommendations made by TRAI were accepted by the Government and DoT through their letter no. L-14001/01/2019-NTG(Pt.) dated 22<sup>nd</sup> October 2021 assigned 5 MHz (paired) spectrum in the 700 MHz band for Public Safety and Security services for captive use along the Railway Track to the Indian Railways. Subsequently, IR has surrendered 1.6 MHz (paired) spectrum assigned to it in 900 MHz band for GSM-R based system in the states/UTs where GSM-R had not been rolled out by IR.

### **C. Request of NCRTC**

1.7 National Capital Region Transport Corporation (NCRTC), a joint venture of government of India and four State Government of National Capital region, is under administrative control of Ministry of Housing & Urban Affairs. NCRTC is implementing the Regional Rapid Transit System (RRTS) in 8 rail corridors including 3 rail corridors of approximate length of 350 km along (i) Delhi-Ghaziabad-Meerut, (ii) Delhi-Gurugram-Alwar, (iii) Delhi-Panipat in Phase-I. Other 5 (five) corridors will be taken up in phase-II, which are under planning stage. The corridors in phase-II includes (iv) Delhi – Faridabad – Palwal, (v) Ghaziabad – Khurja, (vi) Delhi – Bahadurgarh – Rohtak, (vii) Ghaziabad – Hapur, and (viii) Delhi – Shahdara – Baraut. These railway-based systems are designed for the speed of 180 Kilometer per hour (Kmph). Public safety, security and efficient Train Control System are of paramount considerations in such high-speed train operations. NCRTC has, therefore, decided to deploy ETCS level-2 signalling system, mission critical voice, IoT based asset monitoring services and video surveillance from the train for captive use.

1.8 After the release of TRAI recommendations on ‘Allotment of spectrum to Indian Railways for Public Safety and Security services’ dated 25<sup>th</sup>

October 2019, National Capital Region Transport Corporation (NCRTC) in the month of November 2019 submitted its plan to DoT regarding deployment of LTE-R based network as its communication backbone for signalling system and associated functions to meet public safety and security requirement. NCRTC further submitted that it would require 10 MHz (paired) in either 700 MHz band or 900 MHz band and this requirement of NCRTC is same as of Indian Railways. NCRTC noted that TRAI on 25<sup>th</sup> October 2019 while recommending allocation of 5 MHz (paired) spectrum in 700 MHz band to IR for captive use for implementation of ETCS level-2 MC PTT +Voice, IoT based asset monitoring services, PIDS etc., had also recommended that DoT may explore the possibility of assigning the same spectrum in other areas for area specific limited use to other entities for captive use while ensuring that there is no interference to the Railways' network from such use. Thus, NCRTC submitted to DoT that the requirement of NCRTC fits in the said TRAI recommendations and requested for allotment of spectrum of 5 MHz (paired) spectrum instead of 10 MHz (paired) in either 700 MHz or 900 MHz band for captive use.

1.9 Subsequently, NCRTC through its letter dated 10.08.2021 to DoT submitted that:

a) It is in communication with Railway Board since 06.11.2019 to finalize the modalities to share the 5 MHz (paired) spectrum in 700 MHz band assigned to Indian Railways.

b) On advice of the Railway Board, NCRTC had engaged a group of eminent experts to conduct a "Study of feasibility or co-existence of two separate LTE networks of NCRTC and IR in the same spectrum without impacting ETCS and mission critical services". The expert group was the same which was engaged by Indian Railways to study the feasibility of use of LTE technology on Indian Railways. NCRTC further mentioned that the expert group has given technical clearance for the sharing and co-existence of both the systems in the

same frequency band without any interference. The report was submitted to Railway Board on 21.05.2020. A detailed note clarifying the issues raised by the Ministry of Railways was also submitted to Railway Board and subsequently was also shared with DoT vide letter dated 21.05.2020. While sharing the feasibility report, DoT was also requested to expedite the process of spectrum allocation on sharing basis to NCRTC.

- c) Subsequent to allotment of spectrum to Indian Railways, NCRTC conducted series of meeting with Railway Board and RDSO on the topic of LTE deployment, co-existence and interference mitigation.
- d) Ordering of long lead LTE equipment requires confirmation of frequency band. Delay in consent for sharing of allotted spectrum by Indian Railways is adversely affecting the August 2022 project timeline.

In view of the above, NCRTC sought DoT intervention for early approval of allotted spectrum of 5 MHz in 700 MHz band with NCRTC for deployment of ETCS L2 systems for RRTS.

### **Additional information sought from DoT, NCRTC and Indian Railways**

1.10 Additional information/clarifications were sought from DoT vide letter dated 28<sup>th</sup> December 2021. DoT was also requested to share (i) the reasons for not exploring spectrum sharing between IR and NCRTC and seeking TRAI recommendations for separate spectrum requirements of NCRTC in 700 MHz band and (ii) details regarding demand for spectrum requirement from other RRTS/metro/other rail network service providers.

1.11 DoT vide its letter dated 4<sup>th</sup> May 2022 has provided the information/clarifications sought by TRAI. As regards specific query regarding reasons for not exploring spectrum sharing between IR and NCRTC, DoT has informed that:

*“With 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 signalling and train control, therefore, separate spectrum may be required since the services involve safety of life.”*

- 1.12 As regards the details sought by TRAI regarding demand for spectrum requirement from other RRTS/metro/other rail network service providers, DoT has informed as under:

*“No other requests for spectrum requirements from other RRTS/metro/rail networks have been received in DoT. However, Zero-Sum ITS Solutions India Pvt. Ltd., a subsidiary of a Japanese firm, have been granted Experimental license for implementation of fully automated ITS (Intelligent Transport System) solution in Ahmedabad city through collaboration with Ahmedabad Municipal Corporation and Ahmedabad Traffic Police and also granted Experimental license for implementation of fully automated ITS (Intelligent Transport System) solution in Trivandrum City. Experimental license were earlier granted in 700 MHz band and recently in 598-608 MHz band in both city i.e. Ahmedabad and Trivandrum. In case their experiments are found successful, there might be demand for regular assignment of spectrum in these bands or sub-1 GHz bands.”*

- 1.13 In this regard, information was also sought from NCRTC and the Ministry of Railways vide letters dated 28<sup>th</sup> December 2021. While seeking information, Ministry of Railways was also requested to share its views on sharing of 5 MHz (paired) spectrum assigned to IR with NCRTC.

- 1.14 Ministry of Railways in its response dated 7<sup>th</sup> January 2022, informed that based on the discussions held on the subject matter, vide letter

dated 8<sup>th</sup> November 2021, NCRTC has been advised that due to strong possibility of interference in safety and security application and throughput requirements, Indian railways is not in agreement to share the limited spectrum allotted for captive use.

1.15 NCRTC vide its response dated 7<sup>th</sup> January 2022 while providing the information/clarifications sought, also informed that in view of the urgent requirement of spectrum, a meeting was held on 11<sup>th</sup> December 2021 chaired by Hon'ble Minister of Railways and Minister of Communications which was attended by the Secretary DoT, Secretary, Ministry of Housing and Urban Affairs (MoHUA), Chairman, Railway Board, Managing Director, NCRTC and other senior officials of Indian Railways, DoT and NCRTC. Following the deliberation, it was decided that:

- a) Allocation of new spectrum of 5 MHz (paired) spectrum in 700 MHz band will be made to NCRTC/Metro expeditiously, TRAI has been requested to commence the consultation for the same.
- b) As an interim measure NCRTC will be allocated 1.4 MHz (paired) spectrum presently allocated to Indian Railways for GSM-R in 900 MHz band for setting up LTE network to enable commissioning of priority section of RRTS in Azadi ka Amrut Mahotsav.

1.16 In view of the above background, this consultation paper has been prepared to discuss and deliberate the issues involved. This chapter provides the background information. Chapter-II examines the issues involved and Chapter-III summarizes the issues for consultation.

## CHAPTER- II: EXAMINATION OF ISSUES - SPECTRUM REQUIREMENT OF NCRTC AND FOR OTHER RRTS/METRO RAIL NETWORKS

### A. About RSTT

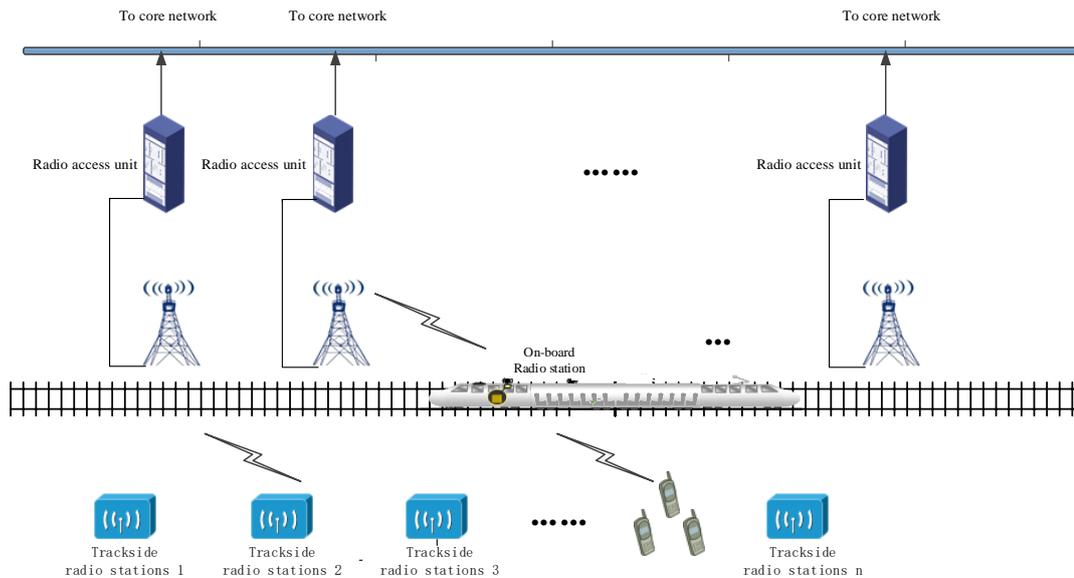
2.1 Railway Radiocommunication Systems between Train and Trackside (RSTT) provide improved railway traffic control, passenger safety and security for train operations. RSTT carry train control, voice dispatching, command, operational information as well as monitoring data between on-board radio equipment and related radio infrastructure located along trackside.

2.2 The main elements<sup>1</sup> of the RSTT may consist of on-board radio equipment, radio access units and other trackside radio infrastructure. Other systems, such as the core network, etc., are supporting systems for the RSTT.

- *Radio access unit*: including antenna and base station, to provide radio access to the terminals (especially cab radio)
- *On board radio equipment*: Radio equipment installed on train as well as handsets (for example, mobile terminals of automatic train control – ATC)
- *Other trackside radio infrastructure*: Radio infrastructure operating along trackside (for example: shunting radio devices)

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<sup>1</sup> ITU Report: Description of RSTT [ITU-R M.2418-0]



**Figure 2.1: Diagram of the architecture of RSTT<sup>2</sup>**

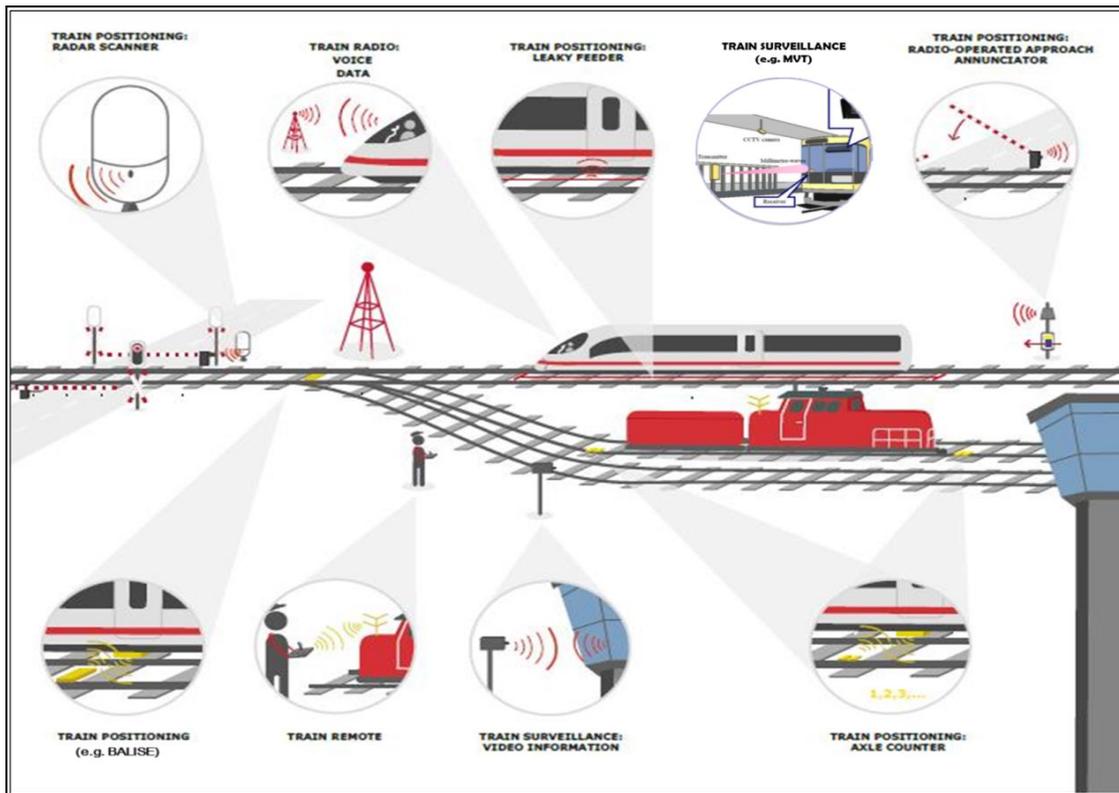
### **Applications of RSTT**

2.3 In general, the main application of RSTT can be categorized into four types, including train radio, train positioning, train remote and train surveillance.

- **Train Radio:** It is used for communication between train and track side for signalling and traffic management with the aim to contribute to safe train operation. Train radio provides mobile interconnect to landline and mobile-to-mobile voice communication and serves as the data transmission channel within various bearer services (Maintenance, Emergency, Train Control (Movement Authorization), Train information (both to train operators & Passengers). For voice communication Train radio provides call functions (point-to-point / group / emergency / conference/ broadcast) with specialized modes of operation (e.g., location depending addressing, functional addressing, call priorities, Push-to-Talk, late-entry and pre-emption).

<sup>2</sup> APT Report on system description, technologies and implementation of RSTT (APT/AWG/REP-78)

- Train Positioning Information: It provides high precision information about the position of trains, location of all units on trackside, motion parameter (speed, distance) of the approaching rolling stock and any obstacle on the tracks in normal and high-speed operation. This information is obtained by detection systems such as Balises, Loops/Leaky cable, Annunciators, Radars, Axle counters. The relevant positioning information can be repeated also by other means, e.g., train radio.
- Train Remote: This application provides data communication between a locomotive and a ground-based system in order to control the engine. The remote driver can operate the locomotive via the ground system. This application enables and allows remote controlled movement of trains typically for shunting operation in depots, shunting yards and/or for banking. This application provides a point to point localized functionality to control trains in an assemble/disassemble operation.
- Train Surveillance: Train surveillance systems enable the capture and transmission of video of the public and trackside areas, driver cabs, passenger compartments, platforms and device monitoring. A set of cameras at specific locations (front, interior, rear view) is used in low to high resolution, low and high framerates depending on the event. Data may be either stored on-board/locally or streamed (e.g., real-time video) to control centres via dedicated radio communication system.



**Figure 2.2: RSTT Services** (Source: ITU)

### **ITU on RSTT**

- 2.4 Resolution 236 (WRC-15)<sup>3</sup> recognized that timely studies are required on technologies providing for railway radiocommunication and that international standards and harmonized spectrum would facilitate worldwide deployment of RSTT. Further, it invited ITU-R to study the spectrum needs, technical and operational characteristics, and implementation of RSTT.
- 2.5 The Resolution 240 of WRC-19<sup>4</sup> – “*Spectrum harmonization for railway radiocommunication systems between train and trackside (RSTT) within the existing mobile-service allocation*” considered that railway transportation contributes to global economic and social development, especially for developing countries. It also considered that spectrum harmonization of the train radio application of RSTT may have priority

<sup>3</sup> [https://www.itu.int/dms\\_pub/itu-r/oth/0c/0a/ROCOA00000C0012PDFE.pdf](https://www.itu.int/dms_pub/itu-r/oth/0c/0a/ROCOA00000C0012PDFE.pdf)

<sup>4</sup> [https://www.itu.int/dms\\_pub/itu-r/opb/act/R-ACT-WRC.14-2019-PDF-E.pdf](https://www.itu.int/dms_pub/itu-r/opb/act/R-ACT-WRC.14-2019-PDF-E.pdf)

among the four categories of RSTT applications viz. train radio, train positioning information, train remote and train surveillance; because the train radio application provides for train dispatching, train control and other important railway services which are used to ensure the safety of passengers and train operations and require high reliability and high quality of services. It also considered that there may be a need to integrate different technologies across multiple bands to facilitate various functions, for instance dispatching commands, operating control and data transmission, into railway train and trackside systems to also meet the needs of a high-speed railway environment.

2.6 The WRC-19 also considered that the technologies for RSTT are evolving, and international or regional organizations, such as the 3rd Generation Partnership Project (3GPP), the International Union of Railways (UIC), the European Telecommunications Standards Institute (ETSI), the European Union Agency for Railways (ERA), etc., are developing specifications for technologies and new functions to evolve RSTT. The implementation of evolving RSTT needs to take account of the development of the railway industry. The deployment of RSTT requires significant long-term investment and a stable radio regulatory environment. The international standards and harmonized spectrum could facilitate deployment of RSTT and provide economies of scale for the railway industry and the harmonization of frequency bands for RSTT does not preclude the use of these frequency bands by any other application of services to which they are allocated.

2.7 The WRC-19 considering above has resolved that to encourage administrations, when planning for their RSTT to consider the study results and other relevant ITU-R Recommendations/Reports with a view to facilitating spectrum harmonization for RSTT, in particular for train radio applications.

2.8 Further, it invited ITU-R Sector to continue development of the ITU-R Recommendation recognizing addressing spectrum harmonization for

RSTT in a timely manner and to further develop and update ITU-R Recommendations/Reports concerning the technical and operational implementation of RSTT, as appropriate.

2.9 The ITU Radiocommunication Assembly, by recognizing Resolution 240 of WRC-19 and that work on draft new Recommendation ITU-R M.[RSTT\_FRQ] was not concluded in the study cycle 2015-2019, has decided for following questions to be studied:

- (i) What are the current and future technologies to maximize efficient and flexible use of spectrum to be used by RSTT?
- (ii) What are the capabilities of the applications of the four RSTT categories (Train radio, Train positioning information, Train remote and Train surveillance) in specific frequency bands?
- (iii) What are the possible solutions and implementation for global/regional harmonization of frequency bands for RSTT focused on bands already allocated to the Mobile Service on a primary basis?

It has decided that the results of the above studies should be included in one or more Recommendation(s) and/or Report(s) and it should be completed by 2023.

2.10 Ongoing study within Working Party 5A is the working document towards a preliminary draft new Recommendation<sup>5</sup> ITU-R M.[RSTT\_FRQ] “Harmonization of frequency bands for railway radiocommunication systems between train and trackside”. Frequency ranges under consideration in ITU-R for a possible regional/global spectrum harmonization for RSTT are available in **Annexure 2.1**.

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<sup>5</sup> <https://www.itu.int/md/R19-WP5A-C-0359/en>

## **European Railway Traffic Management System (ERTMS)**

- 2.11 European Railway Traffic Management System (ERTMS)<sup>6</sup> was developed by European signalling suppliers (UNISIG), European Railways and the GSM-R industry acting together under the guidance of the European Commission. It comprises of European Train Control System (ETCS) for signalling, control and train protection & Global System for Mobile Communications – Railways (GSM-R) for voice and data communication between the track and the train.
- 2.12 ETCS<sup>7</sup> aims to standardize the signalling and train control systems and remove the hindrance to the development of international rail traffic. It specifies for compliance with the High Speed and Conventional Interoperability Directives. It provides an inherently safe operational environment for the movement of trains throughout the network, while facilitating a greater network carrying capacity. It does this through the real-time monitoring, capture and analysis of data relating to movement authorities, precise train location, train speed, braking curves and system integrity. Based upon the analysis of this data, appropriate control orders are issued so that rail traffic operates with the shortest, most efficient, but safest headways.
- 2.13 ETCS offers five functional levels<sup>8</sup> - Level 0, Level STM, Level 1, Level 2, Level 3. The definition of the level depends on how the route is equipped and the way in which information is transmitted to the train.
- Level 0 is meant for trains equipped with ETCS running along non-equipped lines.
  - Level Specific transmission module (STM), is meant for trains equipped with ETCS running on lines where the class B system needs to be operated. Regarding the STM level, the ETCS acts as

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<sup>6</sup> <http://irse.org.hk/eNewsletter/issue06/Technical-Articles/ETCS/ETCS.htm>

<sup>7</sup> <https://www.rssb.co.uk/rgs/standards/GEEN8605%20Iss%201.pdf>

<sup>8</sup> [https://ec.europa.eu/transport/modes/rail/ertms/what-is-ertms/levels\\_and\\_modes\\_en](https://ec.europa.eu/transport/modes/rail/ertms/what-is-ertms/levels_and_modes_en)

an interface between the driver and the national Automatic train protection (ATP).

- Level 1 involves continuous supervision of train movement while a non-continuous communication between train and trackside (normally by means of Euro-balises). Lineside signals are necessary and train detection is performed by the trackside equipment.
- Level 2 involves continuous supervision of train movement with continuous communication, which is provided by GSM-R, between both the train and trackside. Lineside signals are optional in this case, and train detection is performed by the trackside equipment.
- Level 3 is also a signalling system that provides continuous train supervision with continuous communication between the train and trackside. The main difference with level 2 is that the train location and integrity is managed within the scope of the ERTMS system, i.e., there is no need for lineside signals or train detection systems on the trackside other than Euro-balises. Train integrity is supervised by the train, i.e., the train supervises itself to ensure that no coach is accidentally split.

### **Train Radio Technologies**

2.14 The railway industry has been using wireless systems<sup>9</sup> for operational applications for many years. Many long distance and high-speed trains deploy GSM-R and TETRA (another European Standard) networks both for operational voice communications between train drivers and train controllers as well as to carry train signalling and control information. To enhance the Railway Radiocommunication System with broadband capabilities in order to get a greater degree of graphical, and real-time audio-visual functions, along with extensive real-time train monitoring

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<sup>9</sup> [http://www.apr.int/sites/default/files/Upload-files/AWG/APT-AWG-REP-78\\_APT\\_Report\\_RSTT\\_System\\_Description.docx](http://www.apr.int/sites/default/files/Upload-files/AWG/APT-AWG-REP-78_APT_Report_RSTT_System_Description.docx)

and control, the next generation of Train Radio technology based on LTE is being developed.

2.15 LTE is able to serve terminals being mounted on or being integrated in trains from base stations along the trackside. In addition, relaying and direct device-to-device (D2D) communications are also supported. LTE wireless communications has been picked up by many countries as the technology of choice to support mission-critical voice and broadband services for RSTT. LTE characterizes high speed, high security and high-bandwidth capacity that allows it to carry voice and data for train control, on-board video surveillance and infotainment services for passengers on a single IP network. It has latency as 10 milliseconds allowing for support of time-sensitive applications and providing quality of service management. As for GSM-R, LTE-R includes specifically designed algorithms to deliver superior Quality of Services at highest train speeds.

**Table 2.1: Usage of LTE based RSTT (Source: ITU)<sup>10</sup>**

<b>Country</b>	<b>Radiocomm unication Standards</b>	<b>Specific Name</b>	<b>Frequency Range</b>	<b>Data Rates (kbps)</b>	<b>Transmi ssion distance</b>
South Korea	TTAK.KO-06.0438	LTE-R	718-728 773-783	DL: 75000 UL: 37000	-
Australia	3GPP LTE-Adv	Trans-continental NextG (ARTC)	703-803	DL (max): 75000 UL (max): 37000	10-72 km
Australia	3GPP LTE-Adv	Urban Train Radio	1710-1880	DL (max): 34000 UL (max): 16000	10-30 km
Australia	3GPP LTE-Adv and beyond	Train Control Radio Digital Train Radio System (DTRS) ETCS Level 2 (proposed)	UL: 1770-1785 / DL: 1865-1880	DL (max): 110000 MIMO UL (max): 38000	1-5 km

<sup>10</sup> [https://www.itu.int/dms\\_pub/itu-r/opb/rep/R-REP-M.2442-2019-PDF-E.pdf](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2442-2019-PDF-E.pdf)

2.16 As already discussed, Indian Railways has been assigned 5 MHz (paired) spectrum in 700 MHz band for deploying LTE based Public Safety and Security services at stations and in the Trains for Captive use.

**B. Spectrum Assignment to NCRTC and other RRTS/metro rail networks to meet the RSTT requirement**

2.17 NCRTC a Joint Venture company of the Government of India and states of Haryana, Rajasthan and Uttar Pradesh and Delhi, is mandated for implementing the Regional Rapid Transit System (RRTS) project across the National Capital Region (NCR), ensuring a balanced and sustainable urban development through better connectivity and access. is under administrative control of Ministry of Housing & Urban Affairs (MoHUA).

2.18 NCRTC was formally incorporated on 21st August 2013 as a Company under the Company Act, 1956. As a joint 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.

2.19 NCRTC is implementing the Regional Rapid Transit System (RRTS) in 8 rail corridors including 3 rail corridors of approximate length of 350 km along (i) Delhi-Ghaziabad-Meerut, (ii) Delhi-Gurugram-Alwar, (iii) Delhi-Panipat in Phase-I. Other 5 (five) corridors will be taken up in phase-II, which are under planning stage. The corridors in phase-II includes (iv) Delhi – Faridabad – Palwal, (v) Ghaziabad – Khurja, (vi) Delhi – Bahadurgarh – Rohtak, (vii) Ghaziabad – Hapur, and (viii) Delhi – Shahdara – Baraut. These railway-based systems are designed for the speed of 180 Kilometer per hour (Kmph). Public safety, security and efficient Train Control System are of paramount considerations in such high-speed train operations. NCRTC has, decided to deploy ETCS level-

2 signalling system, mission critical voice, IoT based asset monitoring services and video surveillance from the train for captive use.

2.20 The table below provides the uplink throughput requirements per sector at cell edge for NCRTC, as provided by NCRTC:

**Table 2.2: Uplink throughput requirements per sector at cell edge for NCRTC**

Services	UpLink throughput requirements (kbps)	Users	Total Uplink throughput requirements (kbps)
MCPTT	25 kbps	15	375 kbps
ETCS signalling	10 kbps	8	80 kbps
Rolling Stock Health Monitoring	1000 kbps	1	1000 kbps
On-Board Surveillance	500 kbps	2	1000 kbps
Trackside Health Monitoring (IoT)	56 kbps (lower end)	10	560 kbps
Total Uplink Throughput Requirement (kbps)			3015 kbps

Source: NCRTC

2.21 In view of the above, NCRTC has requested DoT for allocation of 5 MHz spectrum in 700 MHz or 900 MHz band for operating mission critical services (signalling and voice & asset monitoring) along the RRTS Corridor. DoT in its back reference on ‘Auction of Spectrum in frequency bands identified for IMT/5G’ dated 29<sup>th</sup> April 2022, while providing views of DoT, has, inter-alia, mentioned that:

*“Request of NCRTC for assignment of 5 MHz (paired) spectrum in 700 MHz band for their LTE-based RRTS System is separately under process in the Department. DoT has sought recommendations of TRAI on spectrum requirements of NCRTC and sharing of same spectrum with other RRTS/metro rail networks. Accordingly, 5 MHz (paired) quantum in 700 MHz band may be*

*reserved in 700 MHz band and not included in the spectrum availability for the forthcoming auction.”*

- 2.22 NCRTC priority section of Sahibabad to Duhai of 1<sup>st</sup> corridor (Delhi – Ghaziabad-Meerut) is to be commissioned by December 2022. In view of urgent requirement of spectrum by NCRTC, as an interim measure, NCRTC has been allocated 1.4 MHz (paired) spectrum, presently allocated to IR for GSM-R, in 900 MHz band on temporary basis for setting up LTE network to enable commissioning of priority section of RRTS in Azadi ka Amrut Mahotsav.
- 2.23 DoT in its reference has requested TRAI to provide its 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.
- 2.24 As per the 3GPP band plan B28 adopted by India for 700 MHz band, 45 MHz (paired) spectrum can be utilized in this band. However, 10 MHz (paired) spectrum has been earmarked for government use and 5 MHz (paired) spectrum has been assigned to Indian Railways for LTE-based public safety and security services (train signalling system for safety and security) across the railway track. Therefore, 30 MHz (paired) spectrum is available for commercial purpose in each of the 22 LSAs in this band. In case 5 MHz (paired) spectrum is earmarked for NCRTC and other RRTS/metro rail networks pan India, only 25 MHz (paired) spectrum will be left for commercial use. One view could be that since 700 MHz band is a prime coverage band for 5G, the remaining spectrum may not be enough for the TSPs for commercial purpose. Another view could be that 30 MHz (paired) spectrum in 700 MHz was put to auction in March 2021; however, no bid was received and leaving the valuable spectrum idle is an economic loss for the nation. Further, since IR has been assigned 5 MHz (paired) spectrum in 700 MHz band, if other rail networks are also assigned spectrum in 700 MHz band, the development of ecosystem for RSTT in this band could be faster,

resulting in economies of scale and thus benefit the people of the country at large.

2.25 It is noted that TRAI had earlier in the month of June 2018, in its recommendations on “Next Generation Public Protection and Disaster Relief (PPDR) communication networks”, had inter-alia, recommended that that 2x10 MHz of dedicated spectrum, 814-824/859-869 MHz, should be assigned for nationwide BB-PPDR services. As per the NFAP released by DoT in October 2018, spectrum bands identified for PPDR includes 380-387.5/390-397.5 MHz, 410-417.5/420-427.5 MHz, 806-811/851-856 MHz and 4940-4990 MHz. In addition, NFAP 2018 also indicates that part of 440-470 MHz may be considered for PPDR. However, no deployment of Next Generation PPDR Communication network has taken place so far. Further, spectrum in 800 MHz band is assigned / earmarked for PMRTS, which is migrating from analog to digital, enhancing spectrum efficiency. Therefore, there may be spectrum availability in 800 MHz band, which may be sufficient to fulfill the requirement of NCRTC for RSTT.

2.26 Another view could be that- as 600 MHz band has been earmarked in India for IMT and technical characteristics of 600 MHz are similar to that of 700 MHz band, some spectrum could be earmarked for NCRTC and other RRTS/Metro rail networks in this band. TRAI in its recent recommendation on ‘Auction of spectrum in frequency bands identified for IMT/5G’ dated 11<sup>th</sup> April 2022, has recommended that for 600 MHz frequency range 612-703 MHz, Band Plan APT 600 (Option B1) should be adopted in India. While recommending this, it was, inter-alia, mentioned that:

*“APT Wireless Group (AWG) has invited 3GPP to immediately start work on technical specifications to support Option B1 and 3GPP has already conducted a study on ‘Extended 600 MHz NR band (Release 17)’ [3GPP TR 38.860 V17.0.0 (2021-09) Technical Report, wherein option B1 and B2 were proposed for this band, the release*

*of technical specifications may not take too long. Further, with the decision of APT, the work on development of device ecosystem would have already begun.”*

- 2.27 Since spectrum requirement for signalling purpose in Railway Networks is of the nature of low bandwidth and high coverage, spectrum in sub-1 GHz bands will be suitable to meet the requirement. Further, since NCRTC is deploying LTE based networks for implementation of ETCS level-2 signalling system and some part of the phase-I network is almost ready for commissioning, it will be prudent that spectrum is assigned in a spectrum band where LTE ecosystem already exists.
- 2.28 In view of the forgoing discussion, first set of issues which needs deliberation is on the spectrum band in which spectrum should be assigned to NCRTC, which can also be allocated to other RRTS/metro rail networks and how much spectrum should be assigned for such purpose.

#### **Issues for Consultation**

**Q1. In which band, spectrum should be assigned to NCRTC for their LTE-R technology based Train control system for RRTS rail corridors?**

**Q2. How much spectrum in the spectrum band(s) suggested in response to Q1, should be assigned to NCRTC to meet its requirement for its RRTS LTE-R based network?**

#### **C. Allocation of same spectrum for other RRTS/Metro rail networks**

- 2.29 DoT in its reference has requested TRAI to provide recommendations on assignment of the same spectrum (spectrum that will be assigned to NCRTC) to other RRTS/metro rail networks pan-India. TRAI vide its letter dated 28<sup>th</sup> December 2021 had requested DoT to share the details

of demand for spectrum requirement received from other RRTS / Metro rail network service providers, if any. DoT vide its letter dated 4<sup>th</sup> May 2022 has informed that no other requests for spectrum requirements from other RRTS/metro/rail networks have been received in DoT.

2.30 While no request for spectrum requirements from other RRTS/Metro rail networks have been received so far by DoT, the possibility of such demand in future in other States of the country cannot be ruled out. Such kind of other RRTS/Metro rail network expected to come up in future may be owned and operated by the Government or Government agencies like Public Sector Units. It is also possible that such future RRTS/Metro rail network operates under Public Private Partnership (PPP) Model or wholly owned by private entities. It is noticed that the spectrum that will be assigned to NCRTC for Regional Rapid Transit System will be used in 8 corridors spreading across four States/UT of India viz. Haryana, Rajasthan, Uttar Pradesh, and Delhi. Considering the future spectrum requirement in other parts of the country, it may be prudent to keep the same spectrum reserved for captive usage for rail networks in India. This may also bring in cost efficiencies.

2.31 Assignment of same spectrum to different RRTS/metro rail networks could involve two different scenarios, (i) where two RRTS/Metro rail networks are geographically separated and (ii) where more than one rail or Metro networks are existing in the overlapping geographical area. These scenarios and issues, which may require deliberation are discussed below:

**(a) Assignment of same spectrum for RRTS/Metro rail networks which are geographically separated**

2.32 For assignment of same spectrum to different RRTS/metro rail networks, which are operating in geographically separated manner such that, there is no interference, it can be easily done without any

complication. For applicability of terms and conditions, the same can be made applicable to each of the RRTS/Metro rail network individually.

- 2.33 The Authority, in its Recommendations on 'Allotment of spectrum to Indian Railways for Public Safety and Security services' dated 25<sup>th</sup> October 2019, had inter-alia recommended that:

*“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.”*

- 2.34 Therefore, for assignment of spectrum to different RRTS/metro rail networks, which are operating in geographically different areas, the government will be having the option to assign the same spectrum which will be assigned to NCRTC, if the geographical area of new RRTS/metro rail network is different from NCRTC corridors and other RRTS/metro rail networks. In view of the TRAI recommendations mentioned above at Para 2.33, the government will also be having the option to assign the same spectrum which has been assigned to Indian Railways, if the geographical area of new RRTS/metro rail network is different and away from Indian Railways rail network, subject to condition that there is no interference to the Indian Railway's network from such assignment. Having said that, since IR has a rail network size of about 68000 route Km spread across the country, the possibility of an RRTS/Metro rail network coming up in an area where it can operate on spectrum frequencies assigned to IR without causing any interference to IR, appears to be remote. There can also be a possibility of using a mix of the two options mentioned above.

## **Issues for Consultation**

**Q3. Do you see any challenge, if the same spectrum is assigned to different RRTS/metro rail networks, operating in geographically separated areas/corridors in the country? If yes, kindly provide details and possible solutions.**

### **(b) Assigning same spectrum to more than one RRTS Metro/rail networks operating in the overlapping geographical area**

2.35 Under this scenario, more than one RRTS Metro/rail network may operate in (i) overlapping geographical area or (ii) geographically closely operating in some stretches of the network.

2.36 DoT vide its letter dated 4<sup>th</sup> May 2022, while responding to TRAI's specific query regarding reasons for not exploring spectrum sharing between IR and NCRTC, DoT has informed that:

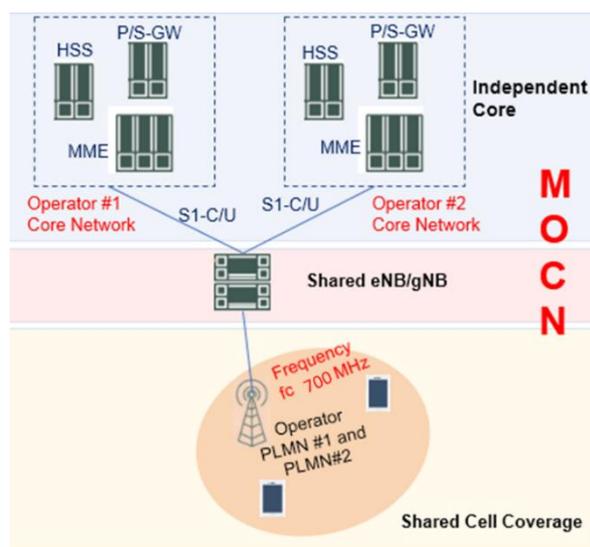
“With regard to NCRTC's request for assignment of spectrum in 700 MHz band, DoT has decided that as in the case of Indian Railways, NCRTC also carries passengers and spectrum will be used for mission critical safety applications of signalling and train control, therefore, separate spectrum may be required since the services involve safety of life.”

2.37 From the above, it can be inferred that sharing of spectrum assigned to Indian Railways (IR) with NCRTC is not being considered by DoT. However, TRAI recommendations have also been sought on assignment of the same spectrum (spectrum that will be assigned to NCRTC) to other RRTS/metro rail networks which may be planned/established anywhere in India. There could be a case that any two or more RRTS/Metro rail networks may have some overlapping geographical areas, may it be a cross over, parallel route or any other kind of overlapping. Since more than one radio network working on same

spectrum frequencies will create interference issues, there is a need to explore the options to have interference free use of same spectrum by more than one agency.

2.38 One option to avoid interference between two RRTS/Metro rail networks in overlapping geographical area could be the sharing of Radio Access Network (RAN). In case more than one RRTS Metro/rail networks are to operate on same spectrum frequencies in overlapping geographical area, the RRTS Metro/rail networks may share the Radio Access Network (RAN) in the overlapping area, which is known as Multi-Operator Core Network (MOCN).

2.39 MOCN is one of the widely used feature available in versions 3GPP Release 8 available since 2008 allows RAN sharing (Radio Access Network - eNodeB) by multiple EPCs (Evolved Packet Core) of different operators. This allows full availability of bandwidth to multiple networks without interference. This can be achieved by adding additional sector/cell in the section of potential interference. MOCN functionality allows the network operator to provide access to same radio network to other operators. Each operator operates its own core network, including one or more independent nodes. Multiple cores may coordinate with each other regarding interference, backhaul, traffic prioritization, individual user authentication, and other parameters through the software to enable end user QoS. The RAN Controller and network software act as a router for different operator core networks connecting user terminals.



**Figure 2.3: Multi-Operator Core Networks**

2.40 With regards to MOCN deployment, it is noted that in 2017, South Korea launched LTE-R for commercial use with 10 MHz (paired) spectrum. However, the assigned 10 MHz (paired) spectrum is common for integrated public network shared for LTE- Public Safety, LTE-Maritime and LTE-Railway. The State-run Korea Rail Network Authority designated KT, Korea’s second largest wireless carrier for the project. To optimize interference, the concerned agencies (Ministry of Land, Infrastructure & Transport; Ministry of Interior & Safety; and Ministry of Oceans & Fisheries) have established Standard Operating Procedure (SOP). RAN Sharing takes place between integrated public networks, resource allocation rules and standard interworking procedures have been set up.

2.41 In case, it is decided that RRTS Metro/rail networks may share the Radio Access Network (RAN) in the overlapping area using Multi-Operator Core Network (MOCN), to take care of a future situation, where another RRTS/Metro rail network may come up in the overlapping geographical area, while assigning the spectrum, it may be clearly mentioned that the same spectrum may be assigned to other RRTS/Metro rail networks in the same geographic area on sharing basis.

2.42 Further, in MoCN, two or more RRTS/Metro rail networks may share the RAN in the overlapping geographic area, which will be connected to their individual core networks. If one RRTS/Metro rail RAN has already been deployed and another RRTS/metro rail network is assigned spectrum in overlapping area on sharing basis, it needs to be explored that what could be the practical difficulties and possible solutions for sharing of RAN. To ensure that the RAN sharing between RRTS/Metro rail networks is done in a smooth manner, there may be a need to put in place guidelines for coordination mechanism.

#### **Issues for Consultation**

- Q4. In case more than one RRTS Metro/rail networks are to operate in overlapping geographical areas, will it be appropriate for RRTS Metro/rail networks to share the Radio Access Network (RAN) in the overlapping areas using Multi-Operator Core Network (MOCN)? Any other feasible mechanism for using same spectrum in overlapping areas may also be suggested with detailed explanation. Kindly justify your response.**
- Q5. In case it is decided that RRTS Metro/rail networks may share the Radio Access Network (RAN) in the overlapping area using Multi-Operator Core Network (MOCN),**
- a) Whether it should be included in the terms and conditions for assignment of spectrum that the assigned spectrum may have to be shared with other RRTS/Metro rail networks to whom government decides to assign the same spectrum frequencies on sharing basis?**
  - b) Whether certain guidelines for coordination mechanism need to be issued or it should be left to the mutual agreement between the RRTS/Metro rail network operators mandated for MOCN RAN sharing? In case,**

**guidelines need to be prescribed, kindly suggest the points to be included in the guidelines.**

- c) Whether commercial arrangements between two RRTS/Metro rail networks for RAN sharing needs to be regulated or left to the mutual arrangement?**
- d) Whether any other conditions need to be prescribed for such RAN sharing? Kindly provide detailed justifications.**

#### **D. License requirement**

2.43 NCRTC and other RRTS/metro rail networks will be using the spectrum for captive use and not for offering any commercial telecom services. However, for establishing wireless captive network using specifically assigned spectrum, an entity should have a permission/license under Section 4 of the Indian Telegraph Act, 1885 to do so. Subsequently, the entities holding such permission/license under section 4 of the Indian Telegraph Act, 1885 may obtain spectrum from DoT for establishing Captive wireless network. The examples of similar type of captive licenses are Captive Mobile Radio Trunking Service (CMRTS) license and Captive VSAT CUG Service license. Therefore, prior to assignment of spectrum to any private entity, the entity must have requisite permission/license under section 4 of the Indian Telegraph Act, 1885.

2.44 The Authority in its recent recommendations on ‘Auction of Spectrum in frequency bands identified for IMT/5G’ dated 11<sup>th</sup> April 2022, under the Chapter on Spectrum for Private Cellular Networks has, inter-alia, recommended that:

*“..for establishing isolated captive wireless private network using IMT spectrum, the entity/enterprise should be provided a Permission/license under Section 4 of the Indian Telegraph Act, 1885. The permission/license may be named as ‘Captive Wireless Private Network (CWPN) permission/License’.”*

2.45 Therefore, one option could be that for NCRTC and other RRTS/metro rail networks also, CWPN Permission/License be made applicable. Another view could be that since Rail/Metro networks involve issues relating to public safety and security and the area of its operation is not limited to a particular geographic area but the train pass through the open area (which may cover more than one LSA), where public cellular networks also operate, a separate category of Permission/License for Captive Wireless Networks for Train Signalling System could be created. However, the Permission/Licensing regime for Captive Wireless Networks for Train Signalling System may be kept very simple and light touch.

#### **Issues for consultation**

**Q6. What should be the permission/licensing regime for operation of wireless networks for NCRTC and other RRTS/metro rail networks? Kindly justify your response with justification.**

**Q7. What should be the broad terms and conditions, which may be included in the Permission/License. Kindly provide detailed response with justification.**

#### **E. Spectrum Charges**

2.46 As regards spectrum charges, TRAI in its recommendation on 'Allotment of spectrum to Indian Railways for Public Safety and Security services' dated 25<sup>th</sup> October 2019 had recommended that:

*“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.”*

- 2.47 The above TRAI Recommendations on ‘Allotment of spectrum to Indian Railways for Public Safety and Security services’ dated 25<sup>th</sup> October 2019 have been accepted by DoT.
- 2.48 Presently, 1.6 MHz spectrum in 900 MHz band and 5 MHz (paired) in 700 MHz band has been assigned to IR on administrative basis for captive usage of their GSM-R based network. Spectrum charges for this spectrum are levied on formula basis as per Orders No. P-11014/34/2009-PP(II) and P-11014/34/2009-PP(IV) dated 22<sup>nd</sup> March 2012.
- 2.49 As already discussed, NCRTC is a Joint Venture company of the Government of India and states of Haryana, Rajasthan and Uttar Pradesh and Delhi. NCRTC was formally incorporated on 21st August 2013 as a Company under the Company Act, 1956. As a joint 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.
- 2.50 For the temporary spectrum assignment made to NCRTC i.e., 1.4 MHz (paired) spectrum in 900 MHz band also, the spectrum charges have been calculated based on the formula-based charging as done in the case of IR.
- 2.51 In its reference dated 29<sup>th</sup> November 2021, DoT has mentioned that as is the case of Indian Railways, NCRTC also carries passengers and spectrum will be used for mission critical safety applications of signalling and train control. DoT has also mentioned separate spectrum is required since the services involve safety of life. Further, DoT has,

inter-alia, requested TRAI to provide recommendations on administrative assignment of spectrum to NCRTC.

- 2.52 In view of the above, the issue that needs to be deliberated is what should be the spectrum charging mechanism for the spectrum that will be assigned to NCRTC and other RRTS/Metro Rail networks.

#### **Issues for Consultation**

- Q8. Would it be appropriate if the spectrum be allocated on the same analogy as Indian Railways, for the same reasons as argued by DoT? If not, what should be the spectrum charging mechanism for spectrum that will be assigned to NCRTC? Kindly provide detailed response with justification.**
- Q9. Whether the terms & conditions and spectrum charges that will be applicable for NCRTC, should be made applicable to the other RRTS/Metro rail networks that may come up in future? If no, what terms & conditions and spectrum charges should be made applicable for the other RRTS/Metro rail networks? Kindly justify your response.**
- Q10. Any other issues/suggestions relevant to the subject, may be submitted with proper explanation and justification.**

### **CHAPTER- III: ISSUES FOR CONSULTATION**

- Q1. In which band, spectrum should be assigned to NCRTC for their LTE-R technology based Train control system for RRTS rail corridors?**
- Q2. How much spectrum in the spectrum band(s) suggested in response to Q1, should be assigned to NCRTC to meet its requirement for its RRTS LTE-R based network?**
- Q3. Do you see any challenge, if the same spectrum is assigned to different RRTS/metro rail networks, operating in geographically separated areas/corridors in the country? If yes, kindly provide details and possible solutions.**
- Q4. In case more than one RRTS Metro/rail networks are to operate in overlapping geographical areas, will it be appropriate for RRTS Metro/rail networks to share the Radio Access Network (RAN) in the overlapping areas using Multi-Operator Core Network (MOCN)? Any other feasible mechanism for using same spectrum in overlapping areas may also be suggested with detailed explanation. Kindly justify your response.**
- Q5. In case it is decided that RRTS Metro/rail networks may share the Radio Access Network (RAN) in the overlapping area using Multi-Operator Core Network (MOCN),**
- a) Whether it should be included in the terms and conditions for assignment of spectrum that the assigned spectrum may have to be shared with other RRTS/Metro rail networks to whom government decides to assign the same spectrum frequencies on sharing basis?**
  - b) Whether certain guidelines for coordination mechanism need to be issued or it should be left to the mutual**

**agreement between the RRTS/Metro rail network operators mandated for MOCN RAN sharing? In case, guidelines need to be prescribed, kindly suggest the points to be included in the guidelines.**

**c) Whether commercial arrangements between two RRTS/Metro rail networks for RAN sharing needs to be regulated or left to the mutual arrangement?**

**d) Whether any other conditions need to be prescribed for such RAN sharing? Kindly provide detailed justifications.**

**Q6. What should be the permission/licensing regime for operation of wireless networks for NCRTC and other RRTS/metro rail networks? Kindly justify your response with justification.**

**Q7. What should be the broad terms and conditions, which may be included in the Permission/License. Kindly provide detailed response with justification.**

**Q8. Would it be appropriate if the spectrum be allocated on the same analogy as Indian Railways, for the same reasons as argued by DoT? If not, what should be the spectrum charging mechanism for spectrum that will be assigned to NCRTC? Kindly provide detailed response with justification.**

**Q9. Whether the terms & conditions and spectrum charges that will be applicable for NCRTC, should be made applicable to the other RRTS/Metro rail networks that may come up in future? If no, what terms & conditions and spectrum charges should be made applicable for the other RRTS/Metro rail networks? Kindly justify your response.**

**Q10. Any other issues/suggestions relevant to the subject, may be submitted with proper explanation and justification.**

**Annexure-1.1: DoT reference dated 29th November 2021**

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

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

Date: 29.11.2021

To,

The Secretary  
Telecom Regulatory Authority of India  
Mahanagar Doorsanchar Bhawan  
Jawahar Lal Nehru Marg (Old Minto Road)  
New Delhi – 110 002.

**Subject: Seeking TRAI recommendations on the spectrum requirements of National Capital Region Transport Corporation (NCRTC) for their LTE technology based RRTS network.**

Sir,

Based on the TRAI recommendations dated 25.10.2019 on “Allotment of spectrum to Indian Railways for Public Safety and Security services”, Government has assigned 5 MHz (paired) spectrum in 700 MHz band to Indian Railways for their LTE technology-based proposed network.

2. Subsequently, 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. Letters dated 06.11.2019 and 10.08.2021 received from NCRTC are enclosed herewith for ready reference.

3. In their request, NCRTC has also informed that delay in sharing of spectrum assigned to Indian Railways is adversely affecting their August-2022 timeline for commissioning of 17 km-priority section of RRTS during 75<sup>th</sup> Anniversary of India’s Independence (Azadi ka Amrut Mahotsav) in 2022.

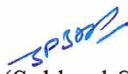
4. As in the case of Indian Railways, NCRTC also carries passengers and spectrum will be used for mission critical safety applications of signalling and train control. Separate spectrum is required since the services involve safety of life.

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

(i) 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.

(ii) Any other recommendations deemed fit for the purpose, including assignment of the same spectrum for other RRTS/metro rail networks pan-India.

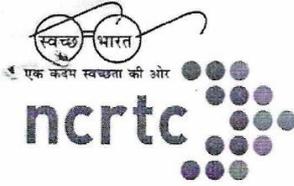
This issues with the approval of Hon'ble Minister for Communications.

  
(Sukhpal Singh)  
Joint Wireless Adviser

Enclosures:

(1) NCRTC's letters dated 06.11.2019 and 10.08.2021 regarding allotment of frequency spectrum to NCRTC for implementation of Train Control System for Regional Rapid Transit System.

(2) Brief note on RRTS, as provided by NCRTC.



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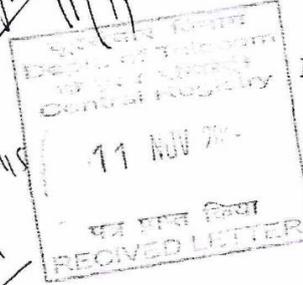
Annex-1  
www.ncrtc.in

भारतीय राष्ट्रीय राजधानी क्षेत्र परिवहन निगम  
(भारत सरकार एवं प्रतिभागी राज्य सरकारों का एक संयुक्त उपक्रम)  
National Capital Region Transport Corporation  
(A Joint venture of Government of India and participating State Governments)

No. NCRTC/S&T/2019/DoT/01

Date: 06.11.2019

The Secretary,  
Department of Telecommunications,  
Sanchar Bhawan, Ashoka Road,  
New Delhi-110001



**Subject: Allotment of frequency spectrum to NCRTC for implementation of Train Control System for Regional Rapid Transit System.**

National Capital Region Transport Corporation (NCRTC), a joint venture of GoI and four State government of National Capital region, is under the administrative control of Ministry of Housing & Urban Affairs, is implementing the Regional Rapid Transit System (RRTS). RRTS is a new, dedicated, high speed, high capacity, comfortable Rail based commuter service connecting regional nodes in NCR. In this important project, which will help in improving accessibility, 8 rail corridors are proposed to be implemented in NCR. The Regional Rapid Transit System is being established with an aim to decongest Nation Capital. Out of these 8 Corridors, following 3 corridors (approximate length 350km) shall be implemented in Phase-I.

gs 15/11/2019  
Sr. Director  
15-11-2019  
Alwar

- Delhi – Ghaziabad – Meerut
- Delhi – Gurugram – Alwar
- Delhi – Panipat

This railway based system is being designed for a speed of 180 Kmph, which will be the first of its kind in the country. Public safety, security and efficient Train Control System are of paramount considerations in such high-speed train operation. NCRTC has, therefore, decided to deploy ETCS level-2 signalling system, mission critical voice, IOT based asset monitoring services and video Surveillance from the train for captive use.

Registered & Corporate Office:  
7/6, सिरी फोर्ट इंस्टीट्यूशनल एरिया, अगस्त क्रांति मार्ग, नई दिल्ली 110049  
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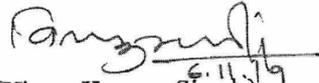
: 2 :

NCRTC has planned to deploy LTE as its communication backbone for signaling system and associated functions to meet public safety and security requirement. For this purpose, NCRTC would require 10 MHz (paired) in either 700 MHz band or 900 MHz band. This requirement of NCRTC is same as of Indian Railways.

It is learnt that TRAI on 25.10.2019, has recommended that Indian Railways (IR) may be allocated 5 MHz (paired) spectrum in 700 MHz band for captive use for implementing ETCS level-2 MC PTT + Voice, IoT based asset monitoring services, PIDS etc. TRAI has also recommended that DOT may explore the possibility of assigning the same spectrum in other areas for area specific limited use to other entities for captive use while ensuring that there is no interference to the Railways' network from such use.

The requirement of RRTS as brought out above, perfectly fits in these recommendations. In view of the requirement of RRTS signalling system as explained above and recommendations of TRAI for Indian Railways, NCRTC's requests for allotment of 5MHz (paired) spectrum instead of 10MHz (paired) in either 700 MHz or 900 MHz band for captive use of NCRTC which is in line with allotment to Indian Railways.

Yours sincerely

  
(Vinay Kumar Singh)



Vinay Kumar Singh, IRSE  
Managing Director

DO No. NCRTC/S&T/2021/DoT/17

Date: 10.08.2021

Dear Sir,

**Sub- Allotment of frequency spectrum to NCRTC for implementation of Train Control System for Regional Rapid Transit System.**

- Ref- 1. Letter number NCRTC/S&T/2019/DoT/01 dated 06.11.2019 to Secretary, DoT.  
2. Letter number NCRTC/S&T/2020/DoT/09 dated 21.05.2020 from Director (System & Operations)/NCRTC to Advisor, Wireless Planning Commission.  
3. Secretary, MoHUA DO number K-14011/17/2018-MRTS-I dated 04.08.2020 to Secretary, DoT  
4. Letter number NCRTC/S&T/2021/DoT/13 dated 09.07.2021 to Chairman, Railway Board.  
5. Letter number NCRTC/2021/DoT/16 dated 09.08.2021 to Member (Infrastructure), Railway Board.

As you are aware, Regional Rapid Transit System (RRTS) is being implemented by National Capital Region Transport Corporation (NCRTC) which is a 50:50 JV of Government of India and Governments of the four participating states of NCR. RRTS will be operated on ETCS Level 2 signalling system on LTE communication backbone by sharing the spectrum (5 MHz in 700 MHz frequency band) allocated to Indian Railways on 09.07.2021. NCRTC is in communication with Railway Board since 06.11.2019 to finalise the modalities to share the spectrum. TRAI had also recommended sharing of spectrum for captive use (25<sup>th</sup> Oct 2019).

2. On advice of Railway Board, NCRTC, had engaged a group of eminent experts to conduct "Study of feasibility of co-existence of two separate LTE networks of NCRTC and IR in the same spectrum without impacting ETCS and Mission Critical Services". The expert group is the same which was engaged by Indian Railways to study the feasibility of use of LTE technology on Indian Railways and consists of IIT Chennai represented by Dr. Ganti Radha Krishna, Dr. P Raja Goundan representing Associated Society – Centre for Excellence in Wireless Technology and Dr. Kuchi Kiran Kumar of IIT Hyderabad. The expert group has given technical clearance for the sharing and co-existence of both the systems in the same frequency band without any interference. This report was submitted to Railway Board on 21.05.2020. A detail note clarifying the issues raised by Ministry of Railways has also been submitted to Railway Board and subsequently was also shared with Department of Telecommunication vide this office letter no. NCRTC/S&T/2020/DoT/09 dated- 21.05.2020 (copy enclosed).

Page 1 of 2

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3. Subsequent to allotment of spectrum to IR, NCRTC has conducted meetings with Railway Board and RDSO on 22<sup>nd</sup> June, 25<sup>th</sup> June and 2<sup>nd</sup> July 2021 on the topic of LTE Deployment, co-existence and interference mitigation, wherein M/s Nokia (vendor for implementing LTE for RRTS project) was also present. Experts of M/s Nokia confirmed that there will be no impact on Indian Railway LTE network due to such sharing. It is in the best interest of the nation to utilize the spectrum as efficiently as possible, which LTE technology permits by enabling coexistence of two separate networks on the same spectrum.

4. Despite the impact on construction progress due to COVID-19, in line with Governments' directive, best efforts are being made to commission the 17-km priority section of RRTS during the 75th Anniversary of India's Independence (Azadi ka Amrut Mahotsav) i.e. in 2022. Ordering of long lead LTE equipment requires confirmation of frequency band. Delay in consent for sharing of allotted spectrum by Indian Railways is adversely affecting the August 2022 project timeline.

5. We seek your kind intervention for early approval for sharing of allotted spectrum of 5 MHz in 700 MHz band with NCRTC for deployment of ETCS L2 system for RRTS.

*With warm regards,*

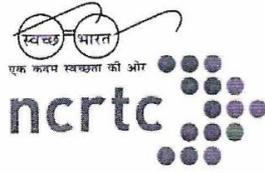
Yours Sincerely,



(Vinay Kumar Singh) 10.8.21

DA- As above.

**Sh. Anshu Prakash**  
**Secretary**  
**Department of Telecommunications**  
Sanchar Bhawan, Ashoka Road,  
New Delhi- 110001



गति से प्रगति

No. NCRTC/S&T/2020/DoT/09

Dated: 21/05/2020

**Wireless Advisor  
Wireless Planning Commission  
DoT  
Sanchar Bhawan  
New Delhi – 110001**

●● www.ncrtc.in

**राष्ट्रीय राजधानी क्षेत्र परिवहन निगम**  
(भारत सरकार एवं प्रतिभागी राज्य सरकारों का एक संयुक्त उपक्रम)  
**National Capital Region Transport Corporation**  
(A Joint venture of Government of India and participating State Governments)

**Sub: Allotment of frequency spectrum to NCRTC for implementation of Train Control Systems for Regional Rapid Transit System.**

- Ref: 1. Our letter No. NCRTC/S&T/2019/DoT/01 dated 06.11.2019, to The Secretary, DOT.  
2. D.O No. K-14011/17/2018-MRTS-I dated 06/12/2019 from Secretary MoHUA  
3. Our letter No. NCRTC/S&T/2019/DoT/04 dated 15.02.2020, to Wireless Advisor, WPC, DoT  
4. Our letter No. NCRTC/S&T/2020/DoT/08 dated 27.04.2020 to Member S&T, Railway Board (Copy enclosed)

With reference to our letters at reference referred above, NCRTC is in constant touch with WPC, DoT and Indian Railways for allocation of LTE spectrum in 700 MHz band on sharing basis with Indian Railways. It was reiterated that NCRTC shall take all necessary and extra precautions for interference avoidance with Indian Railways LTE Network.

Indian Railways suggested that a study may be conducted to assess the feasibility of co-existence of NCRTC RRTS LTE Network and Indian Railways LTE Network.

Indian Railway's had engaged IIT Chennai represented by Dr. Ganti Radha Krishna, Dr. P Raja Goundan representing Associated Society – Center for Excellence in Wireless Technology and Dr. Kuchi Kiran Kumar of IIT Hyderabad to study the feasibility of use of LTE technology on Indian Railways for ETCS Signalling and Mission Critical services. NCRTC approached the same group of eminent experts to conduct our study on "Study of feasibility of co-existence of two separate LTE networks of NCRTC and IR in the same spectrum without impacting ETCS and Mission Critical Services", as they have a clear

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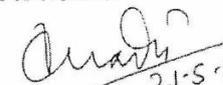
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understanding of the Indian Railway's use case and architecture hence are most suited to offer insight into feasibility of co-existence of two separate LTE networks for ETCS and MCX services. The final report of the study, dated 24.04.2020, has been submitted. The report has been forwarded to Railway Board vide ref 4 above.

The experts studied the NCRTC RRTS network alignment and deployment strategy. The report concludes "that both NCRTC and IR can use the same entire 5 MHz bandwidth for their critical operations in majority of the places without affecting the IR network, even with no coordination with IR, by employing the techniques which have been detailed in the report. However, minimal coordination during the network planned stages in certain locations NCRTC can benefit both, thus enabling the use of the entire bandwidth in all places. Even in the highly unlikely scenario of having any interference, other scheduling methods, transmit beamforming along with signal processing at the receiver using multiple antennas etc. are available to solve the problem. The ETCS operation can be performed with high reliability along with MCPTT and also CCTV surveillance data transfer can be done in majority of the corridor".

NCRTC confirms that suitable technological/administrative solutions, as mentioned, shall be implemented in consultation with Indian Railways to ensure that the two networks deployed by IR and NCRTC, avoid/minimize the interference with each other such that the services of either of the systems are not affected.

It is therefore requested that considering the outcome of the study conducted, WPC, DoT, may expedite the process of spectrum allocation on sharing basis to NCRTC.

  
21-5-2020  
(Navneet Kaushik)

**Director Systems**

Encl: Copy of letter to Railway Board vide ref 4 above.

**Report on**  
Study of feasibility of co-existence of two separate LTE  
networks of NCRTC and IR in the same spectrum without  
impacting ETCS and Mission Critical Services

Report Submitted as part of the project

**LTE-R in RRTS Corridor for NCRTC**

By

Centre of Excellence in Wireless Technology, IIT Madras (CEWIT)

IIT Madras

IIT Hyderabad

Version V2b

April 2020

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## 1. Introduction

National capital region transport corporation (NCRTC) is a joint venture of government of India (GoI) with 50% stake and each of the four state governments of the national capital region (NCR) with 12.5% stake under the administrative control of Ministry of Housing & Urban Affairs. NCRTC is implementing the green field regional rapid transit system (RRTS). It is a new, dedicated, high speed, high capacity, comfortable rail-based commuter service connecting regional nodes in NCR. This railway-based system is being designed for up to 180 Kmph high speed train operations with paramount importance to public safety, security and efficient train control system. It is decided to deploy European train control system (ETCS) level-2 signaling system, mission critical (MC) voice, Internet of things (IoT) based asset monitoring services and video surveillance from the train for captive use. The deployment of ETCS Leve-2 requires a robust and reliable communication infrastructure. NCRTC is planning to deploy a communication system based on LTE technology over a suitable wireless spectrum.

Telecom regulatory authority of India (TRAI) has recommended that Indian railways (IR) may be allotted a bandwidth of 5 MHz + 5 MHz (paired) spectrum in the 700 MHz frequency band for captive use for implementing ETCS level-2 MC push to talk (PTT) + voice, IoT based asset monitoring services, etc. TRAI has also recommended that Department of Telecommunications (DoT) may explore the possibility of assigning the same spectrum in other areas for area specific limited use to other entities for captive use while ensuring that there is no interference to the railways' network from such use. NCRTC has approached DoT for using the same spectrum in the 700MHz band, recommended to IR for its captive use.

The regional rapid transit system (RRTS) corridor alignment crosses Indian Railway alignment at few places and runs in parallel to the IR alignment in some sections. For example, RRTS corridor runs parallel to the IR tracks for about 60 kms with a minimum separation of 20 meters and a maximum separation of 1700 meters between the

tracks. Sarai Kale Khan (SKK) - Shahjahanpur-Neemrana-Behrod (SNB) corridor has crossings with the IR alignments at two locations and runs parallel to the IR alignment for long distances in some sections with a distance of separation from the IR track comparatively higher than the Delhi-Ghaziabad-Meerut corridor. Due to this, there is a concern on whether two separate LTE networks utilizing the same spectrum can coexist over such alignments.

NCRTC is interested to conduct a study of using the same spectrum of 5 MHz + 5 MHz (paired) spectrum in the 700 MHz frequency band by both RRTC and IR without the NCRTC system causing any interference to the IR operations.

IIT Madras, IIT Hyderabad and CEWIT had earlier conducted feasibility studies for use of LTE technology in Indian Railways. Considering the experience these three institutes have on the subject and the deep expertise they have in wireless areas, specifically on LTE technologies, NCRTC has requested CEWIT, IIT Madras and IIT Hyderabad to conduct a study covering the following:

- Study of feasibility of co-existence of two separate LTE networks of IR and NCRTC in the same band.
- Suggest suitable mitigation measures to coexist in close proximity, if required.
- Deployment strategies to get maximum throughput on both networks.

## 2. Coexistence Study for NCRTC and IR LTE Networks

The coexistence study has been conducted by the subject matter experts at Center of Excellence in Wireless Technology (CEWiT), Indian institute of technology Madras (IITM) and Indian institute of technology Hyderabad (IITH) covering the following tasks:

- a) Study of feasibility of co-existence of two separate LTE networks (IR and NCRTC) in the same band
- b) Suggest suitable mitigation measures to coexist in close proximity, if required
- c) Deployment strategies to get maximum throughput on both networks

After conducting the study, this project report was prepared for NCRTC, jointly by CEWiT, IITM and IITH. The study has taken the expert opinion while evaluating the feasibility of co-existence of two separate LTE networks of NCRTC and IR using the same spectrum. The report was prepared based on general understanding of the experts in the subject matter. Nevertheless, when the deployment is done after careful planning, the interference from the NCRTC network to IR network and vice-versa can be minimized/negligible to a considerable extent. Suitable deployment strategies to handle the interference caused in either networks are suggested in this report.

The following investigators mentioned in Table 1 have contributed to this study:

Table 1: Team members from CEWiT, IITM and IITH

Institute	Team Members
CEWiT	Dr. J Klutto Milleth, Mr. Babu Narayanan K J, Dr. P R Goundan
IIT Madras	Dr. Radhakrishna Ganti
IIT Hyderabad	Dr. Kiran Kuchi

CEWiT along with IITM and IITH had earlier studied the feasibility of using LTE for IR in the Indian scenarios and looked at the specific features of the technology that are required for Railways communications. The above three organizations together had studied the coverage and capacity requirements for IR. It had suggested the bandwidth

required to meet those requirements. Also, the team did a coverage and capacity analysis when different frequency bands of the spectrum are used for its deployment.

All the above three organizations and some of their team members who have prepared this report have been participating in 3GPP meetings for over a decade now and contributed significantly in the standardization. They have built expertise over the years due their rich experience in standardization and a good understanding of the 4G and 5G LTE technologies including LTE for railways.

This part of the study was performed over a period of over three weeks and later extended by another two weeks due to the disruptions caused by the corona virus pandemic. It also includes the interaction with NCRTC over email, phone and face to face discussions with Mr. Rishabh Gautam, Sr. DGM/S&T, NCRTC and Mr. Keshav Pihal, AM/S&T, NCRTC in Chennai.

### 3. Structure of the Report

The report is structured as follows:

A Chapter on '**Service Requirement of RRTS using LTE**' gives the bandwidth requirements of various services for RRTS and their priority levels along with the technology options.

A Chapter on '**Information about RRTS Corridor Relevant to the Feasibility Study**' mentions about the various details of the corridor and the inputs received from NRCT over phone, email exchanges and face to face meeting at Chennai.

A Chapter on '**Link Budget/Coverage and Throughput Analysis in 700 MHz band**' provides the link margin for various data rates that can be supported using a paired bandwidth of 5 + 5 MHz in 700 MHz, the coverage and capacity that can be achieved by an eNodeB (eNB) when different modulation schemes like QPSK, 16 QAM and 64 QAM with a code rate of 1/3 are used.

The Chapter on '**Interference Mitigation Methods Related to NCRTC and IR LTE Networks**' discusses the various interference mitigation techniques that can be applicable to the LTE networks deployed along the RRTS corridor and IR corridor maintained by their respective nodal organization.

The Chapter on '**Interference Scenarios Between the LTE Networks and Mitigation Techniques**' identifies the various interference scenario in the LTE networks of NCRTC and IR, and some possible mitigation techniques. Also, suggestions were made to improve at different level of cooperation between both the organizations.

Finally, '**References**' are provided for the models and standards references for estimating the coverage and capacity of such networks.

#### 4. Service Requirements of RRTS using LTE

The following three use cases having different data rate requirements are initially planned with three different priority level.

- a) First priority: Signaling system based on European train control system (ETCS) requiring about 10 kbps
- b) Second priority: Mission critical push to talk (MCPTT) requiring about 50 kbps.
- c) Third priority: Live transmission of onboard closed-circuit television (CCTV) surveillance data requiring about 2 Mbps

It was also clarified by RRTS that the LTE network will not be used for providing data services to any passenger travelling in the train. Wi-Fi access points will be primarily used for media streaming inside the train in all coaches and passengers' phones like in flights, and there is no plan for using Wi-Fi for communication between compartments. It was also informed by NCRTC that the leaky coaxial cables will be deployed in the tunnel/underground sections, and there is no interference expected from the LTE network of RRTS or other LTE network interfering with network in the tunnel/underground sections as they are well isolated in space or frequency band of operations. Further, it was informed that the RRTS and IR trains will not share the station in the same place. Also, both RRTS and the IR networks are independent. The deployment of 5G NR is not considered due to non-availability, LTE considered as it is available for immediate deployment.

## 5. Information about RRTS Corridor Relevant to the Feasibility Study

The following are the inputs provided by NCRTC to carry out this feasibility study based on the exchanges and interactions with the NCRTC employees over phone, email and face to face meetings. The RRTS corridor of Delhi-Ghaziabad-Meerut crosses IR alignments at a few places like at two locations in Delhi-Meerut corridor and runs parallel to the IR alignment for long distances in some sections. The RRTS corridor runs parallel to the IR tracks for about 60 kms with a minimum separation of 20 meters and a maximum separation of 1700 meters between the tracks. Also, NCRTC is expected to operate mass rapid transit system (MRTS) trains. NCRTC tracks are positioned on via ducts which are at a height of 10 meters and 20 meters above the ground level in the open area or in the underground tunnels.

The NCRTC is expected to run the following two type of trains.

- a) RRTS Trains having 6/9 coaches with a total length of 132/200 meters
- b) MRTS Trains having 3 coaches with a total length of 66 meters

The onboard unit (OBU) or the European vital computer (EVC) will be located inside the drivers cab or in the middle of the train. The antennae in the trains are rooftop connected to the LTE modem using a cable, which will in turn be connected to the OBU using ethernet. On the base station side, NCRTC is exploring the option of installing LTE antenna on the overhead electricity (OHE) mast in elevated and at-grade sections and using leaky coaxial cable in tunnel. The height of OHE mast is 6 meters from the rail level. The antenna is mounted on the train roof, which is at 4.35 meters from the rail level will be effectively at a height of approximately 5 meters from rail level. If the antenna is installed on a separate pole instead of the OHE mast, the height of the pole expected to be approximately 6 meters and antenna will be installed at approximately 6 meters from the rail level to avoid the catenary support structure. The OHE mast will be located 2.5 meters approximately from track-center line of the nearest track and 6.5 meters from the track-center line of the other track. The track-centers of up track and down track are separated by 4.5 meters. There will be two tracks on the viaduct, which is between 10 meters and 20 meters above the ground level. When the track transitions from underground to the elevated track it forms a slope/ramp. There are two

underground section in entire Delhi-Ghaziabad-Meerut Corridor, which create four ramp sections. The distance of separation between NCRCT ramp to IR track is as follows:

- a) NCRCT Anand Vihar underground section's entry ramp and IR track between Mandawali - Anand Vihar railway station is approximately 3.10 km. The snapshot of the ramp1 taken from google earth showing actual location of the ramp is shown in Fig. 1.



Fig. 1 – Ramp1

- b) NCRCT Anand Vihar underground section's exit ramp and IR track near Chander Nagar railway station is approximately 1.64 km. The snapshot of the ramp2 taken from google earth showing actual location of the ramp is shown in Fig. 2.

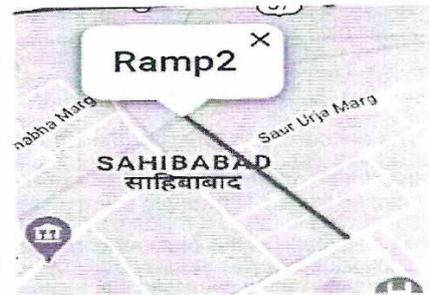


Fig. 2 – Ramp2

- c) NCRCT Brahmpuri underground station's entry ramp and IR track between Partapur – Meerut city railway station is approximately 1.39 km. The snapshot of the ramp3 taken from google earth showing actual location of the ramp is shown in Fig. 3.



Fig. 3 – Ramp3

d) NCRCT Begumpul underground station's exit ramp and IR track near Meerut Cantt railway station is approximately 1.80 km. The snapshot of the ramp4 taken from google earth showing actual location of the ramp is shown in Fig. 4.



Fig. 4 – Ramp4

The two underground section related to the four ramps are at Anand Vihar underground section as shown in Fig. 5 and the other one near Meerut Cantt as shown in Fig. 6, both the sections marked in red colour.

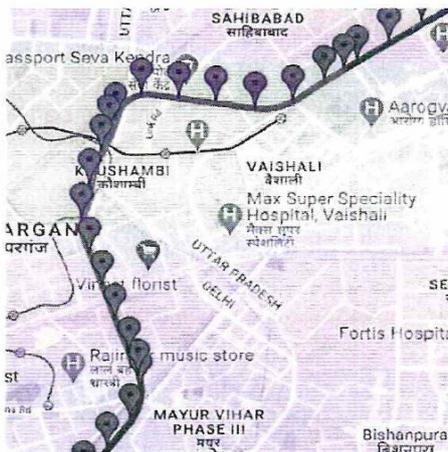


Fig. 5 – Anand Vihar Underground Section



Fig. 6 – Meerut Underground Section

Further, this corridor runs parallel to the IR tracks for about 60 kms with a minimum separation of 20 meters and a maximum separation of 1700 meters between the tracks

The SKK - SNB corridor is elevated using viaduct on the major portion of the corridor and runs parallel to the IR alignment for long distances in some sections with a distance of separation from the IR track comparatively higher than the Delhi-Ghaziabad-Meerut corridor. In some places, there is close to L bend joining as shown in Fig. 7 and flipped

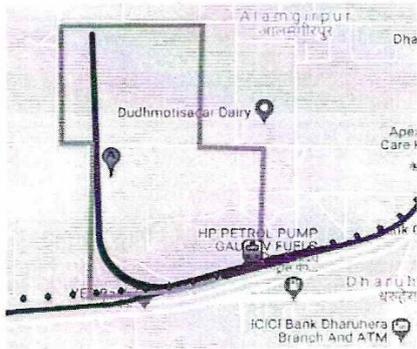


Fig. 7 – L Bend Joining

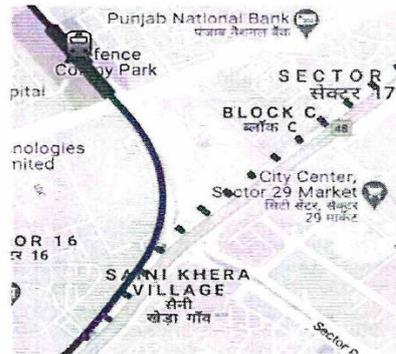


Fig. 8 – Flipped L Bend Joining

L bend joining as shown in Fig. 8, and in some other places, RRTS tracks crosses the IR tracks as shown in Figs. 9 and 10. These places in Figs. 7 – 10 and the parallel corridor running close to each other needs more attention to mitigate interference.

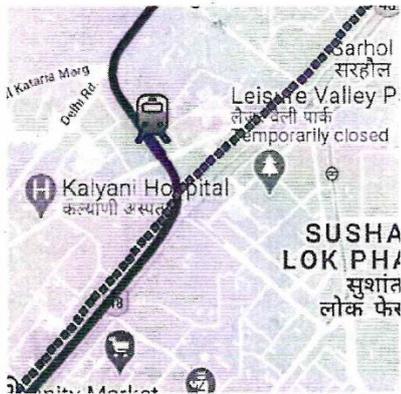


Fig. 9 – First Crossing Over



Fig. 10 – Second Crossing over

The track plan R6 shown in Fig. 11 for all the terminal station, also indicating the ramp down and ramp up locations at the above mentioned four stations are marked in red colour.

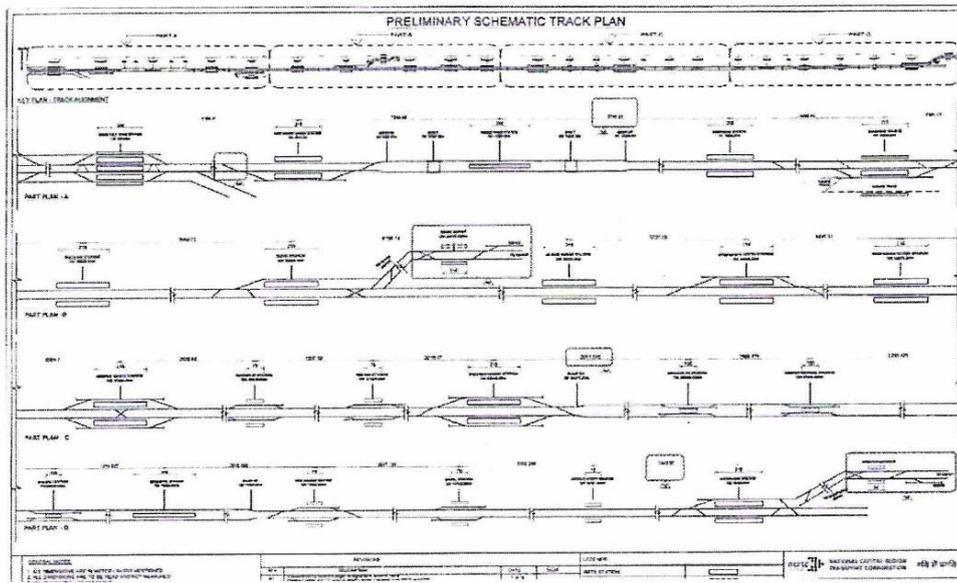


Fig. 11 – Track Plan R6

The simulation run data shared by NCRTC for the scenario C 2051 runs three MRTS trains in between two RRTS trains and six RRTS trains per hour in the SKK – Modipuram and SKK – Meerut South sector. This corresponds to a frequency of 15 trains per hour putting together the RRTS and MRTS in each of the above sector. The timetable detailing the schedule of the trains along with various stops on the corridor are also shared. Since it is only informative and does not alter the findings on the feasibility of using the same spectrum of that of used in IR, it is not included in the report.

## 6. Link Budget/Coverage and Throughput Analysis in 700 MHz band

The link margin is computed for the various modulation schemes QPSK, 16 QAM, and 64 QAM at code rate of 1/3 used in LTE for bandwidths of 5 + 5 MHz for 700 MHz band.

The link margin is given by

$$L_M = P_t + G_t + G_r - P_L - C_L - F_t - F_r - S_r$$

Where,

- $L_M$  - Link Margin
- $P_t$  - Transmit power at the eNodeB
- $G_t$  - Antenna gains at the transmitter
- $G_r$  - Antenna gains at the receiver
- $P_L$  - Path loss, computed using the ITU Rural Macro LoS path loss model
- $C_L$  - Coach penetration loss
- $F_t$  - Transmitter feeder loss
- $F_r$  - Receiver feeder loss
- $S_r$  - Receiver Sensitivity

The various parameters along with their values used for link margin computation are provided in the Table 2.

Table 2: Parameters used in link margin computation

$P_t$	$G_t$	$G_r$	$F_t / F_r$
43 dBm	17 dB	0 dB	1 dB

The ITU rural macro line of sight (LoS) path loss model is given in [ITU-R M.2135] for the LoS link, and the path loss  $P_L$  equation is reproduced here for convenience

$$P_L = 20 \log_{10}(40\pi f_c d/3) + \min(0.03^{1.72}, 10) \log_{10}(d) - \min(0.044h^{1.72}, 14.77) + 0.002 \log_{10}(h) d$$

Where,

- $d$  - Distance between transmission and reception point in meters

$f_c$  – 0.7 GHz (700 MHz in GHz)  
 $h$  – 5 meters

The path loss is computed for 700 MHz band for various distances for a eNB antennas mounted on a tower of 35 meters height, and it is provided in Table 3.

Table 3: Path loss at 700 MHz using ITU rural macro scenario

$f_c$	$P_L$ at 0.5 km	$P_L$ at 4 km	$P_L$ at 5 km	$P_L$ at 6 km	$P_L$ at 7 km
700 MHz	84.61 dB	108.00 dB	111.38 dB	114.40 dB	117.17 dB

The link margin and the throughput that can be achieved are computed for 700 MHz using three different modulation schemes QPSK, 16QAM and 64 QAM at a code rate of 1/3 and they are provided in Table 4. The data rate and sensitivity corresponding to different modulation schemes are obtained from the respective standards document, Table 4: Link Margin for LTE UE operating at 700 MHz and its data rate with 5 MHz bandwidth for various sensitivities as per ETSI TS 136.101

Modulation scheme	Code rate	Data rate at sensitivity	Receiver sensitivity	Link margin (4 km)	Link margin (5 km)	Link margin (6 km)
QPSK	1/3	2.1 Mbps	-97 dBm	48.00 dB	44.62 dB	41.60 dB
16 QAM	1/3	4.2 Mbps	-92 dBm	43.00 dB	39.62 dB	36.60 dB
64 QAM	1/3	6.3 Mbps	-87 dBm	38.00 dB	34.62 dB	31.60 dB

and it is mentioned in the Tables 4 and 5. It is observed that there is enough link margin to support up to 7 km and even beyond that distance to achieve 64 QAM modulation scheme at 1/3 code rate in LTE. The data rate supported for the three modulation QPSK, 16 QAM and 64 QAM with a coding rate of 1/3 in all cases and 30% control overhead supports a data rate of 2.1 Mbps, 4.2 Mbps and 6.3 Mbps, respectively in the thermal noise limited scenario without any co-channel interference. Nevertheless, in the interference limited scenario, the data rate depends on the strength of the interference signal and the interference mitigation capability of the receiver. It is to be noted that when the eNBs are mounted on an OHE Mast, the pathloss is expected to be higher than the eNB at a height of 35 meters, and therefore the interference caused

to the IR network will be less compared to the reverse. The additional margin will compensate for the pathloss. Moreover, capacity can be increased in any case by deploying eNBs closer.

The coverage analysis is performed for 700 MHz band using different modulation schemes QPSK, 16QAM and 64 QAM with a code rate of 1/3. The data rate and sensitivity corresponding to different modulation scheme is obtained from respective standards document, and it is mentioned in the Table 5.

Table 5: Coverage at sensitivity for LTE UE operating at 700 MHz and its data with 5 MHz bandwidth for various sensitivities as per ETSI TS 136.101

Modulation scheme	Code rate	Data rate at sensitivity	Receiver sensitivity	Pathloss at sensitivity	Coverage at sensitivity
QPSK	1/3	2.1 Mbps	-97 dBm	156 dB	26 kms
16 QAM	1/3	4.2 Mbps	-92 dBm	151 dB	23.5 kms
64 QAM	1/3	6.3 Mbps	-87 dBm	146 dB	20.5 kms

It is found from the last row and last column of Table 5 that sufficient link margin is there to support a reliable coverage of up to 20.5 km with 64 QAM modulation scheme at 1/3 code rate in LTE, and can go for further higher distances with lower modulation order like 16 QAM and QPSK. The longer coverage is mainly due to the very good propagation characteristics of the 700 MHz band. Therefore, extra link margin can be used to transmit the signal at a reduced power, which will help to significantly save the power amplifier cost and also reduce the interference to other network without affecting the capacity.

It is to be noted that the Modulation and coding rate used are for illustration purposes, and the LTE technology supports MCS higher than 64 QAM with code rate 1/3 and MCS less than QPSK with code rate 1/3. Therefore, the coverage and capacity will change proportionally depending on the modulation and code rate used for data transmission.

## 7. Interference Mitigation Methods Related to NCRTC and IR LTE Networks

Spectrum being a very scarce resource, the frequency is reused in spatial geographical locations. Even though the strength of the signal gets attenuated as it travels larger distance, it will not vanish and hence it will interfere with the signal transmitted from multiple base stations (a.k.a. eNB). This is called co-channel interference (CCI). It will be difficult to detect the transmitted signal in the presence of CCI. The interference can be mitigated by appropriate transmission and reception techniques and by careful deployment of the eNBs. In this section, some of the interference mitigation techniques that can be considered by NCRTC is discussed.

The method of spatial reuse by using antennas with very narrow beams help to mitigate interference at least in the context of railway deployments. Narrow beam antennas will be beneficial especially in railway network as the tracks are generally straight and narrow, and hence it will limit the radiation of the signal away from the boresight of the antenna. Therefore, it will minimize the interference caused to the other eNB signals when they are not in the boresight. The narrow beam antennas generally have higher gains in the boresight direction compared to broader beam antennas. This will help to radiate the signal to longer distances without causing interference in the direction other than the boresight of the antennas. Therefore, it can be used to increase either the coverage of the eNB to longer distances or to save the transmit power of the eNBs and the UEs. This will also help to reduce either the capital expenditure by deploying lesser number of eNBs or operating expenditure by reducing the transmit power at the eNB with lower rating power amplifier. The optimal number of eNBs can be decided to meet the capacity requirements at optimal cost.

Beamforming and nulling are a technique where the signal from the eNB is beamformed to the desired UE and nulled to the interfering UE. Dynamic beamforming and nulling are performed by appropriate choice of the precoder at every eNB depending on the instantaneous channel state information (CSI). The UE estimates the CSI of either the desired or interference signal or both and feedback the quantized

channel quality information (CQI) like signal-to-interference-plus-noise ratio (SINR) or modulation and coding scheme (MCS) selection, precoding matrix indicator (PMI) by sending the indices reflecting the value. The meaning of the indices is specified in the standards and it will be known by both the eNB and the UE. In order to effectively use this technique, the participating eNBs need to exchange information between them to decide on the appropriate choice of the precoder so that it beamforms in the desired UE direction and nulls in the interference to UE of the neighbouring eNB. This method is used to mitigate the interference in the presence of fading.

Moreover, without considering fading in to account, static beamforming and nulling technique can also be used to mitigate interference by careful planning and deployment of the eNB during the time of installation, where the antenna orientation is such that the boresight of the narrow beam antennas is focused towards the desired railway track so that there is no interference caused in the direction other than from the track as shown in Fig. 12.

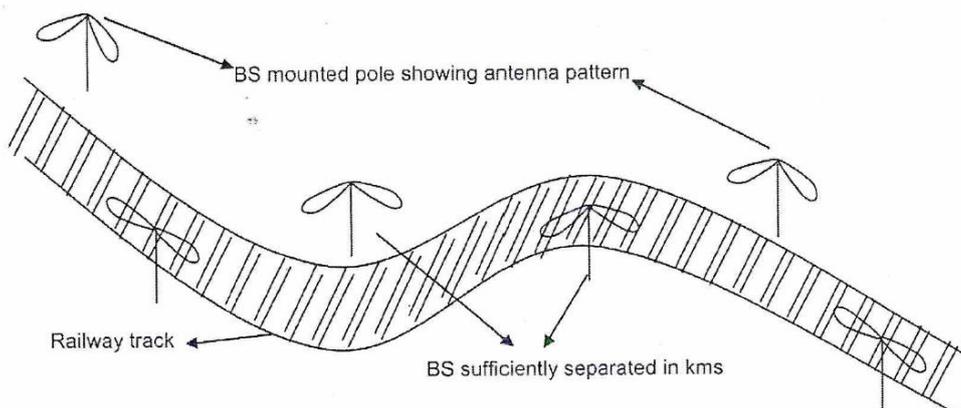


Fig. 12 – LTE eNBs along the Railway Track with Antenna Boresight Focusing the Track

Multiple antennas at the eNB or UE can be used to mitigate the interference. Various receiver processing techniques are available in the literature to mitigate the interference using signal processing methods. When there are  $M$  receive antennas, the receiver will be capable of mitigating  $M-1$  interference as one of the signals will be

desired signal. Simplest of them is the minimum mean square error (MMSE) receiver that can handle M-1 interference.

Interference can be mitigated by scheduling orthogonal resources to UEs that will be in the direction of boresight of neighbouring eNB. This can be performed by statically allocating pre-determined orthogonal resources to the eNBs for serving their respective UEs. The orthogonal resources can be in multiples of RBs among the 25 RBs in frequency domain or in terms multiple of sub frames in time domain or multiple orthogonal RBs in a combination of time and frequency domain. The time frequency resource pattern of the LTE frame structure for a bandwidth of 5 MHz is shown in Fig.

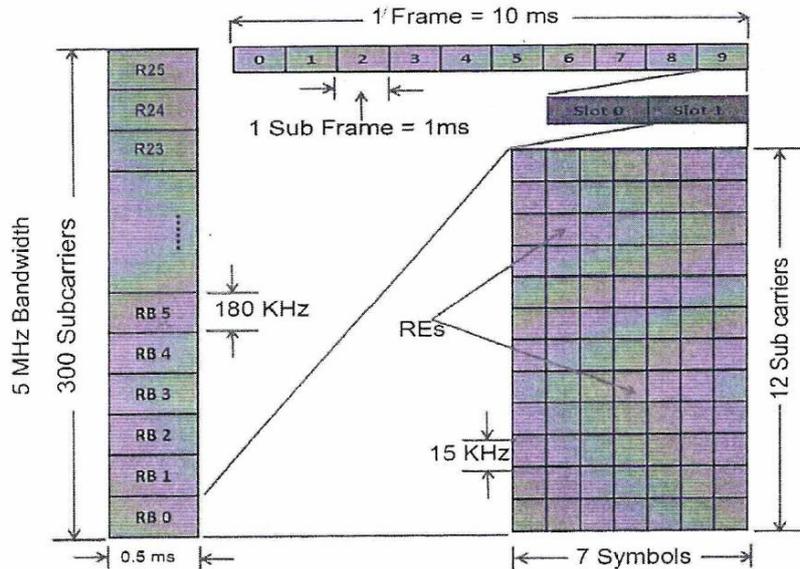


Fig. 13 – LTE Frame Structure for 5 MHz Bandwidth

13. Scheduling of resources to the UEs can be also be dynamically performed by exchanging the CSI and interference information across eNB and schedule their UEs in appropriate time frequency resources to mitigate interference. When this technique is combined with receiver processing, then the link adaptation based on the post processing SINR of the MMSE or interference rejection combining (IRC) receiver, in effect due to fading it can even handle more than M interference as some of the

interference will be already very weak due to fading. This post processing SINR reflects the interference caused at the time of computing it. When the UEs are scheduled at the resources that have the highest post processing SINR, the transmitter and the receiver together mitigate the interference to the best possible extent.

Also, interference can be mitigated using appropriate power control techniques, at least in the uplink, that is the transmission direction from the UE (train) to the eNB.

## **8. Interference Scenarios Between the NCRTC and IR LTE Networks and Mitigation Techniques**

When signals are transmitted in the same frequency resource even at geographically different locations, it will cause CCI at the boundary between the transmitter locations, and this must be handled at the transmitter as well as the receiver. This is a problem that can be efficiently tackled if the network is operated by a single organization in a coordinated manner. The techniques mentioned in the previous section either as an individual scheme or combination of schemes can address the problem. However, when there are two different networks operated by two different organizations like NCRTC and IR, it requires careful planning only at certain locations, not at all locations as the tracks are not close enough in every geographical location and in some cases like underground/tunnels, they are completely isolated. In this section, solutions wherever required are suggested based on different factors obtained from the details shared by NCRTC about this project.

The RRTS runs underground in urban areas and on elevated viaduct in the rural side, and there is slope at the transition point from underground to elevated section. Therefore, following are the three main scenarios need to be considered in the entire RRTS corridor for this study vis-a-vis the IR network along the route:

- a) Underground/tunnel
- b) Ramp up or ramp down
- c) Elevated corridor

### **a) Underground/tunnel**

The first scenario is the underground/tunnel section of the RRTS corridor is completely isolated from IR. Moreover, the IR corridor is sufficiently far away, the LTE network of NCRTC is unlikely to create interference to the operation of IR network when the same 5 MHz bandwidth used by the respective organizations for its operations. The NCRTC can use LTE eNBs or leaky coaxial cable to radiate the wireless signals for signaling, or MCPTT, or CCTV surveillance data depending on the capacity of the network. For

similar reasons, the LTE network of IR will not cause any interference to the NCRTC network, and hence, both the network can operate independent of each other without disturbing the other network using the same bandwidth on the same 700 MHz frequency band. Therefore, using the same 5MHz bandwidth allocated to IR in the 700 MHz band is unlikely to create any interference to the IR network.

**b) Ramp up or ramp down**

The second scenario is the ramp up and ramp down section at the entry and exit points of the underground sections where the track will be close to the ground level before reaching the viaduct level, which is anywhere between 10 and 20 meters from the ground level. Even in this case, the IR railway track is sufficiently far away from the LTE network of NCRTC. However, unlike in underground section, being 700 MHz that can travel larger distances as explained in link budget analysis section, it may cause very minor interference to IR network. However, both NCRTC and IR networks needs only coverage along the track, by using narrow beam antennas can ensure that there is no/negligible interference caused to the IR network. It can deploy its network without any coordination with IR, and without disturbing the IR network operations. However, if IR also uses very narrow beam antennas it will also cause no/negligible interference to the NCRTC network, if at all the signals has the capability to reach each other network.

Using narrow beam antennas will only benefit both the organizations since base stations can now get same coverage using less transmit power because of the gains obtained from narrow beam antennas. This will help in reducing the cost significantly

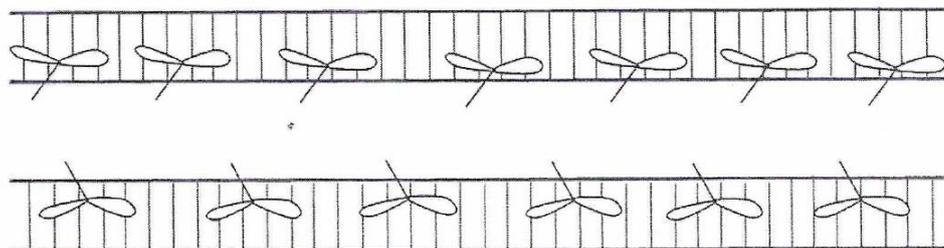


Fig. 14 – Parallel Tracks with Tower on Closer Distance Side with Antennae Focusing Track

as the power amplifier cost decrease exponentially. Furthermore, careful orientation of the antennas in either network will help to avoid the interference as shown in Fig 14. It can be seen from the Fig. 14 that two sectors are created with the back lobe focusing on the other's track so that the interference is avoided in each other's network. Moreover, when narrow beam antennas are used, the boresight will be focusing the track and it can cover larger distance. Furthermore, due to high gain narrow beam antennas, one can reduce the transmit power without sacrificing on the coverage and hence avoid the interference. Further it will help both networks significantly in reducing the cost due to saving obtained by using low power amplifier rating. Therefore, adopting the techniques explained here will ensure that the NCRTC network will avoid interference to the IR network without any cooperation. However, with cooperation between both the organization only at the planning level can ensure that the interference is almost negligible. Therefore, using the same 5MHz bandwidth allocated to IR in the 700 MHz band is unlikely to create any interference to the IR network, NCRTC using this bandwidth in this section of RRTS corridor for its operation will not affect the LTE network operated by IR.

### **c) Elevated corridor**

The third scenario is the elevated corridor section. Generally, in major portion of this section the separation of the tracks is more than 500 meters. Moreover, when the NCRTC network uses narrow beam antennas, it is highly unlikely to cause interference to the IR network. Since the height of the NCRTC's eNB antenna is only 6 to 7 meters from the viaduct, the boresight focusing the track covering larger distance makes the signal to travel parallel to the ground. Furthermore, since the viaduct is around 10 to 20 meters above the ground level, it may not reach the IR's UE which is only 5 meters above the ground level. It also has a very strong attenuation of the signal due the thick concrete structure of the viaduct. Even though the IR's eNB antenna is at 35 meters height, the boresight is focused downward towards the track and since the viaduct is at a greater height, the interference into the NCRTC network will also be less.

Even when the tracks are less than 200 meters, due to the usage of narrow beam antennas, NCRTC is not expected to cause any significant interference to IR eNBs. Moreover, by fixing the antennas on the side of the IR track and focusing the beam towards the NCRTC track (away from the IR Track, i.e., back lobe facing the IR track) will avoid the interference to the IR network. This does not require any cooperation from IR. However, if IR also does plan as explained in the second scenario for the case of parallel tracks, interference will be avoided in both the networks.

More planning is required in the bends shown in Figs. 7 and 8, and at the crossing over points shown in Figs. 9 and 10. In these cases, NCRTC can ensure that it does not cause any interference by fixing the antennas at the corner point of the bend with boresight focusing the NCRTC track. The back lobe facing the IR's track along with the height of the viaduct ensure that there is minimum or negligible interference to the IR's network. However, IR may cause some interference to the NCRTC network if not planned well, but with minimal passive coordination at the time of deployment, IR can deploy the eNB farther from the corner point of the NCRTC's L bend, which will help to reduce the interference to NCRTC by taking advantage of the height of the viaduct. IR can also reduce the height of the tower in these L bend corners to further reduce the interference, if required.

Similarly, more planning is required for the crossing over points of the two tracks in Figs. 9 and 10. In these cases too, similar to the case of L bend, NCRTC's eNB can be located at the cross over point. The strong attenuation of the signals due to the thick concrete viaduct and low height of its antennas and boresight facing the track at a reasonable height from the ground ensures no/negligible interference to IR's network. Apart from that, if required, NCRTC's eNB can be operated at less power to further reduce the interference strength to the IR network. IR may cause some interference to the NCRTC network if a random deployment is done by IR, however with minimal passive coordination at the time of deployment, IR can deploy the eNB farther from the crossing over point with the NCRTC's track, which will help in reducing the interference to NCRTC by taking advantage of the height of the viaduct. Another approach is that IR can reduce the height of its antenna by fixing it underneath the viaduct so that

interference is minimized to NCRTC's network due to the strong attenuation of the interfering signals by the thick concrete of the viaduct. The power can also be reduced to further reduce the interference, if required.

Apart from all these, there is an option of having an understanding with IR to ensure that static orthogonal frequency resources are used at these L bends, corner points and wherever, interference is more than the tolerable limit. In all other places, frequency can be reused fully.

Therefore, using the same 5MHz bandwidth allocated to IR in the 700 MHz band is unlikely to create any interference to the IR network. NCRTC using this bandwidth in this section of RRTS corridor for its operation will not affect the LTE network operated by IR.

Apart from the above-mentioned deployment-based solutions, other interference mitigation techniques like signal processing at the receiver using multiple antennas at the receiver, interference avoiding scheduling etc. can be used to mitigate the interference, if at all there is any. Moreover, the rooftop antennas can be located at the front and back side of the train in case of 4 X 4 MIMO. This may also help to capture the signals from the farthest antenna when the train moves closer the eNB where the side lobe gains will be very less in the narrow beam antennas. If it is 2 X 2 MIMO, use dual polarized antennas to achieve polarization diversity. Apart from all these, since the frequency of the IR's train operation is very less, the chances of interference to the NCRTC's network is also not high. This will enable to cater even the needs of CCTV surveillance data communication in NCRTC network in majority of the places most of the time.

Regarding capacity from the link budget, coverage and capacity analysis section, it is absolutely clear that the highest MCS can be supported in majority of the places. However, there may be a drop in capacity at the L bend points and crossing over points, but the signal processing techniques along with eNB scheduling can maximize the

capacity in this region. Nevertheless, it will not affect the ETCS signaling and the MCPTT and the CCTC surveillance data can be supported in all other places. Moreover, increased capacity in a geographical area can be handled by adding a greater number of eNBs and can reduce the transmit power.

## 9. Conclusions

The feasibility of co-existence of two separate LTE networks, of NCRTC and IR in the same spectrum has been studied by subject matter experts at Center of Excellence in Wireless Technology (CEWiT), Indian institute of technology Madras (IITM) and Indian institute of technology Hyderabad (IITH). Based on the details of the RRTC network shared by NCRTC, an in-depth analysis has been done by the team on the use of LTE technology in the NCRTC and IR sections. The study looked into the issues of co-existence of NCRTC and IR communication networks using 5 MHz (paired) spectrum in the 700 MHz band, discussed several alternatives for mitigating the interference between the networks and also looked into strategies that can maximize the throughput while keeping the interference minimum/negligible. The specific railway network topologies and the possible proximities of the networks have been considered in detail while arriving at the conclusions of the study.

The study concludes that both NCRTC and IR can use the same entire 5 MHz bandwidth for their critical operations in majority of the places without affecting the IR network, even with no coordination with IR, by employing the techniques which have been detailed in the report. However, minimal coordination during the network planned stages in certain locations NCRTC can benefit both, thus enabling the use of the entire bandwidth in all places. Even in the highly unlikely scenario of having any interference, other scheduling methods, transmit beamforming along with signal processing at the receiver using multiple antennas etc. are available to solve the problem. The ETCS operation can be performed with high reliability along with MCPTT and also CCTV surveillance data transfer can be done in majority of the corridor. The study also concludes that the required throughput for these ETCS operations can be very well provided using the spectrum allotted for the purpose by employing the strategies mentioned in the report.

## 10. References

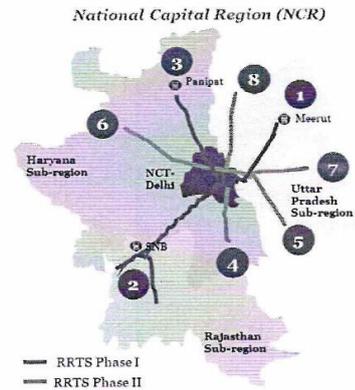
- [1] "Guidelines for Evaluation of Radio Interface Technologies for IMT-Advanced", Report ITU-R M.2135-1(12/2009).
- [2] "LTE Evolved Universal Terrestrial Radio Access (E-UTRA) – User Equipment (UE) Radio Transmission and Reception", ETSI TS 136.101.
- [3] "LTE-R for Indian Railways" submitted to RDSO based on the study conducted by CEWIT, IITM, and IITH.

**Brief note on RRTS**

**1. Regional Rapid Transit System**

1.1. In order to enhance connectivity, improve access to citizens, reduce pollution and congestion and promote balanced sustainable growth in National Capital Region (NCR), the NCR Planning Board (NCRPB) had recommended development of multi-modal transport system with special emphasis on rail based high-speed, high-frequency Regional Rapid Transit System (RRTS) for connecting major regional centers in Functional Plan on Transport for National Capital Region-2032.

1.2. The erstwhile Planning Commission of India (now NITI Aayog) appointed a Task Force (in the year 2006) under the chairmanship of Secretary erstwhile Ministry of Urban Development (now Ministry of Housing & Urban Affairs - MoHUA), which identified eight corridors, out of which three corridors were prioritized viz. Delhi-Meerut, Delhi-Panipat and Delhi-Alwar for implementation in the phase I of RRTS. While Delhi-Ghaziabad-Meerut RRTS Corridor is under construction, the other two prioritised RRTS corridors are in different stages of consideration of Government of India for sanction.



1.3. RRTS is a new, transformational and strategic regional development intervention of Government to empower citizens through access to education, healthcare, employment and economic opportunities. The three prioritized RRTS projects have been included in the National Infrastructure Pipeline (NIP), finalized by Department of Economic Affairs (DEA) and unveiled by Hon'ble Finance Minister. Furthermore, the prioritized RRTS corridor are part of 'Comprehensive Action Plan' (CAP) for Air Pollution Control in Delhi & NCR' and recommendation of 'High Powered Committee on Decongesting Traffic in Delhi'.

1.4. RRTS is being implemented by the National Capital Region Transport Corporation (NCRTC), a joint venture of Government of India (50%) and participating State Governments of Delhi, Rajasthan, Uttar Pradesh and Haryana (each having shareholding of 12.5%). NCRTC has been formed in the year 2013 under the Company Act, 1956 and is mandated for designing, developing, implementing, financing, operating and maintaining RRTS projects in the NCR.

1.5. RRTS is a first-of-its-kind, rail-based, high-speed, high-frequency regional transit system with a design speed of 180 kmph and with all stoppages average speed close to 100 kmph (more than 3 times of metro rail). Being implemented for the first time in India, RRTS, once operational, will be the fastest, most comfortable and safest mode of commuter transport in NCR. RRTS aims to improve quality of life of people by providing equitable,

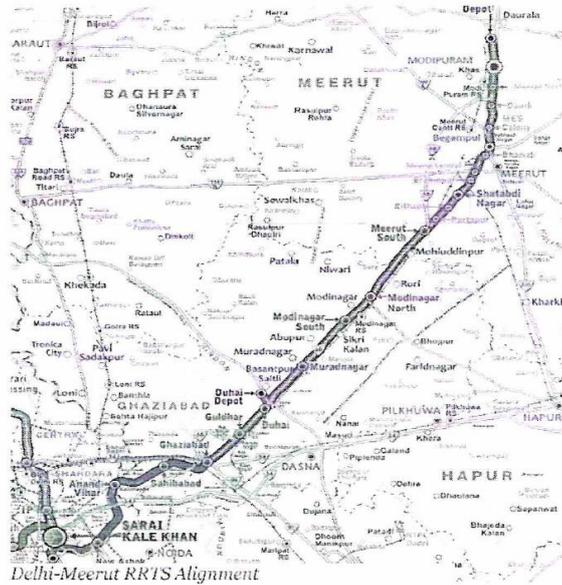
fast, reliable, safe comfortable, efficient & sustainable mobility solutions enabling economic development of NCR.

- 1.6. RRTS will connect all districts/cities of NCR with Delhi, and will run right across the city centers, airport, ISBT, railway, metro etc. thus providing a seamless multi modal transit network to the entire region. Multi-modal integration, being an integral part of RRTS Project shall encourage commuters to shift to public transport from private transport thereby reducing carbon footprint. The three corridors will converge at Sarai Kale Khan in New Delhi and will be interoperable allowing for seamless movement of trains across corridors. A fast and safe mobility system will not only improve regional connectivity but also help promote balanced and sustainable urban development across NCR.



## 2. Delhi-Ghaziabad-Meerut RRTS Corridor

2.1. India's first regional rail, Delhi-Ghaziabad-Meerut RRTS corridor was sanctioned by Government of India in March 2019. Foundation Stone for the project was laid by Hon'ble Prime Minister of India on 8th March 2019. The corridor is approximately 82 km long corridor with 25 stations, which will cover the distance from Sarai Kale Khan in Delhi to Modipuram in Meerut in about 60 minutes (Currently, it takes around 3 hours to commute from Delhi to Meerut).



2.2. Some of the salient features of RRTS are as follows:

- Design Speed of 180 Kmph
- Average Speed close 100 Kmph
- Train every 5 – 10 min
- Interstation distance is between 5 to 10 km
- Safe and reliable service
- **Interoperability:** All the 3 RRTS corridors will converge at Sarai Kale Khan and will be inter-operable allowing trains to move from one corridor to the other seamlessly
- Multimodal integration with Stations of Indian Railways, Metro Stations, ISBTs, City Buses and UPSRTC bus stations
- Besides regional Services, RRTS infrastructure will also be used to operate Local Transit (Metro) Services in Meerut over 21 km with 13 Stations.

2.3. The civil construction work on the entire corridor is in full swing and on schedule. Train Trials in the first priority section of 17 km will begin by **April 2022** and will be operationalized for public carriage in **December 2022**. The complete RRTS corridor is to be commissioned **by March 2025**.

2.4. The National Capital Region Transport Corporation (NCRTC), a joint venture of the Government of India and respective state governments, is mandated for implementing and operating RRTS in the National Capital Region (NCR).

## 3. Signalling and Telecommunication Technology for RRTS

3.1. Two of the defining key features of the RRTS corridor are:

- i. **Interoperability between corridors, which allows for seamless travel from one corridor to other without the need to deboard and change platforms.**
- ii. **High Speed Train Operation: Design Speed of 180 Kmph and Operational Speed of 160 Kmph**

- 3.2. ETCS Level 2 signalling is being used in RRTS network. ECTS is a well-established proven signalling system with deployment in over 25 European countries and 21 countries outside Europe. There are over 100,000 km of trackside equipped with ETCS wayside and 13,000 vehicles equipped with ETCS on-board equipment globally.
- 3.3. Traditionally, ETCS Level-2 systems have been deployed over GSM-R based communication backbone. Since GSM-R vendors have announced end of life of GSM equipment and support will not be available beyond year 2030, hence alternatives are being explored. New ETCS Level 2 implementors are therefore looking for viable alternative to GSM-R.
- 3.4. LTE is the true successor for GSM-R. It far exceeds the requirements of ETCS Signalling System and incorporates the Mission Critical requirements of a reliable data and voice communication system. The following points summarise the advantage of LTE over other technologies
- a) The operational speed of RRTS is 160 kmph which is supported by LTE as it supports up to 350 Kmph.
  - b) It supports Mission Critical communication which support all railway related communication requirements.
  - c) It meets the requirement of upgrading to FRMCS for interoperability with future corridors
  - d) LTE can cater to requirements of ETCS Data, ATO Data and Mission Critical Services including Voice (MCPTT), IoT data.
  - e) LTE system can be upgraded to 5G (the future) just by software upgrade
  - f) LTE offers very low latency (less than 10 ms)
  - g) It offers high bandwidth, high availability & security
  - h) LTE has mass market as it is not a niche technology (Telco Grade)
  - i) Low operating costs (Single multi-operator/multiservice RAN network sharing)
- 3.5. Hence, NCRTC is deploying European train control system (ETCS) Level-2 signalling system, Mission Critical (MC) Voice & Data, and Internet of things (IoT) based asset monitoring services over LTE based communication system in 700 MHz spectrum. The technology option selected has been approved by Ministry of Railways.
- 3.6. Indian Railway, on 08th June 2021 has been allotted 5 MHz paired spectrum in 700 MHz band. NCRTC is seeking allocation of 5 MHz paired spectrum in the 700 MHz band, alongside Indian Railways, for captive usage on NCRTC RRTS Corridors.

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**Annexure 2.1: Frequency ranges under consideration in ITU for a possible regional/global spectrum harmonization for RSTT proposed from within regional groups**

	Region 1		Region 2	Region 3
	Frequency ranges considered for harmonization by Regional group	Harmonized Frequency ranges for Region 1	Frequency ranges considered for harmonization by Regional group	Frequency ranges considered for harmonization by Regional group
Train Radio	ATU: 138-170 MHz, 406.1-430 MHz, 440-470 MHz; 873-880 MHz / 918-925 MHz	876-880 MHz / 921-925 MHz	See Note 2	70-74.8 MHz, 75.2-88 MHz, 142-144 MHz, 146-149.9 MHz, 150.05-156.4875 MHz, 156.5625-156.7625 MHz, 156.8375 161.9625 MHz, 161.9875-162.0125 MHz, 162.0375 170 MHz, 335.4-399.9 MHz, 406.1-430 MHz, 440 470 MHz, 703-748 MHz, 758-803 MHz, 873-915 MHz, 918-960 MHz, 1 770-1 880 MHz, 1 965-1 975 MHz, 2 155 2 165 MHz 43.5-45.5 GHz, 92-94 GHz, 94.1-100 GHz, 102-109.5 GHz
	ASMG: 876-880 MHz / 921-925 MHz			
	For CEPT: 876-880 MHz / 921-925 MHz			
	RCC: 138-174 MHz; 406.2-430 MHz / 440-470 MHz; 876-880 MHz / 921-925 MHz			
Train Positioning	CEPT: 0.984-7.484 MHz 27.09-27.10 MHz	See Note 1	See Note 2	See Note 1
Train Remote	RCC: 138-174 MHz; 406.2-430 MHz / 440-470 MHz; 876-880 MHz / 921-925 MHz	See Note 1	See Note 2	See Note 1
Train Surveillance	See Note 1	See Note 1	See Note 2	See Note 1

Note 1: No Frequency ranges for this RSTT application are harmonized at this time.

Note 2: Region 2 does not have any harmonized frequency bands identified for RSTT at this time.