



Telecom Regulatory Authority of India



Recommendations
on
Allotment of spectrum to Indian Railways for Public Safety
and Security services

25th October 2019

Mahanagar Doorsanchar Bhawan
Jawahar Lal Nehru Marg,
New Delhi- 110002

CONTENTS

CHAPTER- I: INTRODUCTION.....	2
CHAPTER- II: EXAMINATION OF REQUEST OF MINISTRY OF RAILWAYS	18
CHAPTER- III: SUMMARY OF RECOMMENDATIONS	52

CHAPTER- I: INTRODUCTION

A. DoT Reference

- 1.1 The Department of Telecommunications (DoT), through its letter No. L-14001/01/2019-NTG dated 27th February 2019 (**Annexure-I**), informed about the proposal of Ministry of Railways to install an Ultra-high-speed LTE based communication corridor along their rail network for Train-Ground and Train-Train communication. Ministry of Railways has requested DoT to reserve 15 MHz of spectrum in 700 MHz band for this purpose and to begin with, 10 MHz to be allocated free of cost as the proposal is devoid of any commercial gain, but only for enhancing security and passenger amenities. Vide the said letter dated 27th February 2019, DoT requested TRAI to provide recommendations on administrative allotment of spectrum to Indian Railways (IR) and the quantum, price, appropriate frequency band (including 450-470 MHz band) and any other related issue, under the terms of clause 11(1)(a) of TRAI Act, 1997 as amended by TRAI Amendment Act, 2000.

B. Background

- 1.2 IR is India's national railway system operated by the Ministry of Railways. IR has a network size of over 66000 Route Km connecting more than 8000 stations on which 21000 passenger and freight trains run every day to move 8 billion passengers and 1 billion tons of freight annually.
- 1.3 Approximately 2.2 Crore passengers use trains daily, their safety and security are of paramount concern and priority for IR. Further, ever increasing demands for introduction of more trains and stoppages from different parts of the country coupled with IR's limited fixed infrastructure and rolling stock availability, there is a need to ramp up the speed and throughput of trains by upgrading carrying and handling capacity of the existing IR networks.

- 1.4 In India, 1.6 MHz (paired) spectrum in 900 MHz spectrum band has been assigned to IR on administrative basis for captive usage for their GSM-R based network.
- 1.5 For Radiocommunication between train and trackside, at present Indian Railways is using GSM-R of 2G version mobile communication system. It has been presently implemented on 2500 route KMs on Indian Railways. On rest of the network, RSTT is achieved using 5W and 25W VHF sets. Thus, the present RSTT i.e. GSM-R and VHF sets are primarily voice based and has hardly any data handling capacity to serve applications like monitoring alerts from CCTV cameras from coaches, Remote monitoring and diagnostics of rolling stock etc.
- 1.6 "Development of Ultra-high-speed wireless corridor along IR's network" was identified as one of the enabler for transformation of IR in the Chintan Shivar held under the guidance of Hon'ble PM in November 2017. A series of transformational initiatives have been contemplated by IR to bring big strategic shift in Railways operations, passenger safety & security regime, capacity to carry traffic, market share & efficiency, enhancing passenger satisfaction and improve financial health of Railways. One of the key initiatives in this regard is the proposal to install a Modern Railway Signalling and Train Control System (European Train Control System (ETCS) Level-2) based on Mobile Communication system.

C. About RSTT

- 1.7 Railway Radiocommunication Systems between Train and Trackside (RSTT) provide improved railway traffic control, passenger safety and improved security for train operations. It carries train control, voice dispatching, command, operational information as well as monitoring data between on-board radio equipment and related radio infrastructure located along trackside. Radiocommunication networks supporting RSTT are critical for train operations and have stringent requirements for reliability, availability, safety and security.

A. Generic Architecture of RSTT

1.8 The main elements¹ of the RSTT consist of on-board radio equipment, radio access units and other trackside radio infrastructure. Other systems, such as the core network, fiber loop etc., are supporting systems for the RSTT.

- Radio Access Unit: including antenna and base station, aiming 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.

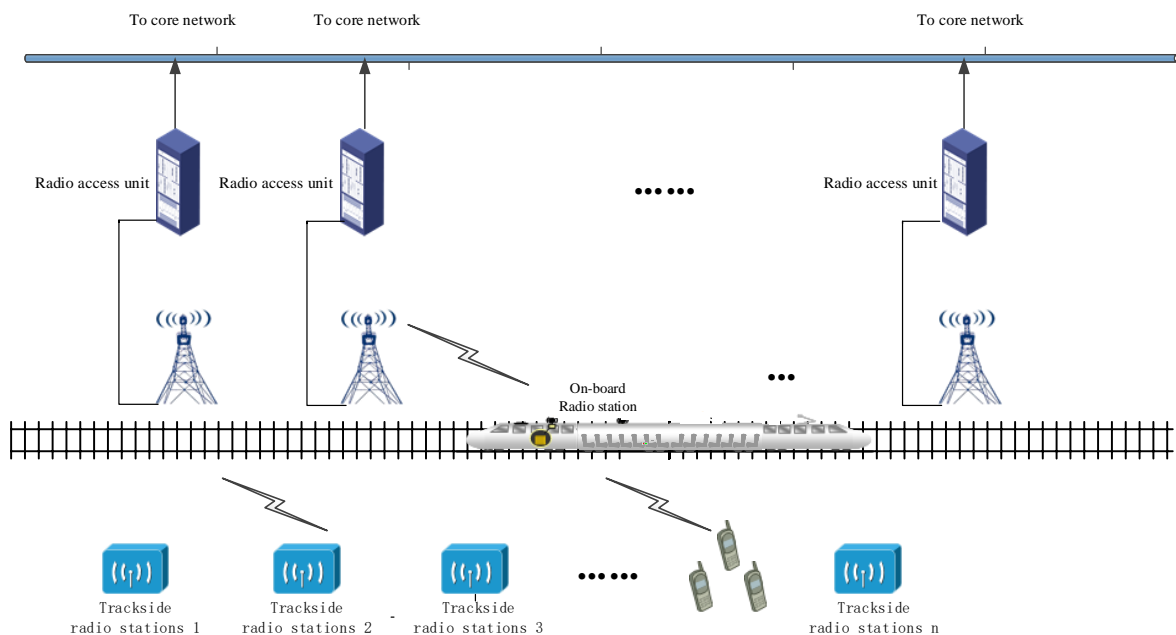


Figure 1.1: Diagram of the architecture of RSTT (Source: APT)

¹ http://www.apr.int/sites/default/files/Upload-files/AWG/APT-AWG-REP-78_APT_Report_RSTT_System_Description.docx

B. Various communications under RSTT

1.9 In general, the main application² of RSTT can be categorized into four types, including train radio, train positioning, train remote and train surveillance.

- Train radio: 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).
- 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 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.

² https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2418-2017-PDF-E.pdf

- Train remote: This application provides data communication between a locomotive and a ground-based system in order to control the engine. It enables remote controlled movement of trains typically for shunting operation in depots, shunting yards.

D. About ETCS

- 1.10 European Train Control System (ETCS) 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.
- 1.11 ETCS offers five functional levels - 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 STM is meant for trains equipped with ETCS and additional Specific Transmission Modules (STM) for interaction with legacy signalling systems (termed as class B systems). The ETCS acts as an interface between the driver and the national Automatic Train Protection (ATP) System.
 - 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.

E. Cause of reference from DoT

1.12 Ministry of Railways has proposed to install an Ultra-high-speed LTE based communication corridor along their network for Train-Ground and Train-Train communication. Ministry of Railways has also requested DoT to reserve 15 MHz of spectrum in 700 MHz band for this purpose and to begin with 10 MHz to be allocated free of cost as the proposal is devoid of any commercial gain, but only for enhancing security and passenger amenities.

1.13 Indian Railways made the following submissions:

- a) Long Term Evolution (LTE) is 4th Generation (4G) Mobile Communication System and is emerging as Global Standard for all new Train Control and Railway Signalling applications replacing the incumbent 2nd Generation (2G) GSM-R technology and is likely to see the broadest deployment of any new wireless technology over the next decade in Railway Safety, Security and Passenger experience applications.
- b) Installing an Ultra-high-speed LTE based communication corridor along IR network would cater to the current and future data and

voice needs for Train-Ground and Train-Train communication for improved train operations, passenger safety and passenger security services and remote rail asset monitoring & management.

- c) Active infrastructure including the BTSs, antennae and associated equipment are responsible for the creation of the radio access network, on which, the mobile devices connect to get access to data. With 700 MHz spectrum, active infrastructure (BTS specifically) spacing requirements will be in sync with location of railway stations spaced every 8-10 Kms. Consequently, mid-section radio infrastructure requirements will almost disappear.
- d) The ITU-R has identified the digital dividend spectrum in the frequency band 698-806 MHz for IMT in Region-3 (Asia-Pacific). This frequency range can provide effective mobile broadband services for Public Safety network and thus is most suitable for Indian Railways requirement.
- e) Adoption of 700 MHz frequency spectrum is growing across world's railways because of its inherent advantages such as wide coverage, low Capex, efficient network utilization etc. Another driving force is the ability in 700 MHz spectrum of LTE to provide efficient high speed, low latency, low setup time, and high-security data connectivity, which is the precondition to provide multimedia and especially mission critical multimedia communication for safety and security application on Railways.
- f) The bandwidth requirements in 700 MHz depend on data usage needs and capacity to carry projected amount of data. IR envisages following applications/facilities which will fuel growth in data usage on deploying LTE technology in 700 MHz:
 - (i) Mission Critical Passenger Safety Services & Applications through ETCS Level 2 or similar Railway Signalling system on IR.

- (ii) Video Surveillance (Live Feed) through CCTV cameras in trains along with Video Analytics for Passenger Security.
 - (iii) Faster data network Communication for voice, video and other related application.
 - (iv) More network-enabled devices (IoT based Asset reliability Monitoring).
 - (v) Providing Wi-Fi facility in trains.
 - (vi) Train and way side Telemetry through Mobile communications.
- g) Spectral bandwidth (critical) requirement (considering 10 Km average distance between towers) for data traffic requirement of Railway for Railway Mobile communication with various applications like provision of Wi-Fi in the trains, Safety critical Signalling system equivalent to ETCS Level 2, provision of downloading of select Video feed/alerts from CCTV cameras in moving trains comes to around 12 MHz.
- h) In light of the finite capacities of LTE and high bandwidth demands of Railway safety and security applications, a chunk of 15 MHz of spectrum for LTE shall be needed. Initially, since Railways may not start operating all services together, the network must have at least 10 MHz of spectrum to begin with as anything less than 10 MHz would not be suitable.
- i) Since frequency is proposed to be used for Passenger Safety and Security services and is not intended for any commercial use, the allotment of spectrum in 700 MHz band be made free of cost.

1.14 To sum up, IR has made the following requests to the DoT:

- (i) To reserve 15 MHz spectrum in 700 MHz frequency band for Indian Railways in the revised National Frequency Allocation Plan.
- (ii) To begin with, allot 10 MHz of spectrum to Indian Railways in 700 MHz frequency band.

- (iii) The spectrum of 10 MHz in 700 MHz frequency band to be allotted free of cost to Indian Railways as it is needed in the Public interest for Mission Critical Safety, Security and Passenger amenities applications by Indian Railways.

1.15 After examining the Draft cabinet note circulated by Ministry of Railways in this regard, DoT provided its comments on 2nd November 2018. Later, Ministry of Railways vide their letter dated 17th January 2019, while furnishing its response to DoT's comments, informed that the Ministry of Finance and Ministry of Law & justice, apart from many other Ministries have supported the Railways demand of 10 MHz spectrum in 700 MHz band free of cost and also requested DoT that their request may be reconsidered favourably. The request of Indian Railways was considered in the Digital Communications Commissions (DCC) and it was decided that the matter may be referred to TRAI.

F. Views of DoT

1.16 DoT examined the request of Ministry of Railways and provided its comments vide letter dated 2nd November 2018. Subsequently, Ministry of Railways vide its letter dated 17th January 2019 submitted its response to the comments/issues raised by DoT. The issue-wise comments of DoT, response of Ministry of Railways and views of DoT are summarized below.

a. 700 MHz and other candidate bands for LTE deployments

1.17 DoT has observed that 700 MHz band is a globally harmonised band deployed for the IMT (International Mobile Telecommunication) applications in the telecommunications service by various countries. In India, this band has been earmarked for the potential IMT services which can be deployed by the Telecom Service providers. This frequency band is spanning from 703-748 MHz/758-803 MHz, occupying total of 45 MHz paired spectrum. Before the availability of this band was announced, 10 MHz paired spectrum of this band had been carved out from this 45 MHz for the Defence use as part of the

Defence band commitment. DoT is now left with 35 MHz of paired spectrum in this band.

1.18 Further, TRAI vide its recommendations dated 1st August 2018, has provided the reserve price and other conditions for auction of various frequency bands including 700 MHz on the request of DoT. TRAI in these recommendations has, inter-alia, noted the following:

- a) With the increased demand for data services and uptake of data hungry applications, the need for spectrum has been ever increasing. Availability of sufficient spectrum is crucial in achieving the objectives of 'Digital India'.
- b) The 700 MHz band is being used worldwide for deployment of 4G and evolution of 5G services due to its excellent propagation characteristics and therefore it is one of the most sought-after bands for deployment of LTE.
- c) TRAI has also recognized the vibrant, ever growing ecosystem that uses 700 MHz for new generation telecom services globally and has advocated auctioning the entire 35 MHz spectrum, so as to emulate the success of APT700 (FDD) plan in India as was employed in more than 50 countries.

1.19 In view of the above, DoT through its letter dated 2nd November 2018, commented that as LTE based enhancements are available in 450 MHz - up to 6 GHz, as mentioned in ITU-R Report (Rep. ITU-R M.2418) on "Description of RSTT" and also, NFAP makes a provision for considering requirements of IMT applications in 450-470 MHz; possibility of deployment of LTE based network of IR may be explored in other frequency bands (e.g. 450-470 MHz etc.).

1.20 In response, Ministry of Railways mentioned that RSTT deployments in 450-470 MHz band has the following challenges:

- a) Limited ecosystem, no handheld devices available and functionality like Push-To-Talk (PTT) is not available which is

must for critical communication services, very limited market and very small number of commercial networks on LTE in this band.

- b) Bandwidth limitation may limit the possibility of mobile broadband capacity and limit the use case like video surveillance and on-board broadband services, Radio Network Redundancy is not possible to implement as it requires minimum 10 MHz to implement redundancy to ensure zero point of failure.
- c) Requirement of 5 MHz guard band between uplink and downlink.

1.21 DoT is of the view that in 450-470 MHz band, TDD plan is available which would not require guard band between uplink and downlink as required in FDD plan. Further, 450-470 MHz band has a contiguous 20 MHz bandwidth available as against IR's requirement of 15 MHz. Accordingly, DoT is of the view that possibility of deployment of LTE based network of IR may be explored in 450-470 MHz band.

1.22 DoT is further of the view that Resolution 236 (World Radiocommunication Conference (WRC)-15) invites WRC-19, based on the results of ITU-R studies, to take necessary actions, as appropriate, to facilitate global or regional harmonized frequency bands, to the extent possible, for the implementation of Railway Radiocommunication Systems between Train and Trackside (RSTT), within existing mobile service allocations. This agenda item (AI 1.11) would be addressed in WRC-19 to be held this year. Based on the ITU-R studies, detailed characteristics, implementations of current and planned RSTT and spectrum needs of RSTT would be finalized. Also, possible harmonization of frequency ranges for RSTT on global or regional basis would be done. This would ensure availability of radio systems operating in globally or regionally harmonized frequency ranges which may lead to economies of scale. Accordingly, DoT is of the view that it would be prudent to take decision on proposal of spectrum assignment to the Indian Railways based on the outcomes of WRC-19 to be held in November-2019.

b. Scarcity of spectrum in 700 MHz band for commercial telecom networks

- 1.23 DoT commented that in case the request of Indian Railways for allotment of 15 MHz spectrum is considered, only 20 MHz spectrum in 700 MHz band will be left for IMT services for the Access networks. This may not be sufficient for 4G/5G services considering that 3 to 4 service providers will be providing services in each service area. Reserving 15 MHz spectrum in 700 MHz band for Indian Railways may limit the supply of the spectrum and hamper the growth plans of the Telecom operators. Further, frequency bands below 700 MHz band are not presently available for allotment for IMT services in India. Therefore, 700 MHz band is the prime band for providing better coverage in rural areas.
- 1.24 In response, Ministry of Railways mentioned that critical requirement of IR is of 10 MHz, reserving 10 MHz for IR will leave 25 MHz for allotment to IMT services in India. Better rural coverage is possible even in lower frequency bands like 600 MHz, 450-470 MHz.
- 1.25 DoT is of the view that 700 MHz band is the lowest frequency band in which Access spectrum may be assigned to commercial Telecom Service Providers in India. Accordingly, spectrum in this band was put to auction in October 2016 and will again be offered for bidding in the upcoming auction. Reserving 15 MHz spectrum in 700 MHz band for Indian Railways may limit the supply of the spectrum that potentially would hike up the price of this crucial spectrum and could jeopardise the growth plans of the Telecom operators. Accordingly, spectrum in frequency bands other than 700 MHz band (e.g. 450-470 MHz) may be explored for meeting requirements of Indian Railways.

c. Requirement of Indian Railways along the track only, not complete geographical coverage

- 1.26 DoT commented that LTE based communication is proposed to be used along the Rail tracks laid by IR, for which, 15 MHz of 700 MHz

spectrum has been demanded from DoT. If this quantum of spectrum is reserved for Railways network, the same spectrum cannot be reused by Telecom operators in respective service areas. This is because potential interference prevents sharing of the same spectrum between Railways for covering the railway tracks and Telecom operators in their licensed service area.

- 1.27 In response to the above, Ministry of Railways submitted that the contention of potential interference between railway communication network and Telecom operators' network is not appropriate due to guard band between various frequencies deployed in the network.
- 1.28 In this context, DoT has mentioned that Indian Railways requires its network to be deployed along the track only. Current assignments to Indian Railways' GSM-R network in 900 MHz band are also in use along the track only. However, considering potential interference between railway communication network and Telecom operators' network, frequency carriers assigned to Indian Railways' network along the track in 900 MHz band are not assigned for commercial telecom networks.
- 1.29 DoT has further mentioned that in 450-470 MHz band, contiguous 20 MHz bandwidth in TDD plan is available for exploitation by Indian Railways. Also, this spectrum in 450-470 MHz band has not yet been planned for assignment to commercial telecom operators through auction. Accordingly, DoT is of the view that possibility of assignment of spectrum to Indian Railways in 450-470 MHz band may be explored.

d. Legality in administrative allotment of spectrum for Indian Railways in light of Hon'ble Supreme Court judgment dated 2nd February 2012 in 2G case

- 1.30 DoT vide comments provided on 2nd November 2018, had mentioned that a policy decision is also required to be taken as to whether spectrum can be assigned to Indian Railways administratively in light of the judgment dated 2nd February 2012 of Hon'ble Supreme Court in

Writ Petition (Civil) No. 423 of 2010 (2G case). Accordingly, DoT commented that views of Department of Legal Affairs, Ministry of Law and Justice, may be taken regarding administrative allotment of spectrum for Indian Railways.

- 1.31 In response to this, Ministry of Railways has mentioned that Ministry of Law and Justice has supported the request of Indian Railways and have provided favourable comments on the Draft Cabinet Note circulated by Ministry of Railways in this regard.

e. Pricing of Spectrum in 700 MHz band

- 1.32 DoT vide comments provided on 2nd November 2018, had mentioned that spectrum in 700 MHz band is a valuable spectrum as the reserve price provided by TRAI in their recommendations dated 1st August 2018 on pan-India basis comes out to be Rs. 98,520 crore for 15 MHz (paired) spectrum.
- 1.33 In response to this, Ministry of Railways has mentioned that Ministry of Finance has supported the request of Indian Railways for allotment of spectrum free of cost and have provided favourable comments on the Draft Cabinet Note circulated by Ministry of Railways in this regard.
- 1.34 DoT is of the view that Indian Railways has sought 15 MHz (10 MHz for the time being) in 700 MHz band free of cost for enhancing safety, security and passenger amenities for unlimited period whereas the spectrum has, at current TRAI recommendations Reserve Price, the potential to fetch about Rs. 1 Lakh crore as upfront for only 20 years. During all these 20 years, it would also fetch few Thousand crore of rupees in the form of Spectrum Usage Charges (SUC) accruable quarterly. 450-470 MHz band, on the other hand, has no demand from the Industry and service providers at present. Further, instead of 15 MHz spectrum as requested by Indian Railways, 450-470 MHz band has a total of 20 MHz spectrum for exploitation.

- 1.35 DoT also mentioned that Indian Railways has been assigned 1.6 MHz (paired) spectrum in 900 MHz band for their existing GSM-R based Public Safety and Security network, for which, no upfront payment towards assignment of spectrum has been paid. However, spectrum charges, on formula basis, are payable annually by Indian Railways for their existing radiocommunication networks, including GSM-R based network.

G. Reference Received from DoT

- 1.36 The Department of Telecommunications (DoT), through its letter No. L-14001/01/2019-NTG dated 27th February 2019 **(Annexure-I)**, informed about the proposal of Ministry of Railways to install an Ultra-high-speed LTE based communication corridor along their network for Train-Ground and Train-Train communication. Ministry of Railways had also requested DoT to reserve 15 MHz of spectrum in 700 MHz band for this purpose and to begin with 10 MHz to be allocated free of cost as the proposal is devoid of any commercial gain, but only for enhancing security and passenger amenities. Through the said letter, 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, under the terms of clause 11(1)(a) of TRAI Act, 1997 as amended by TRAI Amendment Act, 2000.
- 1.37 As the information given in its reference dated 27th February 2019 was not sufficient, the Authority vide its letter dated 19th March 2019 to DoT, sought additional information on some of the issues. Through its letter dated 10th May 2019 **(Annexure-II)**, DoT provided the information sought by the Authority.

H. Consultation process

- 1.38 A consultation paper on "Allotment of spectrum to Indian Railways for Public Safety and Security services" was issued on 14th June 2019 and specific issues were discussed. The last date for submission of the

comments was 22nd July 2019 and for counter-comments it was 5th August 2019. The Authority received comments from 12 stakeholders and counter comments were received from two stakeholders. These are available on TRAI's website www.trai.gov.in. An Open House Discussion was conducted on 26th August 2019 in New Delhi.

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

CHAPTER- II: EXAMINATION OF REQUEST OF MINISTRY OF RAILWAYS

A. Need to upgrade from GSM-R

- 2.1 At present, IR is using GSM-R based networks similar to various Railway networks deployed around the world. In India, 1.6 MHz (paired) spectrum in 900 MHz band has been assigned to Indian Railways for deployment of its GSM-R based network.
- 2.2 As approximately 2.2 Crore passengers use trains daily, their Safety and Security is of paramount concern and priority for IR. Further, due to ever increasing demands for introduction of more trains and stoppages from different parts of the country coupled with IR's limited fixed infrastructure and rolling stock availability, there is need to ramp up the speed and throughput of trains by upgrading carrying and handling capacity of the existing IR networks.
- 2.3 In the last decade, public networks have evolved from voice-centric second-generation systems, e.g., Global System for Mobile Communications (GSM) with limited capabilities, to fourth-generation (4G) broadband systems that offer higher data rates, e.g., long-term evolution (LTE). The GSM communications systems are being decommissioned as the public communication market is evolving toward the Third Generation Partnership Project (3GPP) LTE. As a consequence, GSM-R also has a foreseeable end to its lifetime. It is thus relevant to replace the current GSM-R technology with the next-generation railway-dedicated communication system providing improved capacity and capability.
- 2.4 There has always been a demand for increase in speed of trains. A new system is required to fulfill High Speed Rails (HSR) operational needs, offering new services but still coexisting with GSM-R for a long period of time. The selection of a suitable wireless communication system for HSRs needs to consider issues such as performance, service attributes, frequency band, and industrial support. Compared with GSM systems, LTE has a simple flat architecture, high data rate, and

low latency, making it an acknowledged acceptable bearer for real-time HSR applications.

- 2.5 According to the information submitted by Ministry of Railways, GPRS for data communication upto 14.4 Kbps is supported by GSM-R for data transport in the same way as with the regular GSM system. IR envisages that with the proposed LTE system in 700 MHz frequency band, it will yield peak data rate of 50/10 (DL/UL) Mbps and peak spectral efficiency of 2.55 bps/Hz.
- 2.6 IR has proposed to implement European Train Control System (ETCS) Level-2 for signalling, control and train protection purpose.

B. Other countries having plans to upgrade from GSM-R

- 2.7 Many countries are planning to shift to LTE based communication systems. ITU collected information on usage of Railway Radiocommunications Systems in 2016 by way of circulating a questionnaire. The questionnaire, inter-alia, asked about plans to migrate existing railway system. ITU published the responses³ received from 27 countries in 2017. Relevant responses received from the countries having plans to migrate to LTE based system or upgrade their existing systems are summarized in Table 2.1.

Table 2.1: Summary of the relevant responses to ITU Questionnaire

S.No.	Country	Response on plans to migrate existing system
1	South Korea	South Korea has already launched LTE-R using 718-728/773-783 MHz (U/D) frequencies.
2	Australia (Queensland Rail)	It has proposed to use ETCS level 2 and it is likely to be LTE based.
3	France	It is planning to migrate its GSM-R to a new technology to be defined by 2022 at EU level.
4	Japan	Is interested in the RSTT to provide the high-speed data to the train crews and passengers from the train communication network. So, Japan is studying mmWave band radiocommunication systems for railway systems to provide high-speed data to the train

³ https://www.itu.int/dms_pub/itu-r/md/.../R15-WP5A-C-0469!N17-P2!MSW-E.docx

S.No.	Country	Response on plans to migrate existing system
		crews and passengers to realize more secure and comfortable railway transport services.
5	China	China is planning to migrate the system. A field test related to LTE-based next generation railway radiocommunication system is planned to be carried out in 2018 on some high-speed railway line to verify system capacity and technical characteristics for RSTT in different typical scenarios.
6	Qatar	Migration to LTE will be assessed once technology is fully standardized and matured in rail environment.
7	Spain	GSM-R will be migrated in the future to a new broadband radiocommunication system. This new system is under definition in this moment by UIC (Railways International Union) and ERA (European Railway Agency).
8	Switzerland	The successor system of GSM-R (FRMCS) will originally be operated in 7 MHz of the 873-876 / 876-880 MHz and 918-921 / 921-925 MHz band. The services of GSM-P in 2G and 3G for non-critical railway applications will be migrated by 4G/LTE in 800 MHz, 1800 MHz, 2100 MHz and 2600 MHz.
9	United Kingdom	No programme is in place to replace the existing system, although a proposal to deploy GPRS over GSM-R is under review to support European Rail Traffic Management System (ERTMS) roll-out.

2.8 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.

2.9 Further, eLTE is being used in China on the Zhengzhou Metro Line 1, where it provides wireless ground-to-train voice, data and video channels, and on Shuo Huang Railway (the freight operator in China) between the multiple locomotives (slave and driver) of the freight trains

using 1800 MHz LTE TDD network, which has resulted in significant capacity augmentation of the freight line.

2.10 In this background, the following section deliberates the issues involved.

D. Issue wise analysis

i) Spectrum Requirement

2.11 Presently, spectrum for IMT services in India is being assigned through auction process and the spectrum sold is liberalized (technology agnostic). With the passage of time, several spectrum bands have been earmarked for IMT services in India. Table 2.2 given below provides the details of these spectrum bands.

Table 2.2: Spectrum bands earmarked for IMT services in India

Band	Uplink Frequency (MHz)	Downlink Frequency (MHz)	3GPP band no.	Duplexing Scheme
700 MHz	703 -748 MHz	758-803 MHz	28	FDD
	(35 MHz has been earmarked for Access services)			
800 MHz	824-844 MHz	869-889 MHz	5	FDD
900 MHz	890-915 MHz	935-960 MHz	8	FDD
1800 MHz	1710-1785 MHz	1805-1880 MHz	3	FDD
	(55 MHz has been earmarked for Access services)			
2100 MHz	1920-1980 MHz	2110-2170 MHz	1	FDD
	(40 MHz has been earmarked for Access services)			
2300 MHz	2300-2400 MHz		40	TDD
	(80 MHz has been earmarked for Access services)			
2500 MHz	2500-2690 MHz		41	TDD
	(40 MHz has been earmarked for Access services)			
3300 - 3600 MHz	3300-3600 MHz (25 MHz spectrum (3400 MHz - 3425 MHz) is identified for ISRO's use in Indian Regional Navigation Satellite System (IRNSS))		Not yet auctioned but TRAI has recommended: (i) TDD Duplexing scheme (ii) Barring the specific locations where ISRO is using the 25 MHz of spectrum, the entire spectrum from 3300 MHz to 3600 MHz should be made available for access services	

- 2.12 IR has requested to reserve 15 MHz (paired) in 700 MHz band and initially assign 10 MHz (paired) for LTE based communication corridor along their network for Train-ground and Train-Train Communication.
- 2.13 The 700 MHz band is being used worldwide for deployment of LTE due to its excellent propagation characteristics and therefore it is one of the most sought-after band for deployment of LTE. LTE device ecosystem is developing fast in this band.
- 2.14 Among the sub-1 GHz bands, 700 MHz band is the pioneer band for 5G services also. 5G will provide seamless coverage, high data rate, low latency, and highly reliable communications. It will increase energy efficiency, spectrum efficiency, network efficiency as well as efficiency of other systems. Along with enhanced connectivity to individuals, it will also help in digitalizing various industrial verticals. Thus, 5G will have a much larger economic impact on a country.
- 2.15 DoT, in its reference dated 27th February 2019, has stated that in 700 MHz band, only 35 MHz (paired) is available for TSPs and considering the fact that there are about four TSPs in each LSA, reserving 15 MHz spectrum in 700 MHz band for Indian Railways may limit the supply of spectrum that potentially would hike up the price of this crucial spectrum and could jeopardise the growth plans of the Telecom operators. Considering the physical characteristics of the spectrum bands, lower frequency bands provide wider coverage and better penetration. Currently, 700 MHz band is the lowest frequency band available for allotment for IMT services in India. Therefore, 700 MHz band is the prime band for providing better coverage.
- 2.16 DoT has further stated that IR would be using the spectrum along the railway track. If same frequencies are allotted to TSPs, it may cause interference issues. If the frequencies are assigned to IR for entire country, it may lead to inefficient utilization of this precious spectrum band.

2.17 DoT is also of the view that spectrum in 450-470 MHz is available and has not been earmarked for IMT services. Some countries are using this band for Railway Radiocommunication. 20 MHz spectrum is available in this band, which could be made available for IR. Being a lower frequency band, this can also meet the coverage requirement of IR.

2.18 In the ITU-R Report M.2442-0 (11/2018) on “Current and future usage of railway radiocommunication systems between train and trackside”, following has been mentioned:

“China plans to extend the length of railways to 175000 kilometres, including 38000 kilometres high-speed railways (account for 21.7%) by 2025. According to China railway’s medium and long-term development plan, the railway traffic would strongly increase approximately from 2020. In order to meet the increased railway service requirements, China Railway Corporation (CRC) has proposed the evolution of future RSTT, which is a FDD LTE-based system. Currently, CRC is planning to carry out a field trial of LTE-based RSTT in 2018. The test will be conducted on a high-speed line, from BEIJING to SHENYANG, and the system under test will be operated at 450 MHz frequency band (i.e. LTE band 31).”

2.19 DoT is of the view that Resolution 236 (WRC-15) invites WRC-19, based on the results of ITU-R studies, to take necessary actions, as appropriate, to facilitate globally or regionally harmonized frequency bands, to the extent possible, for the implementation of RSTT, within existing mobile service allocations. This agenda item (AI 1.11) would be addressed in WRC-19 to be held this year. Based on the ITU-R studies; detailed characteristics, implementations of current and planned RSTT and spectrum needs of RSTT would be finalized. Also, possible harmonization of frequency ranges for RSTT on global or regional basis would be done. This would ensure availability of radio systems operating in globally or regionally harmonized frequency ranges which may lead to economies of scale. Therefore, DoT is of the view that it would be prudent to take decision on proposal of spectrum assignment to the Indian Railways based on the outcomes of WRC-19 to be held in November-2019.

- 2.20 As regards quantum of spectrum, IR has submitted that spectral bandwidth (critical) requirement (considering 10 Km average distance between towers) for data traffic requirement of Railway for Railway Mobile communication with various applications like provision of Wi-Fi in the trains, Safety Critical Signalling System equivalent to ETCS Level 2, provision of downloading of select Video feed/alerts from CCTV cameras in moving trains comes to around 12 MHz.
- 2.21 IR has also submitted that in light of the finite capacities of LTE and high bandwidth demands of Railway Safety and Security applications, 15 MHz of spectrum for LTE shall be needed. Initially since Railways may not operate all services, the network must have at least 10 MHz of spectrum to begin with. Anything less than 10 MHz would not be suitable due to applications performing unreliably or system not being available 100%.
- 2.22 South Korea launched LTE-R for commercial use in 2017. A common 10 MHz spectrum in 700 MHz band has been assigned for integrated public network for public safety-LTE, LTE-Maritime and LTE-Railway.
- 2.23 As per a study undertaken by China⁴ on spectrum needs of Railway RSTT with respect to train radio applications considering frequency range of 450 MHz band, spectrum needs of RSTT arrived at were:

	Uplink	Downlink
Minimum spectrum needs	11.9 MHz	4.7 MHz
Maximum spectrum needs	14.04 MHz	8.38 MHz

- 2.24 It was noted that the request of IR for spectrum allocation is for deployment of LTE based signalling system, which will provide mission critical passenger safety service and applications through ETCS Level 2 system. Therefore, allotment of suitable spectrum to IR for deployment of LTE based RSTT system is of prime importance.

⁴ Report ITU-R M.2442 'Current and future usage of railway radiocommunication systems between train and trackside'. (https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2442-2019-PDF-E.pdf)

- 2.25 In the above background, the stakeholders were requested to furnish their comments on the spectrum band i.e. 700 MHz, 450-470 MHz or any other band, which would be appropriate for assignment to Indian Railways for RSTT and how much spectrum may be assigned to IR for RSTT.

Comments received from the stakeholders

- 2.26 Many stakeholders opined that spectrum in 700 MHz band should not be allocated to Indian Railways. The reasons cited by the stakeholders are:
- (i) If 10 or 15 MHz is assigned to Indian Railways from the available 35 MHz then 20 to 25 MHz spectrum may not be sufficient for the TSPs to fulfil the NDCP 2018 objectives.
 - (ii) It is globally harmonized for IMT usage, very suitable for coverage purposes (including rural and inbuilding coverage).
 - (iii) It is one of the prime band for deployment of 5G. This band has been globally identified for IMT 2020 (5G) by ITU as well as NFAP.
 - (iv) Economic benefits of countrywide mobile broadband in 700 MHz outweigh those of set-asides for application-specific uses.
 - (v) IR use is limited to along the railway tracks; therefore, this precious spectrum will remain unutilized in rest of the country.
- 2.27 Some stakeholders have submitted that the Authority should wait for the outcome of WRC-19 so that Indian Railways can be benefitted with globally harmonized spectrum bands for meeting their requirements of RSTT. One stakeholder has mentioned that according to the GSM-R industry, GSM-R will be supported until 2025-2030; therefore, IR should continue to deploy GSM-R based Radiocommunication Systems for Public Safety and Security till such time that a new alternate proven technology in a globally harmonised spectrum band for Railways is identified by WRC-19 of ITU.

- 2.28 Many stakeholders are of the opinion that Indian Railways can be allocated spectrum in the 450-470 MHz for deployment of LTE based RSTT. One of these stakeholders has also mentioned that spectrum in Band 71 (i.e. 663 – 698/ 617 – 652 MHz) may also be explored.
- 2.29 One stakeholder is of the view that bands B26 (814-849/859-894) and B27 (807-824/852-869) in the 800 MHz spectrum could also be considered for railways, if PPDR is not implemented in these bands.
- 2.30 One more stakeholder has opined that spectrum in 800 MHz band i.e. 3GPP Band 26 should be assigned to Indian Railways. It has also been stated that the Authority has also recommended 2x10 MHz spectrum of 3GPP Band 26 on no cost basis for LTE based nationwide broadband PPDR network. Further, deploying communication networks based on LTE technology on harmonized spectrum for both RSTT and PPDR allows easy co-ordination and interworking between the two networks during disaster situation, which is essential and best practice worldwide.
- 2.31 One stakeholder submitted that success of GSM-R is largely attributed to the allocation of common 4 MHz (876–880 MHz in the uplink band, 921–925 MHz in the downlink band) spectrum across Europe. Most of the European Operators are targeting to maintain their existing GSM-R deployments till 2035 and possibly beyond. It is in their interest to protect their existing investments. Therefore, the stakeholder is of the opinion that allocation of 4 MHz in 900 band (i.e. 2.4 MHz in addition to 1.6 MHz already allocated in 900 band) to Indian railways will be an immediate solution for full deployment of ETCS Level 2. For spectrum in other bands, the stakeholder has mentioned that India should follow UIC⁵ standards for Future Railway Mobile Communication System (FRMCS) and Harmonization of spectrum in line with the European countries / operators. As regards use of 450-470 MHz band, the stakeholder has opined that there is no live

⁵ UIC (French: Union internationale des chemins de fer) or International Union of Railways is an international rail transport industry body

reference of deployment of ETCS Level2 in main line railway using 450 to 470 MHz spectrum. Ecosystem of devices (Cab Radio / Modem, Handsets, Dispatcher etc.) does not exist in 450-470 MHz. Railway signalling systems are normally designed with highest level of safety features. Since deployment of ETCS Level 2 signalling in 450-470 MHz will be non-standardized and without proper references, it is not recommended. Nowhere in the world, there is any reference of ETCS Level 2 or its equivalent working on band 450-470 MHz.

2.32 Another stakeholder opined that spectrum is not the monopoly of only commercial use but is equally important and critical for space, defence, railways, national security and social needs. IR requirement is for public safety and security. Railways should be given free spectrum of 700 MHz for Wifi and signalling use, because IR will use spectrum for deployment of Mission Critical Voice and Data for the passenger safety.

2.33 Indian Railways in its counter comments has made the following submissions:

- a) The views of the stakeholders that ‘since 700 MHz band has been earmarked for IMT service, no spectrum should be assigned to IR in this band’, are not correct. 10 MHz in this band has already been allotted to Ministry of Defence.
- b) Social gains realized from improvement in safety and security of the passengers as well as faster train operations could be far more than that indicated by stakeholders. Economists have time and again stressed that the Indian Railways have the potential to boost the Indian economy and GDP in a big way.
- c) GSM-R and the 1.6 MHz GSM-R spectrum (in 900 MHz band) allotted to IR are inadequate.
- d) The ecosystems for 450-470 MHz band Radio and hand-held devices in this band are not available. Functionality like PTT is not available, which is must for critical communication services. Non-

standardized/proven system cannot be tried for safety applications.

- 2.34 Regarding quantum of spectrum that should be assigned to IR, one stakeholder has responded that to begin with, 5 MHz FDD or 10 MHz TDD may be assigned to IR in 450-470 MHz band and Band 71 may also be explored. Few stakeholders have responded that initially, 10 MHz spectrum be provided to IR in 450-470 MHz band, which may be increased in the future based on requirements and utilization of allocated spectrum; however, the spectrum should be strictly allocated for Railway's operational and signalling requirement. Another stakeholder is of the view that 2 x10 MHz block size from 800 MHz spectrum band i.e. 3GPP Band 26 should be assigned to Indian Railways.

Analysis

- 2.35 A good public transport not only provides mobility, it is also vital to improve our quality of life, can shape land use and development patterns, generate jobs, drives economic development and also helps in bridging the gap between urban and rural areas. Indian Railways has shortened the distance and developed the outlook of people. By connecting various areas of the country, railways has made internal trade convenient. They carry goods and passengers to various places easily. Railway network is useful for internal security of country and also carry the defence material to various locations during external threat. Railways have increased the mobility of labour and capital which has contributed to the rapid industrialization of the country. Having said all this, time and again questions arise on safety and security of the passengers and goods being carried by the trains. Further, there is a considerable gap between the carrying capacity and the demand. "Development of Ultra-high-speed wireless corridor along IR's network" was identified as one of the enabler for transformation of IR. One of the key initiatives in this regard is the proposal to install a Modern Railway Signalling and Train Control System based on Mobile Communication system.

- 2.36 The technological development has been touching almost every aspect of human lives and Railways cannot be an exception. Certainly, there is a need to modernize the railway signalling system to derive the benefits of newer and better technologies.
- 2.37 Indian railway has proposed to install LTE based Railway Signalling and Train Control System, for which it has requested that 15 MHz spectrum in 700 MHz band may be reserved and to begin with 10 MHz may be assigned to it. IR had proposed that this spectrum would be used for the following purposes:
- i) Mission Critical Passenger Safety Services & Applications through ETCS Level 2 or similar Railway Signalling system on IR.
 - ii) Faster data network Communication for voice, video and other related application.
 - iii) More network-enabled devices (IoT based Asset reliability Monitoring).
 - iv) Train and way side Telemetry through Mobile communications.
 - v) Providing Wi-Fi facility in trains.
 - vi) Video Surveillance (Live Feed) through CCTV cameras in trains along with Video Analytics for Passenger Security.
- 2.38 As mentioned earlier, DoT is of the view that instead of 700 MHz band, IR should explore using 450-470 MHz for its requirements. DoT is also of the view that it would be prudent to take decision on proposal of spectrum assignment to the Indian Railways based on the outcomes of WRC-19.
- 2.39 The issues related to RSTT frequency harmonization are covered under the Agenda item AI 1.11 of WRC 2019. As regards agenda item AI 1.11, the Report of the CPM on technical, operational and regulatory/procedural matters to be considered by the WRC 2019, mentions as follows:

“Three methods have been proposed to satisfy this agenda item:

- Method A: No change to the RR except suppression of Resolution 236 (WRC-15);
- Method B: Add a new Resolution [A111-METHOD B] (WRC-19) specifying frequency ranges for RSTT and referencing the most recent version of Recommendation ITU-R M.[RSTT_FRQ] and consequently suppress the Resolution 236 (WRC-15);
- Method C: Add a new Resolution [B111-METHOD C] (WRC-19) without specifying frequency ranges for RSTT, while referencing the most recent version of Recommendation ITU-R M.[RSTT_FRQ] and consequently suppress the Resolution 236 (WRC-15).”

From the above, it appears that the WRC-19 planned in October-November 2019 will not be in a position to take a final call on harmonization of spectrum for RSTT.

- 2.40 Many stakeholders in their comments have opined that no spectrum in 700 MHz band should be given to IR.
- 2.41 One stakeholder opined that spectrum is not only for commercial use but is equally important and critical for space, defence, railways, national security and social needs. IR requirement is for public safety and security and it should be given free spectrum of 700 MHz for Wi-Fi and signalling use, because IR will use spectrum for deployment of Mission Critical Voice and Data for the passenger safety.
- 2.42 Few of the stakeholders have commented that there is no live reference of deployment of ETCS Level2 in main line railway using 450-470 MHz spectrum. Ecosystem of devices (Cab Radio / Modem, Handsets, Dispatcher etc.) does not exist in 450-470 MHz.
- 2.43 It is noted that some countries have adopted TETRA technology for their railway communication systems in the spectrum range from 380 MHz to 470 MHz and device ecosystem is available in 450-470 MHz for TETRA technology.

- 2.44 Nevertheless, IR has proposed to deploy LTE based Railway communication system for which it has requested to reserve 15 MHz paired spectrum in 700 MHz band and to begin with 10 MHz (paired) to be assigned to IR. LTE being the newer technology and provides an evolution path to 5G, several countries are looking at LTE as a natural replacement for GSM-R. If LTE based system is deployed by Railways, the benefit of continuous technological evolution will come naturally.
- 2.45 In India, 700 MHz band has a total of 45 MHz (paired), out of which, 10 MHz (paired) has been earmarked for Defence and the remaining 35 MHz (paired) was put to auction for IMT services in 2016, wherein it received no bid. Considering the facts that (i) the ecosystem in this band has developed further, (ii) the TSPs have been grappling with the issue of coverage resulting in no-coverage zones and call drops and (iii) 700 MHz Band is being seen as prime band for 5G, the TSP may like to have spectrum in this band in their kitty.
- 2.46 Indian Railways envisages to use the spectrum for the following services:
- a) Safety Services: Signalling (ETCS Level-2) [consist of communication between On-Board Equipment and Trackside Equipment]
 - b) Voice Communication: MCPTT communication and voice calling on-board train
 - c) IoT Based Asset Reliability Monitoring
 - d) Security Services: Video Surveillance (Live Feed) through CCTV Cameras in trains.
- 2.47 During the Open House Discussion, Professor Kiran Kuchi from IIT, Hyderabad mentioned that they have carried out a study on data rate and spectrum requirement for implementing LTE based ETCS Level-2 signalling system by Indian Railways. Subsequently, the Report on the study was shared by IIT, Hyderabad with the Authority through e-mail. The three key outcomes of the study are shown below:

a) Data rate requirement for various requirements of IR

S.No	Application	Data rate requirement in download	Data rate requirement in upload
1	ETCS Level-2	100 Kbps	100 Kbps
2	MC PTT + Voice	660 Kbps + 1000 Kbps	660 Kbps + 1000 Kbps
3	IoT services	2 Mbps	2Mbps
4	Passenger information display system	100 Kbps	10 Kbps
	Total Requirement	3.86 Mbps	3.86 Mbps
5	On Board Video Surveillance (minimum per Train)	200 Kbps	Upto 40 Mbps
	Total including Video Surveillance	4.06 Mbps	Upto 43.86 Mbps

In panic, bandwidth requirement for on-board video surveillance per coach: minimum 6 Mbps

b) Spectrum requirement in 700 MHz band

Functionality	Spectrum Requirement
ETCS Level-2 (train control, Safety, signalling etc.), MCPTT + Voice, Passenger Information and IoT based asset monitoring	5 MHz (paired)
Video Surveillance System	10 MHz or more (paired)

c) Ecosystem in 450-470 MHz band: Only few chipset companies support the UE receivers while the base station radio ecosystem is weak in this band. Further, NB-IoT products are not available in the 450-470 MHz band.

2.48 From the reports published by Global mobile Suppliers Association (GSA), it is seen that the LTE device ecosystem in 700 MHz band has

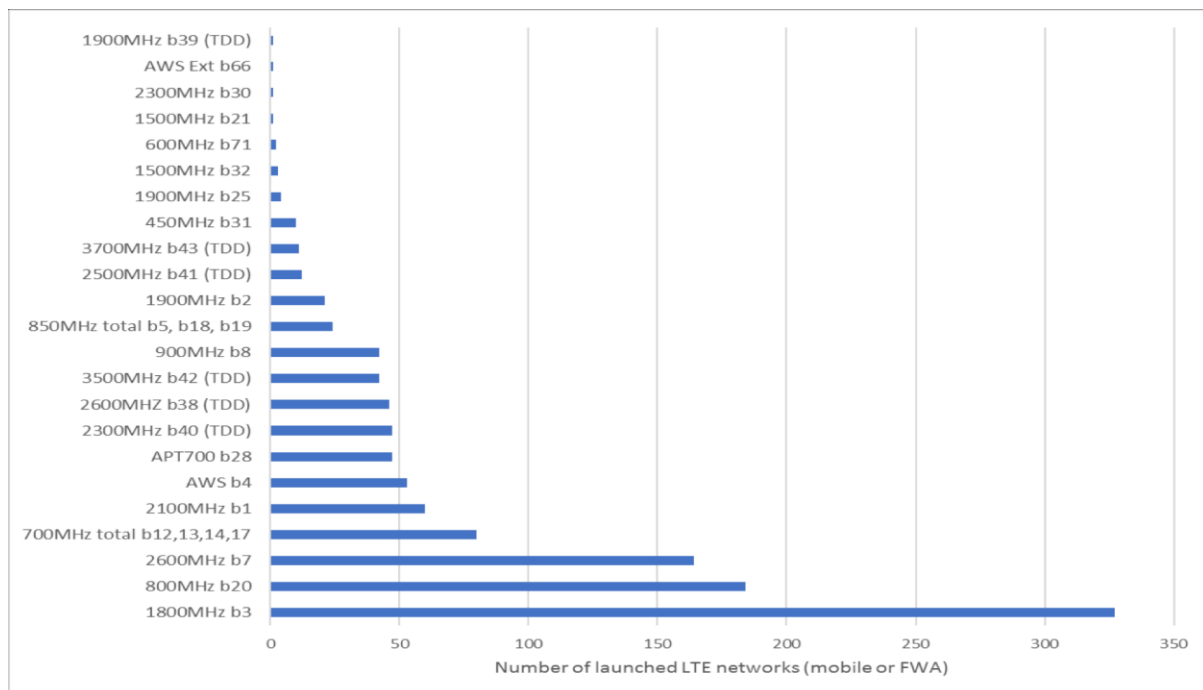
been increasing at a fast pace. From the information on LTE networks launched as of April 2019 published by GSA, it is seen that very few LTE networks have been launched in 450-470 MHz spectrum band, while in 700 MHz band, nearly 50 LTE networks have been launched. It may also be seen that number of LTE networks launched using 700 MHz band are same as that launched in 2300 MHz band. The details are provided in Table 2.3 and Figure 2.1 given below:

Table 2.3: LTE supported user devices in APT 700 MHz band (Band 28)

Month & Year	Number of LTE supported user devices
October-2016	469
May-2018	1212
September-2019	2000

Source: GSA Reports

Figure 2.1: Number of LTE Networks launched as of April 2019



Source: GSA Reports

2.49 As can be seen from the outcomes of the Study conducted by IIT, Hyderabad, the data rate requirement for implementation of ETCS Level-2 based train signalling system, Mission Critical Push To Talk (MCPTT), Voice, IoT services for assets management and passenger

information display is only 3.86 Mbps, which can be easily met with 5 MHz of paired spectrum. Larger bandwidth is required only on account of requirement of uploading of CCTV Video surveillance data from all the coaches of the train. For one coach, the upload data rate requirement for video surveillance is around 6 Mbps whereas for entire train, it is upto 40 Mbps. As per the LTE throughput table given below, the downlink peak data rate for 5 MHz bandwidth is 36.7 Mbps with 2 x 2 MIMO and uplink peak data rate is 18.3 Mbps with 64 QAM modulation.

Table 2.4: LTE FDD System Throughput

Transmission Mode/System Bandwidth	No of Useable Resource Block	SISO	Transmit	MIMO 2x2	All Transmission Mode	
		Downlink Peak (Mbps)	Downlink Peak (Mbps)	Downlink Peak (Mbps)	Uplink Peak (Mbps) 16 QAM	Uplink Peak (Mbps) 64 QAM
1.4 MHz	6	4.4	4.4	8.8	3	4.4
3 MHz	15	11.1	11.1	22.1	7.5	11.1
5 MHz	25	18.3	18.3	36.7	12.6	18.3
10 MHz	50	36.7	36.7	75	25.5	36.7
15 MHz	75	55.1	55.1	110	37.9	55.1
20 MHz	100	75	75	150	51	75

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

further enhanced by increasing the number of BTSs, using MIMO and higher order modulation techniques [64 QAM]. It is further noted that 5 MHz (paired) spectrum is not available either in 800 MHz band or 900 MHz band on pan-India basis.

- 2.51 Spectrum is one of the resources which can be used as an input in a multitude of services, whether for communications or other applications. Communications services encompass a wide range of forms, including narrow or broadband mobile telecommunications, broadcasting, aeronautical and marine communications, as well as communications for public bodies such as, defence, railways or emergency services.
- 2.52 Spectrum can be in short supply because there may be more potential users of particular frequencies than available spectrum. There is, therefore, a need for rationing its use and giving priority to more important applications.
- 2.53 Core principles in the management and allocation of spectrum should be to allocate the spectrum to the highest value uses or uses which ensure maximum benefits to society.
- 2.54 Economic objectives relate to ensuring that spectrum is used in ways which meet the country's goals covering the efficient allocation of resources – that spectrum is employed by both private and public sector organisations in ways which meet the country's economic growth and other objectives.
- 2.55 In defining high-level objectives for spectrum policy, it is sensible to take, as a starting point, the maximisation of value of outputs produced by the spectrum available, including the valuation of public outputs provided by the government or other public authorities. Suppose a given quantity of spectrum is available for use in two sectors, mobile communications and train safety. How should it be divided between the two uses? Because end-users derive benefit from both services, allocating the entire spectrum exclusively to one or the

other use may create an artificial shortage of spectrum. Some kind of compromise is required which reflects the value end-users place on both services, the cost of providing them and the amount of spectrum they require.

- 2.56 In allocating spectrum, priority should initially be given to services which are highly valued by end-users, with end-users expressing the value to them directly by making individual purchasing decisions. However, in some cases, where government is providing the public service such as Railways, the government might express that value on citizens' behalf by providing the service publicly.
- 2.57 Since the Train safety is of utmost importance from point of view of passengers travelling in, allocation of spectrum for train signalling purpose (ETCS Level-2) will provide higher benefits to society. It is important for Indian railways to have the latest standards of Train signalling system in order to improve the passenger safety as well as to improve the operational efficiency. LTE based communication System based on ETCS Level-2 shall certainly provide an edge to Indian Railways in respect of Train Safety and operational efficiency. The objective of meeting country's goal and economic growth is getting fulfilled in case certain spectrum is provided to Indian Railways in LTE band. As the LTE-R is being deployed in 700 MHz band and the ecosystem is also available in this band, the Authority feels that spectrum may be provided to Indian Railways in 700 MHz band for faster deployment of ETCS Level-2 signalling in India.
- 2.58 In view of the forgoing discussion, the Authority is of the view that 5 MHz (paired) spectrum in 700 MHz band may be allocated to Indian Railways for implementing ETCS Level-2, MC PTT + Voice, IoT based asset monitoring services, passenger information display system and live feed of Video Surveillance of few coaches at a time. To implement video surveillance of all the coaches in the train, Indian Railways may explore other communication means such as:

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

(ii) use of public telecommunications network (TSPs network) for sending continuous video surveillance data streams to its control center.

2.59 Spectrum is a scarce natural resource, it is necessary to have a mechanism to ensure that it is utilized efficiently. When spectrum is assigned administratively, it becomes all the more important to have stringent measures to ensure that the spectrum assigned is put to efficient use and it does not remain unutilized. Ministry of Finance while giving its support to the proposal of IR, has also indicated certain conditions to be imposed while giving spectrum, one of which is to ensure optimal utilization of frequency spectrum. From the request of the Indian Railways, it is seen that they want to implement LTE based radiocommunication system at the earliest. However, considering the vast rail track network of IR, it is bound to take some time to implement it. Considering the above, the Authority is of the view that efficient and timely utilization of spectrum be ensured through a process of periodical monitoring. Further, as discussed earlier, IR has already been assigned 1.6 MHz in 900 MHz band for its GSM-R network. Once IR migrates to LTE based network, this 1.6 MHz spectrum in 900 MHz band may be taken back from IR.

2.60 In addition to the above, since the use of IR is limited to its railway track network, it needs to be ensured that the spectrum is put to efficient use. Therefore, the Authority is of the view that for the areas where IR is not using the assigned frequencies, DoT may explore the possibility of assigning the spectrum 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.

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

- (a) Out of the 35 MHz (paired) spectrum available in 700 MHz band, 5 MHz (paired) spectrum may be allocated to Indian Railways for implementing ETCS Level-2, MC PTT + Voice, IoT based asset monitoring services, passenger information display system and live feed of Video Surveillance of few coaches at a time. The remaining 30 MHz (paired) in 700 MHz band may be put to auction in the forthcoming auction.**
- (b) To implement the Video Surveillance System for all coaches of the Train (Security services), Indian Railways may explore other communications means such as-**
 - (i) Dumping the Video Surveillance data to the system using high capacity WiFi when the train reaches a station.**
 - (ii) Using Public Telecommunication Network (TSPs network) for sending continuous video surveillance data streams to its control center.**
- (c) Efficient and timely utilization of spectrum be ensured through a process of periodical monitoring. Further, the 1.6 MHz spectrum already assigned to IR in 900 MHz band may be taken back from IR upon migration to LTE based network.**
- (d) As Indian Railways would be using the assigned spectrum along its railway track network and stations only, DoT may explore the possibility of assigning the same spectrum in other areas for area-specific limited use to other entities for captive use. However, it should be ensured that there is no interference to the Railways' network from such use.**

a. Spectrum Assignment Methodology

2.62 Hon'ble Supreme Court of India, through its judgment dated 2nd February 2012, quashed the licenses granted on or after 10th January

2008 and ordered to issue fresh licenses by auctions. This decision of the Hon'ble Supreme Court had a major bearing on the process of award of spectrum, the assignment of which was earlier done administratively. Since 2012, total five auctions have been held for assignment of spectrum in various access bands. In August 2018, the Authority sent its recommendations on auction of spectrum in different access spectrum bands, including 700 MHz band.

- 2.63 While access spectrum is being assigned through auctions to wireless access service providers, spectrum assignment is being made administratively at administrative spectrum charges on formula basis to certain category of captive / public / commercial service providers such as Internet Service Providers (ISPs) and PMRTS for providing public/ commercial service.
- 2.64 Presently, 1.6 MHz spectrum in 900 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 22nd March 2012.
- 2.65 IR has requested that the spectrum in 700 MHz be assigned free of cost as the proposal is devoid of any commercial gain, but only for enhancing safety, security and passenger amenities. Ministry of Railways has also mentioned that Ministry of Law & Justice and Ministry of Finance have supported the request of Indian Railways and have provided favourable comments on the Draft Cabinet Note circulated earlier by Ministry of Railways in this regard.
- 2.66 In its letter dated 28th March 2019 to DoT, IR has further clarified that the bandwidth requirement of 10 MHz in 700 MHz frequency band is for data usage needs for following safety and security applications/facilities:
- (i) Mission Critical Passenger Safety Services & Applications through a Modern Train Control System for Railway Signalling

system on IR. Modern Train control will augment train carrying capacity on Railway network because of increased speed and less fixed distance between the trains. This will allow more number of trains to be handled safely on the same fixed infrastructure.

- (ii) Video Surveillance (Live feed) through CCTV networks in trains along with Video Analytics for passenger Security.
- (iii) Faster data network Communication for voice, video and other related applications like IoT based Asset reliability, Monitoring and Train and way side telemetry through Mobile communications.

2.67 Through its earlier letter, IR had also mentioned that they envisage provision of Wi-Fi facility onboard and the spectrum requirement indicated by IR also considers provision of Wi-Fi in the trains.

2.68 In view of the foregoing discussion, the stakeholders were requested to provide their inputs on what should be the methodology (including price) of allotment of spectrum to Indian Railways for RSTT in India, in both, IMT band already earmarked for mobile services and other bands such as 450-470 MHz. The Stakeholders were also asked to comment upon whether they foresee any challenge if IR makes internet services available onboard i.e. within the train using spectrum allocated for signalling purpose.

Comments received from the stakeholders

2.69 Many stakeholders have opined that any commercial spectrum band earmarked for mobile services should be assigned via auction. They have further submitted that in case it is decided that spectrum in IMT bands which have already been earmarked for mobile services, be assigned to IR, it should either participate in Auction or pay the auction determined price. One of the stakeholders also submitted that Railways is a commercial organisation and safety & control system are part of operation and would be part of the cost of operation and they should bear this cost; in case market price is not available, it should be based on the reserve price recommended by TRAI and Indian

Railways should be asked to pay difference of reserve price & market price to be discovered in next auction from date of assignment. On the other hand, most of these stakeholders have opined that in case it is decided to assign spectrum in other spectrum bands (including 450-470 MHz band), the existing process followed by DoT for assignment of spectrum administratively for captive usage can be followed as IR would be using the spectrum for RSTT services only; however, the spectrum should be used for specified uses and IR should not be allowed to offer any commercial services such as Wi-Fi.

- 2.70 One stakeholder has opined that IR should be asked to pay the auction price for spectrum assigned in any band. In case the auction price is not available in some band, then the nearest band price may be taken. If at a later date price is determined, then any difference in price must be paid. For 450 MHz band, the nearest band that must be selected is 700 MHz band.
- 2.71 One stakeholder has submitted that spectrum in 450-470 MHz band may be administratively allocated to IR at a discounted price or can be even given free of cost, as this is for public benefit. Another stakeholder has submitted that spectrum with 2x10 MHz block in Band 26 having similar radio propagation characteristics as 700 MHz band is recommended by the Authority on no cost basis for PPDR, the same approach should be extended to Indian Railways while harmonizing the spectrum requirement for PPDR and RSTT.
- 2.72 One of the stakeholders submitted that allocation methodology should support fair and non-discriminatory access to spectrum principles and without creating artificial scarcity for mobile operators, avoiding a limited performance and inflated spectrum costs.
- 2.73 Some of the stakeholders opined that Indian Railways should be assigned spectrum free of cost. Reasons cited were:
- i. any spectrum allocation meant for larger public good should be done by Government administratively and free of cost.

- ii. Railways will be using the spectrum for deployment of Mission Critical Voice and Data for the safety of the passengers.

2.74 One stakeholder has quoted, Supreme Court's February 2012 judgment⁶ on "Writ Petition (Civil) No. 423 Of 2010", that allows for using natural resources (spectrum in our case) for "larger public good" with reference to the following point, as mentioned in the judgment:

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

It has been further submitted that the Union Government, later, had opted for a Presidential Reference asking a series of questions seeking clarity on the 2G judgment. The basic question was whether auction as a mode of disposal of natural resources under the government's control was a constitutional requirement. The Supreme Court's response to this was in negative. Further, court observed that *"Auctions may be the best way of maximizing revenue, but revenue maximization may not always be the best way to sub serve the public good. 'Common good' is the sole guiding factor under Article 39 (b) for distribution of natural resources"*. The stakeholder is, thus, of the view that when the endeavors of state policy are to attain social good, an auction cannot be considered the sole criteria for allocation of natural resources⁷.

2.75 One of the stakeholders has submitted that the outcome of the WRC-19 be examined so that IR can get benefitted with globally harmonized spectrum bands for meeting their requirements of RSTT.

⁶ The Supreme Court Of India Civil Original Jurisdiction Writ Petition (Civil) No. 423 Of 2010", case no - W.P.(C) No.-000423-000423 / 2010 dated February 2, 2012, <http://supremecourtindia.nic.in/jonew/judis/39041.pdf>, accessed on November 27, 2017.

⁷ Keeping Vigil by Harish Salve; published on October 28, 2012; <https://www.businesstoday.in/magazine/focus/2g-presidential-reference-sc-clarity-on-natural-resources/story/188856.html>; accessed on July 8, 2019

- 2.76 One of the stakeholders in its counter comments has submitted that Railways should be given free spectrum in 700 MHz band and did not agree that IR should take part in auctions, ultimately railways belong to Govt. of India and citizens money, so the Govt. pays to Govt. hardly makes any sense and the burden will unnecessarily be passed to citizens.
- 2.77 Indian Railways in its counter comments submitted that
- a) Regarding pricing mechanism for spectrum allocation, Indian Railways requires 10 MHz spectrum in 700 MHz band, free of cost as this proposal is devoid of any commercial gain, but only for enhancing safety of trains, security of passengers, disaster management and IOT based assets monitoring.
 - b) 10 MHz Spectrum in this band has already been allotted to Ministry of Defence on free of cost basis. Thus, the assertions of the principle of service neutrality, assessment of economic spectrum in allotment do not hold good.
 - c) The proposal of allotment of 10 MHz spectrum in 700 MHz band to IR has already concurred by Ministry of Law & Justice.
- 2.78 As regards provision of Wifi services, all the stakeholders are of the view that spectrum assigned for such captive use should not be used for commercial usage. Further, reasons cited are:
- a) In case IR is permitted to provide Wi-Fi services to the passengers, there will be a direct hit on revenue of TSPs and chances of interference would also be there.
 - b) Only licensed TSP can provide Internet services. To provide commercial service like Internet, Railways should obtain the appropriate authorization under Unified License and necessarily obtain their spectrum resources through auctions and comply with the applicable Regulation and Quality of service norms.
 - c) Any provision of Internet services onboard should be done by facilitating the TSPs to install their own infrastructure.

- d) The main spectrum requirement for Indian Railways is RSTT i.e. signalling purpose. This requirement concerning railway safety and passenger safety shall not be compromised for providing complementary internet services onboard.
- e) Allocation of spectrum for mission critical voice and data for the Railways should not be used for any other purposes.

2.79 Indian Railways in its counter comments has agreed that any commercial use of spectrum can only be undertaken by a licensed telecom service provider. Indian Railways (not as a service provider for internet services) requires captive 10 MHz spectrum in 700 MHz band, free of cost, as this proposal is devoid of any commercial gain, and is only for enhancing safety of trains, security of passengers, disaster management and IOT based assets monitoring. This spectrum is not for the purpose of providing On-board internet services in trains for commercial purposes.

Analysis

- 2.80 As can be seen from the above, many of the stakeholders have opined that if spectrum is assigned to IR in the bands already earmarked for mobile services, IR should take part in auction or pay the equivalent price; however, in case it is decided to assign spectrum to IR in other bands such as 450-470 MHz band, DoT may assign the same on administrative basis for captive use and the same may be charged as per the existing formula based method. Some of the stakeholders have opined that irrespective of the spectrum band in which spectrum is assigned to IR, spectrum should be assigned administratively free of cost.
- 2.81 As regards provision of internet services on board, most of the stakeholders have opined that the spectrum should be used for specified uses and IR should not be allowed to offer any commercial services such as Wi-Fi. Indian Railways in its counter comments has also agreed that any commercial use of spectrum can only be

undertaken by a licensed telecom service provider. The Authority also concurs with the view of the stakeholders.

- 2.82 Indian Railway is being operated by Ministry of Railways, Government of India and it has larger goal of socio-economic benefit by providing reliable, safe and secure railway services rather than increasing profitability. Certainly, by deploying latest technology, IR would be benefited by (i) improving carrying capacity as speed of the trains can be increased safely and also the inter-train fixed distance can be reduced substantially, (ii) providing reliable, safer and secure services, (iii) lowering operational and management costs by implementing IoT based asset management. However, at the end of the day, it will benefit the people using railway services and fuel the growth of overall economy of the country.
- 2.83 DoT in its reference has sought the Recommendations of the Authority on administrative allotment of spectrum to Indian Railways.
- 2.84 Spectrum is a natural resource. Its value depends on its use. If it is not used, it has no value. If deployed for providing commercial services, its value would be different. It may be worth mentioning that spectrum reserve price is determined considering various factors including revenue potential for TSPs. For provision of mobile services, which is the core business of TSPs, spectrum is the key ingredient, using which, the services are consumed by the subscribers. Whereas, Indian Railways core business is to provide transport services and trains being mobile, spectrum is required along the track network to meet its signalling requirement and not for the services consumed by the passengers/users; thus, the spectrum requirement is captive requirement rather than commercial requirement. Therefore, it would not be rational to ask IR to pay the auction determined price i.e. equivalent to that paid/payable by the TSPs. Further, if spectrum is assigned for captive use, there exists a formula-based charging mechanism. It may be pertinent to mention that presently IR has been assigned 1.6 MHz in 800 MHz band on administrative basis for captive use and DoT is charging for this spectrum on formula basis.

2.85 In view of the above, **the Authority recommends 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.

c. Any other method by which Indian Railways can implement LTE based radiocommunication system

2.86 IR has requested for spectrum in 700 MHz band for deployment of Pan-India LTE-R network for the ETCS Level 2 operation along the 66000 route Km of railway line. It will be the biggest project of signalling system in Indian Railways. As mentioned by DoT, if 15 MHz spectrum in 700 MHz band is reserved for Railways network, the same spectrum cannot be reused by Telecom operators in respective service areas. This is because potential interference prevents sharing of the same spectrum between Railways for covering the railway tracks and Telecom operators in the licensed service area. Thus, the spectrum reserved for IR will remain under-utilized in terms of geographical use. Therefore, it would be prudent that other options are also explored.

2.87 One option could be to get the LTE-R based network built and deployed through one of the existing TSP who may have spectrum in 700 MHz band⁸. In this scenario, the TSP will build the network for IR along the railway track for ETCS Level 2 based on LTE-R standards and at the same time utilize the same frequencies for its commercial operation elsewhere. This will take care of the effective utilization of the spectrum and state of art LTE-R network for IR. The control, use and operation of the LTE-R may be with IR only whereas the maintenance and SLA could be maintained by the concerned TSP. It may be worth

⁸ Spectrum in 700 MHz is to be put up for auction by DoT in the forthcoming auction expected to be held in late 2019.

mentioning here that in 2017, South Korea launched LTE-R for commercial use, wherein the State-run Korea Rail Network Authority designated KT, Korea's second largest wireless carrier for the project.

- 2.88 Another option could be to have an integrated network for Public Safety i.e. Public Protection and Disaster Relief (PPDR) and Railways, similar to the way implemented in South Korea. As discussed earlier, South Korea launched LTE-R for commercial use with 10 MHz (paired) spectrum in 2017. However, the assigned 10 MHz (paired) spectrum is common for integrated public network shared for Public Safety-LTE, 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.
- 2.89 PPDR communication supports a wide range of services related to day to day life of public such as maintenance of law and order, protection of life and property, disaster relief and emergency responses. PPDR and Railways, both have the requirement of a robust communication system. Since requirement of railway is limited to the rail network, it could be possible that a common network is put in place which can be used for PPDR as well as railway communication.
- 2.90 The Authority in its recommendations on “Next Generation Public Protection and Disaster Relief (PPDR) communication networks” dated 4th June 2018, *inter-alia*, recommended the following:
- Government to set up pan-India integrated Broadband PPDR (BB-PPDR) Communication Network (to be called “National BB-PPDR Network”) based on 3GPP PS-LTE technology.
 - 2x10 MHz of dedicated spectrum should be allocated nationwide to the Special Purpose Vehicle (SPV) under Ministry of Home

Affairs (MHA) on no-cost basis for LTE based broadband PPDR networks.

- 814-824/859-869 MHz should be assigned for nationwide BB-PPDR services.
- 20 MHz of spectrum in the frequency range 440-470 MHz (preferably 450-470 MHz) should be allocated for future evolution of broadband PPDR.

2.91 From the above, it can be seen that the Authority has recommended that 10 MHz (paired) spectrum in 800 MHz spectrum band be allocated for nationwide PPDR network. This 10 MHz (paired) spectrum could be used for PPDR as well as Railway communication. A single TSP may deploy integrated network using 10 MHz (paired) spectrum having PS-LTE deployment for PPDR agencies and LTE-R deployment for Indian Railways. This will require coordination and Standard Operating Procedures (SOP) between Ministry of Home Affairs and Indian Railways.

2.92 In view of the foregoing discussion, the stakeholders were requested to provide their connects on whether the requirement of IR for RSTT can be fulfilled using alternate methods such as-

Alternate (i) a TSP could build, deploy and maintain LTE-R network for IR; while the control, use and operation of the LTE-R network may be with IR,

Alternate (ii) there could be a common integrated network (with common spectrum) for Public Safety i.e. Public Protection and Disaster Relief (PPDR) and Railways, using PS-LTE and LTE-R technology respectively.

Comments received from the stakeholders

2.93 Some of the stakeholders have responded that an approach similar to alternate (i) can be followed where different TSPs can associate with IR for different areas, which will result in more efficiency and innovation in setting up of RSTT.

- 2.94 One stakeholder opined that the alternate (i) is a feasible option. Under this option, while the RSTT related services can be controlled by Railways, the commercial and monetization part can be left to the partner TSP. The TSP can be permitted to offer the onboard Wi-Fi and other services. Additionally, the TSP can use the towers built for this network, to provide service to nearby areas, as well, thus becoming a win-win situation. The stakeholder also opined that the Alternate (ii) can also be explored. However, such a utility will require a detailed discussion and agreement with the PPDR agencies as well, as there is a possibility of operational issues due to multiple Authorities using the same network or same frequency spots in overlapping geography. Going by Authority's existing recommendation of PPDR, this proposal will lead to a very complex situation involving multiple Government agencies using common network resources, which is provided majorly by BSNL/MTNL and partially by a private TSP. One simpler way would be to let private TSP provide the network for PPDR and Railways both, while using the spectrum resources for commercial use in remaining areas.
- 2.95 One stakeholder supported Alternate (i) with the modification that Telecom PSU Operators could build, deploy and maintain LTE-R network for IR; while the control, use and operation of the LTE-R network may be with IR. Network slicing will allow Telecom PSUs to dedicate a portion of their spectrum to provide best quality of service for application-specific uses.
- 2.96 One stakeholder commented that mobile operators have provided services to vertical industries for years, notably in 3G and 4G, and will also provide dedicated services using 5G. This allows for competition between operators in order to secure the best financial deal possible via commercial arrangements. Network slicing will allow mobile operators to dedicate a portion of their spectrum to provide best quality of service for application-specific uses.
- 2.97 Few of the stakeholders favoured alternate (ii), wherein there could be a common integrated network (with common spectrum) for Public

Safety i.e. Public Protection and Disaster Relief (PPDR) and Railways, using PS-LTE and LTE-R technology respectively. It was submitted that in view of the merits of cost and resource optimisation including spectrum requirements, this method may be a more viable option, though this method will have its implementation challenges as it is required to roll out a nation-wide network on the scale of Bharat Net. To optimize interference, the concerned ministries shall establish Standard Operating Procedures (SOP). The operational control of network rests with the respective Ministries through a dedicated core or dedicated slice of the common core. The maintenance of the network can be taken care by a third party.

- 2.98 Some of the stakeholders opined that RSTT network must be developed and governed by the IR. IR network should work as a stand-alone Island network with no connectivity to any public network. This will secure the network from any external IP threats and also the network will not be overloaded in case of any disaster / accident.
- 2.99 Indian railways in its counter comments submitted that it is not possible to run mission critical communication applications and safety related train control applications on commercial network of mobile operators. It may endanger the safety of trains. This was the reason for roll out of GSM-R on Railways in the world. Further, mixing PPDR use with RSTT use in the 800 MHz band is likely to result in interference along the path of Railways. This is not advisable for Mission Critical Passenger Safety Services.

Analysis

- 2.100 Some stakeholders have favoured alternate (i); however, it has potential of exposing IR network into various kinds of threats. Some have favoured alternate (ii); however, this option would involve multiple agencies and coordination requirement could come into the way of its successful and timely implementation. Some stakeholders have opined that to ensure security of the network, IR network should

work as a stand-alone Island network with no connectivity to any public network.

- 2.101 Considering the proposal of the IR, which is basically to enhance safety and security of the IR passengers and goods, the Authority is of the view that at this point of time, it may be appropriate that IR network may work as a stand-alone. Building a stand-alone network would provide many benefits such as, (i) IR can develop the network as per its own requirements, (ii) IR will have full control over capacity utilization, and (iv) IR can implement the network so as to conform to the desired Quality of Service (QoS) requirement & Standards.

CHAPTER- III: SUMMARY OF RECOMMENDATIONS

3.1 The Authority recommends that

- (a) Out of the 35 MHz (paired) spectrum available in 700 MHz band, 5 MHz (paired) spectrum may be allocated to Indian Railways for implementing ETCS Level-2, MC PTT + Voice, IoT based asset monitoring services, passenger information display system and live feed of Video Surveillance of few coaches at a time. The remaining 30 MHz (paired) in 700 MHz band may be put to auction in the forthcoming auction.**
- (b) To implement the Video Surveillance System for all coaches of the Train (Security services), Indian Railways may explore other communications means such as-**
 - (i) Dumping the Video Surveillance data to the system using high capacity WiFi when the train reaches a station.**
 - (ii) Using Public Telecommunication Network (TSPs network) for sending continuous video surveillance data streams to its control center.**
- (c) Efficient and timely utilization of spectrum be ensured through a process of periodical monitoring. Further, the 1.6 MHz spectrum already assigned to IR in 900 MHz band may be taken back from IR upon migration to LTE based network.**
- (d) As Indian Railways would be using the assigned spectrum along its railway track network and stations only, DoT may explore the possibility of assigning the same spectrum in other areas for area-specific limited use to other entities for captive use.**

However, it should be ensured that there is no interference to the Railways' network from such use.

[Para 2.61]

3.2 The Authority recommends 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.**

[Para 2.85]

Annexure I

(Without its Annexures)

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

No.: L-14001/01/2019-NTG

Date: 27.02.2019

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

Subject: Recommendations of TRAI on administrative allotment of spectrum to Indian Railways for Public Safety and Security services at stations and in the trains and the quantum, price and appropriate frequency band (including 450-470 MHz band).

Sir,

This is to inform that Indian Railways has proposed to install an Ultra high speed LTE based communication corridor along their network for Train-ground and Train-Train communication. Ministry of Railways had requested Department of Telecom (DoT) to reserve 15 MHz of spectrum in 700 MHz band for this purpose and to begin with 10 MHz to be allocated free of cost as this proposal is devoid of any commercial gain, but only for enhancing security and passenger amenities.

2. The Draft cabinet note circulated by Ministry of Railways in this regard was examined and comments of DoT were provided on 02.11.2018. Copies of the Draft Cabinet Note and DoT comments dated 02.11.2018 thereon are placed at **Annexure-I** and **Annexure-II** respectively.
- 2.1. Later, Ministry of Railways vide their letter dated 17.01.2019 (**Annexure-III**) has informed that the Ministry of Finance and Ministry of Law & Justice, apart from many other Ministries have supported the Railway's demand for allotment of 10 MHz spectrum in 700 MHz band free of cost.
- 2.2. In view of the comments received from Ministry of Finance and Ministry of Law & Justice, apart from other Ministries, Ministry of Railways has requested that the issue may be reconsidered as their requirement is devoid of any commercial gain and necessary for effective implementation of the project on Indian Railways to enhance safety of running trains, provide secured travel for passengers and improve on board amenities.

3. The request of Indian Railways was considered in the Digital Communications Commission (DCC). A brief on the issues considered by DCC is placed at **Appendix**. After discussion, it was decided that the matter may be referred to TRAI. The decision of the DCC is annexed as **Annexure-IV**.

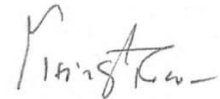
4. In view of the above, TRAI is requested to provide:

- i. Recommendations on administrative allotment of spectrum to Indian Railways and the quantum, price and appropriate frequency band (including 450-470 MHz band) under the terms of clause 11 (1)(a) of TRAI Act, 1997 as amended by TRAI Amendment Act 2000.

TRAI may examine the request of the Indian Railways in the context of its earlier recommendations with respect to auction of spectrum including its recommendation dated 01.08.2018 wherein TRAI has recommended that all available spectrum in 700 MHz band may be put to auction.

- ii. Any other recommendations deemed fit for the purpose.

Encl: As above.



(M. P. S. Alawa)

Sr. Deputy Wireless Adviser

Brief on Indian Railways' request regarding their proposal for installation of Public Safety and Security services at stations and in the trains

1. Indian Railways has proposed to install an Ultra high speed LTE based communication corridor along their network for Train-ground and Train-Train communication. Ministry of Railways had requested Department of Telecom (DoT) to reserve 15 MHz of spectrum in 700 MHz band for this purpose and to begin with 10 MHz to be allocated free of cost as this proposal is devoid of any commercial gain, but only for enhancing security and passenger amenities.
2. Draft cabinet note circulated by Ministry of Railways in this regard was examined and comments of DoT were provided on 02.11.2018. Copies of the Draft Cabinet Note and DoT comments dated 02.11.2018 thereon are placed at **Annexure-I** and **Annexure-II**.
- 2.1. Later, Ministry of Railways vide their letter dated 17.01.2019 (**Annexure-III**) has informed that the Ministry of Finance and Ministry of Law & Justice, apart from many other Ministries have supported the Railway's demand for allotment of 10 MHz spectrum in 700 MHz band free of cost.
- 2.2. In view of the favourable comments received from Ministry of Finance and Ministry of Law & Justice, apart from other Ministries, Ministry of Railways has requested that the issue may be reconsidered favourably as their requirement is devoid of any commercial gain and necessary for effective implementation of the project on Indian Railways to enhance safety of running trains, provide secured level for passengers and improve on board amenities.
3. The request of Indian Railways was considered in the Digital Communications Commission (DCC). In this matter, the following was considered by DCC:
 - 3.1. **700 MHz and other candidate bands for LTE deployments**
 - 3.1.1. 700 MHz band is a globally harmonised band deployed for the IMT (International Mobile Telecommunication) applications in the telecommunications service by various countries. In India, this band has been earmarked for the potential IMT services which can be deployed by the Telecom Service providers. This frequency band is spanning from 703-748 MHz/758-803 MHz, occupying total of 45 MHz paired spectrum (45+45). Before the availability of this band was announced, 10 MHz paired spectrum (10+10) of this band had been carved out from this 45 MHz for the Defence use as part of the Defence band commitment. Department is now left with 35 MHz of paired spectrum in this band.
 - 3.1.2. Further, TRAI vide recommendations dated 01.08.2018 has provided the reserve price and other conditions for auction of various frequency bands including 700 MHz on the request of DoT. In these recommendations TRAI has noted the following:

- i. With the increased demand for data services and uptake of data hungry applications, the need for spectrum has been ever increasing. Availability of sufficient spectrum is crucial in achieving the objectives of 'Digital India'.
 - ii. The 700 MHz band is being used worldwide for deployment of 4G and evolution of 5G services due to its excellent propagation characteristics and therefore it is one of the most sought after band for deployment of LTE.
 - iii. TRAI has also recognised the vibrant, ever growing eco system that uses 700 MHz for new generation telecom services globally and has advocated auctioning the entire 35 MHz spectrum, so as to emulate the success of APT700 (FDD) plan in India as was employed in more than 50 countries.
- 3.1.3. Ministry of Railways, in their Draft Cabinet Note had also identified the advantages of choosing the 700 MHz for their network which coincidentally by similar logic has been attributed by TRAI for patronising this band for the exclusive Telecom service in India.
- 3.1.4. In this context, it was mentioned by DoT (in comments dated 02.11.2018) that High frequency bands have larger propagation loss and more severe fading; therefore, lower frequency bands may be preferred for deployment of **Railway Radiocommunication Systems between Train and Trackside (RSTT)** network which is expected to cover a wider geographical area.
- 3.1.5. Further, as LTE based enhancements are available in 450 MHz – up to 6 GHz, as mentioned in ITU-R Report (Rep. ITU-R M.2418) on Description of RSTT (**Annexure IV**) and also, NFAP makes a provision for considering requirements of IMT applications in 450 - 470 MHz; possibility of deployment of LTE based network of Indian Railways may be explored in other frequency bands (e.g. 450-470 MHz etc.).
- 3.1.6. In response to this, Ministry of Railways has mentioned that RSTT deployments in 450-470 MHz band has the following challenges:
- a) Limited ecosystem, no handheld devices available and functionality like PTT is not available which is must for critical communication services, very limited market and very small number of commercial networks on LTE in this band.
 - b) Bandwidth limitation may limit the possibility of mobile broadband capacity and limits the use case like video surveillance and on-board broadband services, Radio Network Redundancy is not possible to implement as it requires minimum 10 MHz to implement redundancy to ensure zero point of failure.
 - c) Interference challenges (5 MHz guard band between uplink and downlink).
- 3.1.7. In this context, it may be noted that in 450 - 470 MHz band, TDD plan is available which would not require guard band between uplink and downlink as required in FDD plan available in 700 MHz band. Further, 450 - 470 MHz band has a contiguous 20 MHz bandwidth available as against Indian railways' requirement of 15 MHz.

Accordingly, possibility of deployment of LTE based network of Indian Railways may be explored in 450-470 MHz band.

3.1.8. It may further be noted that Resolution 236 (WRC-15) invites WRC-19, based on the results of ITU-R studies, to take necessary actions, as appropriate, to facilitate global or regional harmonized frequency bands, to the extent possible, for the implementation of railway radiocommunication systems between train and trackside (RSTT), within existing mobile service allocations.

3.1.8.1. To address this agenda item (AI 1.11), ITU-R has undertaken studies towards the development of two ITU-R Reports and one Recommendation. ITU-R studied the generic architecture, main applications, current technologies, generic operating scenarios of RSTT and developed Report ITU-R M.2418. ITU-R circulated a questionnaire to administrations of Member States, gathering information on the usage of RSTT. Responses received have been included in Report ITU-R M.[RSTT.USAGE] which also includes the detailed characteristics, implementations of current and planned RSTT and the spectrum needs of RSTT. ITU-R commenced development of Recommendation ITU-R M.[RSTT_FRQ], which provides possible harmonization of frequency ranges and frequency arrangements for RSTT on global or regional basis. Copy of relevant extract from the draft CPM (Conference Preparatory Meeting) Report issued in this regard is placed at **Annexure-V**.

3.1.8.2. Based on the Report ITU-R M.2418, it was conveyed to Ministry of Railways to explore possibility of deployment of LTE based network of Indian Railways other frequency bands (e.g. 450-470 MHz etc.).

3.1.8.3. This agenda item (AI 1.11) would be addressed in WRC-19 to be held this year. Based on the ITU-R studies; detailed characteristics, implementations of current and planned RSTT and spectrum needs of RSTT would be finalized. Also, possible harmonization of frequency ranges for RSTT on global or regional basis would be done. This would ensure availability of radio systems operating in globally or regionally harmonized frequency ranges which may lead to economies of scale. In view of the above, it would be prudent to take decision on proposal of spectrum assignment to the Indian Railways based on the outcomes of WRC-19.

3.2. Scarcity of spectrum in 700 MHz band for commercial telecom networks

3.2.1. DoT *vide* comments provided on 02.11.2018, had further mentioned that while considering the request of Indian Railways for allotment of 15 MHz spectrum, only 20 MHz spectrum in 700 MHz band will be left for IMT services for their Access network. This may not be sufficient for 4G/5G services considering that 3 to 4 service providers will be providing services in each service area. Reserving 15 MHz spectrum in 700 MHz band for Indian Railways may limit the supply of the spectrum that potentially would hike up the price of this crucial spectrum and could jeopardise the growth plans of the Telecom operators. It may further be mentioned that frequency bands below 700 MHz band are not available for allotment for IMT

services in India. Therefore, 700 MHz band is the prime band for providing better coverage in rural areas.

3.2.2. In response to this, Ministry of Railways has mentioned that critical requirement of Indian Railways of 10 MHz for Indian Railways will leave 25 MHz for allotment to IMT services in India. Better rural coverage is possible even in lower frequency bands like 600 MHz, 450-470 MHz.

3.2.3. In this context, it may be mentioned that 700 MHz band is the lowest frequency band in which Access spectrum may be assigned to commercial telecom service providers in India. Accordingly, spectrum in this band was put to auction in October-2016 and will again be offered for bidding in the upcoming auction. Reserving 15 MHz spectrum in 700 MHz band for Indian Railways may limit the supply of the spectrum that potentially would hike up the price of this crucial spectrum and could jeopardise the growth plans of the Telecom operators. Accordingly, spectrum in frequency bands other than 700 MHz band (e.g. 450-470 MHz) may be explored for meeting requirements of Indian Railways.

3.3. **Requirement of Indian Railways along the track only, not complete geographical coverage**

3.3.1. DoT *vide* comments provided on 02.11.2018, had mentioned that LTE based communication is proposed to be used along the Rail tracks laid by Indian Railways for which 15 MHz of 700 MHz spectrum is demanded from DoT. If this quantum of spectrum is reserved for Railways network, the same spectrum cannot be reused by Telecom operators in respective service areas. This is because potential interference prevents sharing of the same spectrum between Railways for covering the railway tracks and Telecom operators in rest of the areas in a particular service area.

3.3.2. In response to this, Ministry of Railways has mentioned that the contention of Potential interference between railway communication network and Telecom operators' network is not appropriate due to guard band between various frequencies deployed in the network.

3.3.3. In this context, it may be mentioned that Indian Railways requires its network to be deployed along the track only. Current assignments to Indian Railways' GSM-R network in 900 MHz band are also in use along the track only. However, considering potential interference between railway communication network and Telecom operators' network, frequency carriers assigned to Indian Railways' network along the track are not assigned in other areas to commercial telecom networks.

3.3.4. Further, in 450 - 470 MHz band, contiguous 20 MHz bandwidth in TDD plan is available for exploitation by Indian Railways. Also, this spectrum in 450 - 470 MHz band has not yet been planned for assignment to commercial telecom operators through auction. Therefore, possibility of assignment of spectrum to Indian Railways in 450 - 470 MHz band may be explored.

3.4. Legality in administrative allotment of spectrum for Indian Railways in light of Hon'ble Supreme Court judgment dated 02.02.2012 in 2G case

- 3.4.1. DoT *vide* comments provided on 02.11.2018, had further mentioned that a policy decision is also required to be taken as to whether spectrum can be assigned to Indian Railways administratively in light of the judgment dated 02.02.2012 of Supreme Court in Writ Petition (Civil) No. 423 of 2010 (2G case). Views of Department of Legal Affairs, Ministry of Law and Justice, may be taken regarding administrative allotment of spectrum for Indian Railways.
- 3.4.2. In response to this, Ministry of Railways has mentioned that Ministry of Law and Justice has supported the request of Indian Railways and have provided favourable comments on the Draft Cabinet Note circulated by Ministry of Railways in this regard.

3.5. Pricing of Spectrum in 700 MHz band

- 3.5.1. DoT *vide* comments provided on 02.11.2018, had further mentioned that spectrum in 700 MHz band is a valuable spectrum as the reserve price as provided by TRAI in their recommendations dated 01.08.2018 on pan-India basis comes out to be Rs. 98,520 crore.
- 3.5.2. In response to this, Ministry of Railways has mentioned that Ministry of Finance has supported the request of Indian Railways for allotment of spectrum free of cost and have provided favourable comments on the Draft Cabinet Note circulated by Ministry of Railways in this regard.
- 3.5.3. In this context, it may be mentioned that Indian Railways has sought for 15 MHz (10 MHz for the time being) in 700 MHz band to be allocated free of cost only for enhancing safety, security and passenger amenities for eternity whereas the spectrum has, at current TRAI recommendations Reserve Price, the potential to fetch about Rs. 1 lakh crore as upfront for only 20 years. During all these 20 years, it would also fetch few thousand crore of rupees in the form of Spectrum Usage Charges (SUC) accruable quarterly. 450 - 470 MHz band, on the other hand, has no demand from the Industry and service providers at present. Instead of 15 MHz spectrum as requested by Indian Railways, 450 - 470 MHz band has a total of 20 MHz spectrum for exploitation.
- 3.5.4. It may also be noted that Indian Railways has been assigned 1.6 MHz (paired) spectrum in 900 MHz band for their existing GSM-R based Public Safety and Security network for which no upfront payment towards assignment of spectrum has been paid. However, spectrum charges on formula basis are payable annually by Indian Railways for their existing radiocommunication networks including GSM-R based network.

- 3.6. Considering the above, DCC decided to seek recommendations of TRAI on the issue of administrative allotment of spectrum to Indian Railways and the quantum, price and appropriate frequency band (including 450-470 MHz band).

Annexure-II

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning & Coordination Wing

6th floor, Sanchar Bhawan,
20, Ashoka Road, New Delhi-110001.

No.: L-14001/01/2019-NTG

Date: 10.05.2019

To,

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

Subject: Additional information sought by TRAI in the matter of administrative allotment of spectrum to Indian Railways for Public Safety and Security services at stations and in the trains and the quantum, price and appropriate frequency band (including 450-470 MHz band).

Reference: (1) DoT letter No. L-14001/01/2019-NTG dated 27.02.2019.
(2) TRAI letter No. 103-2/2019-NSL-II dated 19.03.2019.

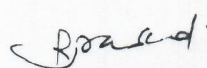
Sir,

Kind attention is invited to DoT's letter dated 27.02.2019 referred above, wherein recommendations were sought from TRAI in the matter of administrative allotment of spectrum to Indian Railways for Public Safety and Security services at stations and in the trains and the quantum, price and appropriate frequency band (including 450-470 MHz band).

2. TRAI vide their letter dated 19.03.2019 informed that certain documents have been provided by DoT, however, in order to get more clarity on related aspects and to examine the matter, detailed clarification on some of the points and some additional information is required. In this regard, certain information was sought from Ministry of Railways. A copy of response received from Ministry of Railways vide their letter dated 28.03.2019 is enclosed as Annexure 1.

3. Point-wise information/clarification as sought by TRAI vide letter dated 19.03.2019 is placed at Annexure 2.

Encl: As above.


(R. B. Prasad)
Joint Wireless Adviser
Phone: 2337 2183

FTS-38071
11/4/2019

Annexure 1
2407/7102/2019
29/3/19

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
RAILWAY BOARD

No. 2017/Tele/14(1)/1 Pt-1

Dated: 28.03.2019

✓ Wireless Adviser,
Wireless Planning & Coordination Wing,
Ministry of Communications,
Department of Telecommunications,
6th Floor, Sanchar Bhawan, 20, Ashoka Road,
New Delhi.

Sub: Additional information/clarifications regarding administrative allotment of spectrum in 700 MHz frequency band to Indian Railways for proposed LTE Network to enhance Public Safety and to improve security regime at stations and in trains.

Ref: - (i) Telecom Regulatory Authority of India's letter No.103-2/2019-NSL-II dt. 19.03.2019.
(ii) Wireless Planning & Coordination Wing's letter No.L-14001/01/2019-NTG dated 26.03.2019

This is in reference to Digital Communication Commission (DCC) decision to seek recommendations from Telecom Regulatory Authority (TRAI) for administrative allotment of spectrum in 700 MHz frequency band to Indian Railways. The proposed LTE based communication backbone network in 700 MHz frequency band is to enhance passenger Safety and to improve Security regime at stations and in trains. TRAI vide reference (i) has sought additional information and clarifications to get more clarity on the related aspects to examine the matter. Accordingly, item wise remarks are as below:-

SNo	Clarification item	Remarks of Indian Railway
1	Provide in detail the systems functionalities and purpose for which the spectrum in 700 MHz band is proposed to be used by Indian Railways.	<ul style="list-style-type: none"> ❖ Indian Railways(IR) has a network size of over 66,000 Route KMs (RKM) connecting more than 8,000 stations on which 21,000 Passenger and Freight trains run every day to move over 8 billion passengers and 1 billion tons of freight annually. 2.25 Crore passengers (approx) use train services daily, their Safety and Security is of paramount concern and priority for IR. Furthermore, the ever-increasing demands for introduction of more trains and stoppages from different parts of the country coupled with IR's limited fixed infrastructure and rolling stock availability, there is need to ramp up the speed of trains to upgrade carrying and handling capacity of the existing Railway networks. ❖ Indian Railways is looking to operationalize applications around Safety (ETCS Level 2, emergency communications etc.), internal management (staff communication, remote asset monitoring, etc.) and passenger security/experience (free

Page 1 of 3

		<p>browsing, free audio/video entertainment, live CCTV monitoring etc.).</p> <ul style="list-style-type: none"> ❖ These requirements are highly varied in their bandwidth and network latency. Also, live on-board CCTV monitoring over the mainline requires high bandwidth (8 cameras per coach for with H.265 Codec). ❖ Global benchmarking shows that railway operators are presently not using such an application – the data is stored in the train and is used for post-processing as required. ❖ Considering various options, IR has planned to deploy Global Standard LTE for mission critical Railway application. LTE is poised to replace the incumbent 2nd Generation (2G) GSM-R technology.
(ii)	What is the total length of Railway track in Route kms for which the proposed system will be deployed in 700 MHz	The proposed LTE communication system in 700 MHz frequency band is planned to be deployed over entire Indian Railways network. Uniform backbone communication system will enhance Passenger Safety, security and asset reliability applications progressively over 66,000 Route KMs (RKMs) connecting more than 8,000 stations and covering about 21000 passenger and goods trains running daily.
(iii)	What is the time frame in which the system is proposed to deploy and made operational by Indian Railways?	The LTE back bone communication system is proposed to be deployed and made operational on Indian Railways in a time frame of 3-5 yrs from allotment of spectrum in 700 MHz frequency band to IR.
(iv)	What is the system presently used by Indian Railways for the purpose of Radio communication between Train and Trackside(RSTT)	<p>Radio communication between Train and Trackside (RSTT) at present is GSM-R of 2G version mobile communication system. It has been presently deployed over 2500 Rkms on IR. On the Balance network, RSTT is achieved using 5W and 25 W VHF sets.</p> <p>Thus, the present RSTT i.e GSM-R & VHF sets are primarily voice based with hardly any data handling capability of to serve applications like monitoring alerts from CCTV cameras from coaches, Remote monitoring and diagnostics of rolling stock, free infotainment etc.</p>
(v)	For the purpose of GSM-R, DoT has allocated 1.6 MHz paired spectrum to Indian Railways in 900MHz band. How the allocated 1.6 MHz paired spectrum is being utilized by Indian Railways	GSM-R in 900 MHz spectrum band (890-915/935-960 MHz) in 1.6 MHz paired bandwidth has been functional on Indian Railways. Since available spectrum bandwidth is limited to 1.6 MHz in 8 spots, therefore Railway specific application of Mobile Communication only has been functional which includes <i>functional addressing</i> (Calling a user by assigned function, rather than by a fixed number) and <i>location dependent addressing</i> . Additionally, Railway-specific characteristic includes Advanced Speech Call Item (ASCI) such as <i>Voice Broadcast Service</i> (VBS) to communicate to a group of handsets simultaneously is also available.
(vi)	What is the data rate (data seed) of the present system deployed by Indian Railways for the communication between Train and Trackside?	GSM-R characteristics are similar to GSM 2G system in general. The General Packet Radio Services (GPRS) for data communication upto 14.4 Kbps is supported by GSM-R for data transport in the same way as with the regular GSM system.
(vii)	What is the future/proposed data speed requirement of Indian Railways for the	<p>IR's data speed requirement envisaged in the proposed LTE system in 700 MHz frequency band are as under:-</p> <ul style="list-style-type: none"> ○ Peak data rate, downlink/uplink of 50/10 Mbps, ○ Peak spectral efficiency of 2.55 bps/Hz,

	proposed system in 700 MHz band?	
(viii)	Which technology/system is proposed to be deployed by Indian Railways in 700 MHz for communication between Train and Trackside?	<ul style="list-style-type: none"> o In April 2017, Samsung Electronics launched LTE solution on the 41km-long Busan Metro line 1 that covers 40 stations in the region. o In China, Huawei has deployed on ShuoHuang Railways (The Freight operator in China) LTE communication between the multiple locomotives (slave and driver) of the freight trains. The implementation has resulted in the significant capacity augmentation of the freight line. o IR proposes to take a lead by leveraging its vast network and scale railways operations in evolving defining and introducing LTE of 4G/5G compatibility.
(ix)	Whether such system can operate in other frequency bands also? If yes, what are those frequency bands?	Yes, such system can operate in 800/900 MHz band other than 700 MHz frequency band.
(x)	Whether any commercial telecom services are proposed to be provided by Indian Railways to its passengers using spectrum in 700 MHz band, besides RSTT communications?	<p>Indian Railways has sought for spectrum in 700 MHz frequency band to be allocated free of cost as this proposal is devoid of any commercial gain, but only for enhancing safety, security and passenger amenities.</p> <p>The bandwidth requirements of 10 MHz in 700 MHz frequency band is for data usage needs for following safety and security applications/facilities:</p> <p>(i) Mission Critical Passenger Safety Services & Applications through a Modern Train Control System for Railway Signaling system on IR. Modern Train Control system will augment trains carrying capacity on Railway network because of increased speed and less fixed distance between the trains. This will allow more number of trains to be handled safely on the same fixed infrastructure.</p> <p>(ii) Video Surveillance (Live Feed) through CCTV networks in trains along with Video Analytics for Passenger Security.</p> <p>(iii) Faster data network Communication for voice, video and other related application like IoT based Asset reliability Monitoring and Train and way side Telemetry through Mobile communications</p>

(Sunil Gupta)

Exec. Director (Tele. Dev)
E-Mail: edtd@rb.railnet.gov.in
Fax: 030-44198/011-23304198

Information sought by TRAI vide their letter No. 103-2/2019-NSL-II dated 19.03.2019

S. No.	Clarification Item	Remarks
(i)	Provide in detail the systems functionalities and purposes for which spectrum in 700 MHz band is proposed to be used by Indian Railways.	<ul style="list-style-type: none"> • Indian Railways (IR) has a network size of over 66,000 Route KMs (RKMs) connecting more than 8,000 stations on which 21,000 Passengers and Freight trains run every day to move over 8 billion passengers and 1 billion tons of freight annually. 2.25 Crore passengers (approx) use train services daily, their Safety and Security is of paramount concern and priority for IR. Furthermore, the ever-increasing demands for introduction of more trains and stoppages from different parts of the country coupled with IR's limited fixed infrastructure and rolling stock availability, there is need to ramp up the speed of trains to upgrade carrying and handling capacity of the existing Railway network. • Indian Railways is looking to operationalize applications around Safety (ETCS Level 2, emergency communications etc.), internal management (staff communication, remote asset monitoring etc.) and passenger security/experience (free browsing, free audio/video entertainment, live CCTV monitoring etc.). • These requirements are highly varied in their bandwidth and network latency. Also, live on-board CCTV monitoring over the marine requires high bandwidth (8 cameras per coach with H.265 Codec). • Global benchmarking shows that railway operators are presently not using such an application - the data is stored in the train and is used for post-processing as required. • Considering various options, IR has planned to deploy Global Standard LTE for mission critical Railway application. LTE is poised to replace the incumbent 2nd Generation (2G) GSM-R technology.
(ii)	What is the total length of Railway Track in Route Kilometers for which the	The proposed LTE communication system in 700 MHz frequency band is planned to be deployed over entire Indian Railways network. Uniform

	proposed system will be deployed in 700 MHz band?	backbone communication system will enhance Passenger Safety, security and asset reliability applications progressively over 66,000 Route KMs (RKMs) connecting more than 8,000 stations and covering about 21000 passenger and goods trains running daily.
(iii)	What is the time frame in which the system is proposed to be deployed and made operational by Indian Railways?	The LTE back bone communication system is proposed to be deployed and made operational on Indian Railways in a time frame of 3-5 years from allotment of spectrum in 700 MHz frequency band to IR.
(iv)	What is the system presently used by Indian Railways for the purpose of Radio communication between Train and Trackside (RSTT)?	Radio communication between Train and Trackside (RSTT) at present is GSM-R of 2G version mobile communication system. It has been presently deployed over 2500 Rkms on IR. On the balance network, RSTT is achieved using 5W and 25 W VHF sets. Thus, the present RSTT i.e. GSM-R and VHF sets are primarily voice based with hardly any data handling capability of to serve applications like monitoring alerts from CCTV cameras from coaches, Remote monitoring and diagnostics of rolling stock, free infotainment etc.
(v)	For the purpose of GSM-R, DoT has allocated 1.6 MHz paired spectrum to India Railways in 900 MHz band. How the allocated 1.6 MHz paired spectrum is being utilized by Indian Railways?	GSM-R in 900 MHz spectrum band (890-915/936-960 MHz) in 1.6 MHz paired bandwidth has been functional on Indian Railways. Since available spectrum bandwidth is limited to 1.6 MHz in 8 spots, therefore Railway specific application of Mobile Communication only has been functional which includes <i>functional addressing</i> (Calling a user by assigned function, rather than by a fixed number) and <i>location dependent addressing</i> . Additionally, Railway-specific characteristic include Advanced Speech Call Item (ASCI) such as <i>Voice Broadcast Service</i> (VBS) to communicate to a group of handsets simultaneously is also available.
(vi)	What allocation methodology has been adopted by DoT while allocating the 1.6 MHz paired spectrum to Indian Railways in 900 MHz band?	1.6 MHz (paired) spectrum in 900 MHz band has been assigned to Indian Railways on administrative basis for captive usage of their GSM-R based network.
(vii)	What are the charges being levied (along with the basis for such charges) to Indian	Spectrum charges for this spectrum are levied on formula basis as per Order No. P-11014/34/2009-PP dated 22.03.2012(Copy enclosed as Annexure 3).

	Railways for the allocated GSM-R spectrum?	Amount of spectrum charges per BTS are 7,69,000/- (which include Royalty of Rs. 7,68,000/- and License Fee of Rs. 1,000/-). For handheld and vehicle-mounted stations, only license fee @ Rs. 250/- per station is charged.
(viii)	What is the data rate (data seed) of the present system deployed by Indian Railways for the communication between Train and Tracksides?	GSM-R characteristics are similar to GSM 2G system in general. The General Packet Radio Services (GPRS) for data communication upto 14.4 Kbps is supported by GSM-R for data transport in the same way as with the regular GSM system.
(ix)	What is the future/proposed data speed requirement of Indian Railways for the proposed system in 700 MHz band?	IR's data speed requirement envisaged in the proposed LTE system in 700 MHz frequency band are as under: <ul style="list-style-type: none"> o Peak data rate, downlink/uplink of 50/10 Mbps, o Peak spectral efficiency of 2.55 bps/Hz.
(x)	Which technology/system is proposed to be deployed by Indian Railways in 700 MHz for communication between Train and Tracksides?	<ul style="list-style-type: none"> o In April 2017, Samsung Electronics launched LTE solution on the 41 km-long Busan Metro line that covers 40 stations in the region. o In China, Huawei has deployed on ShuoHuang Railways (The Freight operator in China) LTE communication between the multiple locomotives (slave and driver) of the freight trains. The implementation has resulted in the significant capacity augmentation of the freight line. o IR proposes to take a lead by leveraging its vast network and scale railways operations in evolving defining and introducing LTE of 4G/5G compatibility.
(xi)	Whether such system can operate in other frequency bands also? If yes, what are those frequency band(s)?	Yes, such systems can operate in 800/900 MHz band other than 700 MHz frequency band.
(xii)	Whether any commercial telecom services are proposed to be provided by Indian Railways to its passengers using spectrum in 700 MHz band, besides RSTT communications?	<p>Indian Railways has sought for spectrum in 700 MHz frequency band to be allocated free of cost as this proposal is devoid of any commercial gains, but only for enhancing safety, security and passenger amenities.</p> <p>The bandwidth requirements of 10 MHz in 700 MHz frequency band is for data usage needs for following safety and security applications/facilities:</p> <ul style="list-style-type: none"> i. Mission Critical Passenger Safety Services &

		<p>Applications through a Modern Train Control System for Railway Signalling system on IR. Modern Train Control System will augment trains carrying capacity on Railway network because of increased speed and less fixed distance between the trains. This will allow more number of trains to be handled safely on the same fixed infrastructure.</p> <p>ii. Video Surveillance (Live Feed) through CCTV networks in trains along with Video Analytics for Passenger Security.</p> <p>iii. Faster data network Communication for voice, video and other related applications like IoT based Asset reliability Monitoring and Train and way side Telemetry through Mobile communications.</p>
--	--	--

Annexure 3

Government of India
Ministry of Communications & IT
Department of Telecommunication
Wireless Planning & Co-ordination (WPC) Wing

Sanchar Bhavan,
20, Ashoka Road,
New Delhi-110 001

No. P-11014/34/2009-PP (II)

Date: 22nd March, 2012

ORDER

Subject: Royalty charges for Assignments of Frequencies to 'Captive Users' (users being charged on formula basis) including all Government Users, involving **Multi Channel Operations for Fixed/ Land/ Land Mobile Stations.**

In pursuance of Power conferred by section 4 of the Indian Telegraph Act, 1885(13 of 1885) and in supersession of this Ministry's Orders No. R-11014/26/2002-LR dated 06.05.2003, No. R-11014/26/2002-LR dated 01.04.2003, No. R-11014/4/87-LR (pt.) dated 20.07.1995 and No. R-11014/4/87-LR dated 09.12.1987, the Central Government has decided the following Royalty charges for Assignments of Frequencies to 'Captive Users' (users being charged on formula basis) including all Government Users, involving **Multi Channel Operations for Fixed/ Land/ Land Mobile Stations:-**

2. *Annual Royalty* is calculated as per the following formula and rules:

$$\text{Annual Royalty (in Rupees)} = \sum_{i=1}^n M_i \times W, \text{ where } n = \text{no. of carriers.}$$

- i. The Basic Royalty (M) given below is for *one* carrier frequency in a *Basic Link* (simplex) of 2 Fixed/ Land/ Land Mobile stations (1 station for broadcasting).
- ii. Duplex circuits (with two central frequencies) and Semi-duplex circuits shall be charged at twice the rate of simplex (single central frequency) circuits.
- iii. For multi-frequency circuits, even if operating in simplex mode, the Basic Royalty shall be charged for each frequency separately.
- iv. For the purpose of charging Royalty under Table-B, the *Bandwidth Factor W* shall be as per *Table-C*, given below.
- v. For all carrier frequencies, the chargeable bandwidth shall include the *Guard Bands* required to be provided as per *ITUs*.
- vi. The rates of Royalty apply to the specified *polarization(s)* of the assigned frequencies.
- vii. In addition to above, the explanatory "Notes" on the applicability of royalty charges, are as following:
 - To determine the "Maximum Distance" slab applicable to a case, the 'maximum power rating/ assigned' of the transmission equipment be considered, and expressly recorded in the assignment instrument Decision Letter, Agreement-in-Principle, or Wireless Operating License (DL/ AIP/ WOL).



Royalty Charges for Multi-channel

- The *duration* of a radio frequency assignment will normally be one or two years. If an applicant desires, and frequencies are available, the duration of assignment may be fixed as three or four or five years.
- Before issuing any DL/ AIP/ WOL, full amounts of Royalty shall be submitted by the applicant in advance for the entire duration of the DL/ AIP/ WOL.
- For all assignments of frequencies, all applicants or users shall pay the applicable Royalty, License Fee, etc. **at the rates and terms in force from time to time, all previously paid amounts being adjusted on pro-rata basis.**

Table-B For The 'M' Factor

Distance Cat.	"Maximum Distance (KM) Over Which the F/L/LM Network would operate"	Royalty Charges (in Rs.) for of the Basic Link.
		<i>M</i>
I	<= 2	1500
II	<= 5	3000
III	> 5 <= 25	6000
IV	> 25 <= 60	12000
V	> 60 <= 120	22500
VI	> 120 <= 500	37500
VII	> 500	50000

Table-C for The 'W' Factor

Slabs of Adjacent Channel Separation (BW), in MHz	Values of W
Up to and including 2	30
More than 2 but <= 3.5	40
More than 3.5 but <= 7	60
More than 7 but <= 14	90
More than 14 but <= 28	120
> 28	120+30 x (Excess bandwidth to 28 MHz / 7) [@]

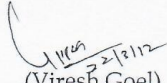
@: That is, in steps of 7 MHz or part thereof.

- viii. Any "single channel service" that uses a channel bandwidth in excess of 375 KHz shall be covered by Charging Table-C above, where the Bandwidth Factor "W" is used from the lowest value of 30 onwards.
3. For Charging of "Licence fee and other fees, Surcharge/ late fee and Charging Methodologies for Royalty / licence fees, Order No. No. P-11014/34/2009-PP (IV) dated 22nd March, 2012 shall be applicable

[Signature]
21/5

Royalty Charges for Multi-channel

4. This issues with the concurrence of the Wireless Finance Division, vide this Dy. No.482/Sr.DDG(WPF), dated 19/3/12.
5. This Order shall come into force from 1st April 2012.


(Viresh Goel)
Deputy Wireless Advisor
to the Government of India

Copy to:

1. All concerned
2. Wireless Finance Division
3. Wireless Monitoring Organisation
4. Director, IT DoT for uploading on DoT website
5. DWA(ASMS) for uploading on WPC Wing website

Government of India
Ministry of Communications & IT
Department of Telecommunication
Wireless Planning & Co-ordination (WPC) Wing

Sanchar Bhavan,
20, Ashoka Road,
New Delhi-110 001

No. P-11014/34/2009-PP (IV)

Date: 22nd March, 2012

ORDER

Subject: Licence fee and other fees, Surcharge/ late fee and Charging Methodologies for Royalty / licence fees for 'Captive Users' (users being charged on formula basis) including all Government Users.

In pursuance of Power conferred by section 4 of the Indian Telegraph Act, 1885(13 of 1885) and in supersession of this Ministry's Orders No. R-11014/28/2004-LR dated 23.03.2005, and No. R-11014/4/87-LR dated 20.07.1995 the Central Government has decided the following rates of Licensee fees, and other fees, Surcharge/ late fee and Charging Methodologies for Royalty / licence fees for different types of Assignments of Frequencies to 'Captive Users' (users being charged on formula basis) including all Government Users. :-

2. License Fees

Sl. No.	Type of License	Annual License Fee, Rs.	Remarks
i.	Fixed/ Land Station	500	Per station
ii.	Land Mobile Station	250	Per station
iii.	Captive paging (Hub)	2000	Per Hub
iv.	Maritime Mobile Station (fishing trawlers)	500	Per trawler
v.	Maritime Mobile Station (Ships)	5000	Per ship
vi.	Aero-mobile Station	5000	Per aircraft
vii.	USR (short range)	250	Per station
viii.	Fixed station of Microwave links/ Radar Station/NLD station/BTS	1000	Per station
ix.	CMRTS fixed station	500	Per fixed station
x.	CMRTS Mobile Station	250	Per mobile station; vehicle mounted or hand-held
xi.	Fixed station in Satellite Network, e.g., DTH/ Teleport/ DSNG/ NLD/ ILD/ DCP/ IP-II	1000	Per Fixed Station
xii.	Captive V-SAT	500	Per Hub or Terminal
xiii.	INMARSAT	250	For Mobile terminal
xiv.	INMARSAT	500	For Fixed terminal

NOTE: License Fee for standby sets shall also be charged at the same rates.

Licence fee, late fee and Charging Methodologies

3. Fees for issuing duplicate copies and License Modification

Sl. No.	Type	Fee in Rupees
i.	Duplicate copy of License (Without Schedule)	500
ii.	Duplicate copy of Schedule(s) of a License	500
iii.	Duplicate copy of Renewal Certificate	250
iv.	License Modification	1000

4. Charging Methodologies for Royalty / licence fees:

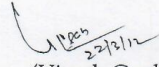
- No radio frequency be assigned, reserved, or blocked through a Decision Letter, Agreement-in-Principle, or any other instrument of like nature unless the applicant pays, in advance, all applicable license fees and royalty charges for the full duration of authorization/ assignment of the radio frequency, or minimum of one year, whichever is less.
- Upon successful processing of an application requesting for an assignment of radio frequency (RF), the applicant be informed about the License Fees and Royalty required to be deposited by him. These shall be calculated for the full period of the requested assignment. Where the period is greater than one year, the wireless user/ applicant has to pay the license fee and royalty in annual installments in advance every year.
- Immediately thereafter, but in no case later than thirty (30) days from the date of issue of the said letter, the applicant shall pay the charges for issue of License/ DL/ AIP, if otherwise permissible. If, on the other hand, the payment is not received within this period of 30 days, the application will be treated as *cancelled* and the frequencies shall be freed for being assigned to others. If the same applicant wants to subsequently pursue the application, he shall be required to submit a *fresh* application.
- The amounts due for different periods may be determined as follows.

License Period	License Fee payable	Royalty payable from the date of DL/ AIP/ WOL, as the case may be	Method of payment
One month or less	At specified flat rate.	Annual royalty divided by 12.	Full license fee & royalty to be paid in advance at the time of issue of DL/ AIP/ license.
More than one month but up to one year	At specified flat rate.	On pro-rata basis. However, part of a month shall be taken as one month.	-- do --
More than one year	At specified flat rate.	On pro-rata basis. However, part of a month shall be taken as one month.	Pay the L/fee plus Royalty for the entire duration in advance at issue of DL/ AIP/ license, OR pay it in annual advance instalments.

- In case the licensee defaults on one of the annual installment payments, all the remaining installments shall become immediately payable.

Licence fee, late fee and Charging Methodologies

- vi. A Licensee shall be responsible to apply for the renewal of his/ her existing frequency authorization or wireless operating license (WOL), within a period of thirty (30) days *before* the expiry of the said WOL/ AIP/ DL.
- vii. **Surrender of a License/ AIP/ DL:** Spectrum charges are payable minimum for one month and thus on surrender of licenses the Royalty charges in excess of one month can be adjusted. However, any monetary refund can only be made if the payments have been received for more than one year and surrender results the Royalty charges in excess of 1 year. The word "surrender" in this paragraph shall mean surrender of a complete **License/ AIP/ DL** with all its frequency assignments.
5. **Surcharge/Late Fee for Late Renewal of Wireless Station Licenses:** Surcharge/ Late fee for delayed renewal of various licenses shall be levied on the total amount due (i.e. license fee *plus* royalty charges) @ 2% per month or part thereof, subject to the minimum of Rs. 250/- per license. In case the delay is more than one year the said late fee shall be applied in an *annually compounded* manner.
6. This issues with the concurrence of the Wireless Finance Division, vide this Dy. No.482/Sr.DDG(WPF), dated 19/3/12.
7. This Order shall come into force from 1st April 2012.


(Viresh Goel)
Deputy Wireless Advisor
to the Government of India

Copy to:

1. All concerned
2. Wireless Finance Division
3. Wireless Monitoring Organisation
4. Director, IT DoT for uploading on DoT website
5. DWA(ASMS) for uploading on WPC Wing website