Telecom Regulatory Authority of India

Recommendations

on

"Next Generation Public Protection and Disaster Relief (PPDR) communication networks"

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CONTENTS

CHAPTER I: INTRODUCTION

1.1 Communication plays an important role in rescue and relief operations during emergency or disaster situations, especially in a country like India which is highly prone to natural disasters like floods, earthquakes, coastal cyclones and also, manmade disasters like accidents, terrorist attacks etc. The effectiveness and efficiency of public protection and law enforcement also pivots on robust and reliable communication networks.

1.2 PPDR agencies – including police departments, fire departments, emergency medical professionals, para-military forces and many others – need resilient communication networks for their day-to-day, emergency and disaster relief operations.

1.3 Currently, Indian PPDR agencies rely on narrow-band digital trunking technology like TETRA and P25 systems or old analog systems for their communication in the field, which are primarily meant for voice communication. The PPDR communication networks are designed and run by independent state agencies. The PPDR agencies are issued license by Department of Telecommunications (DoT) under Captive Mobile Radio Trunking Service (CMRTS) category. Accordingly spectrum is allocated by Wireless Planning & Coordination Wing (WPC Wing) of DoT in the 300 MHz, 400 MHz or 800 MHz bands.

1.4 The current framework has resulted in fragmented spectrum assignments with inefficient use of precious and prime sub-GHz frequency. Despite consuming large amounts of costly spectrum, it does not meet the evolving needs of the public safety and emergency communication such as access to instant messaging, high-quality images and video, mapping and location services, remote control of robots, and other applications. Moreover, it has been observed that PPDR agencies have their individual networks in place, which work in silos. This results in inability to have seamless

communication and information sharing among the PPDR agencies. This is due to the fact that their networks are either not inter-operable or they are just not compatible with each other. This deprives the agencies of instant cross-agency coordination and exchange of mission-critical information which eventually results in ineffective mitigation of safety and disaster situation.

1.5 To overcome the limitations of current PPDR communication networks, next generation PPDR communication networks should be deployed with enhanced broadband capabilities, unified framework and comprehensive policy. Broadband PPDR (BB-PPDR) using LTE, is the optimal choice for an integrated PPDR network providing cutting-edge services standardized by 3GPP in Rel. 12, 13 and 14. LTE broadband trunking, featuring large bandwidths, high data-rates, and IP-based operation, supporting multimedia communication including eMBMS (video) to/from disaster site, is becoming the mainstream in the market, ushering an era of LTE-based public-safety networks.

1.6 The Authority is aware of the importance of reliable communication setup for PPDR agencies. Accordingly, some steps have been taken by the Authority in the recent past to address certain primary issues in this area. In November 2013, TRAI sent its recommendations on priority routing of calls of persons engaged in response and recovery. This is partially implemented by the Government. If this is fully implemented, it can facilitate inter-agency communication over commercial networks at the time of first response to an emergency. It is a known fact that the networks get overloaded during emergencies resulting in denial of service to first responders. Another initiative by TRAI was its recommendations on single number based Integrated Emergency communication and response system (IECRS) issued in April 2015. The Government has accepted this recommendation and has adopted 112 as the single emergency number in

India and guidelines have been issued to implement IECRS across the country.

1.7 Keeping in view the need to have a robust policy framework for the introduction of an advanced, reliable, robust and responsive PPDR communication system in the country, the Authority suo-motu took up the issue of "Next Generation PPDR Communication Networks" for public consultation as per Section 11(a) of TRAI Act, 1997.

1.8 The Authority issued the Consultation Paper (CP) on 09th October 2017 titled "Next Generation Public Protection and Disaster Relief (PPDR) communication networks" raising specific issues for consideration of stakeholders. The last date for submitting written comments and counter-comments was fixed as 20th November 2017 and 4th December 2017 respectively. On account of PPDR communication networks being a critical issue that requires extensive analysis, the industry association (COAI) requested the Authority to extend the last date for submitting written comments and counter-comments. The Authority also wrote to Ministry of Home Affairs (MHA), National Disaster Management Authority (NDMA), all the State Governments/Union Territories (UTs) seeking their inputs on the subject. Inputs from wider consultation with State Governments/UTs and various Ministries will be valuable in forming comprehensive recommendation by the Authority. Accordingly, the last date for submission of written comments and counter-comments was extended to 4th December 2017 and 18th December 2017 respectively.

1.9 The CP has elaborated on the issues and shortcoming with the existing PPDR network, features of Next Generation PPDR networks, technical specifications and spectrum availability and future requirements. Execution models prevailing in various countries for Next Generation PPDR network have been deliberated and included in the CP as international practices.

1.10 In response to the CP, the Authority received 17 comments and 02 counter comments from the stakeholders. These were placed on the TRAI website www.trai.gov.in . An Open House Discussion (OHD) was conducted on 15th February 2018 at Delhi. Meetings were held with major users of PPDR communication networks viz; Ministry of Home Affairs (MHA) and National Disaster Management Authority (NDMA) to understand user requirements. After analyzing various issues involved and also considering the comments received from stakeholders in their written responses and during the OHD, the Authority has finalized these recommendations.

1.11 For drafting this recommendation, various documents available in the public domain, published by government agencies/departments, telecom regulators in many countries, research agencies/institutions, academic institutions, telecom vendors, operators and international agencies/forums etc. were referred with the purpose to make the recommendation balanced and comprehensive. Excerpts from certain documents, which had domain relevance, are also included in this recommendation.

1.12 The recommendations comprise of four chapters. Chapter-II discusses the framework and execution model for Broadband PPDR communication networks. Chapter–III covers the Spectrum requirements for Broadband PPDR communication networks. Chapter-IV lists a summary of the recommendations.

CHAPTER II: FRAMEWORK AND EXECUTION MODELS FOR BROADBAND PPDR COMMUNICATION NETWORKS

A. Need for next generation PPDR communication networks

2.1 The Authority raised the issue in the CP for comments of the stakeholders on whether the existing fragmented model of PPDR communication network in the country is adequate to meet the present day challenges. The Authority further asked the stakeholders to list down the deficiencies, if any, in the existing model of PPDR communication network.

2.2 There was a general consensus amongst the stakeholders that the existing fragmented model of PPDR communication network in the country is not adequate to meet the present day challenges.

2.3 The key challenges with the existing fragmented model of PPDR communication network identified by the stakeholders are listed below-

i. Narrowband PPDR networks -can support only voice communication
ii. Non-interoperable networks due to which PPDR agencies face a challenge to have seamless information sharing with other agencies
iii. Limited budget to roll out state of the art digital network based on mission critical technologies
iv. Extremely high administrative spectrum and license fees for captive users– almost 10 times the license fees than in developed countries
v. Long time frame for getting necessary DoT licenses – minimum 9 months to an average 12-18 months to get a CMRTS and spectrum license
vi. The PPDR networks in the country are still evolving from analogue to Digital trunking
vii. The number of wireless sets per population is the lowest in the world

2.4 Few stakeholders were of the opinion that there should be a unified national infrastructure for critical communication, for use by all public

safety agencies, leveraging LTE technology. According to them, this will provide cost efficient deployment, efficient spectrum usage and seamless upgrades without stranding capacity due to multi-user environment.

2.5 One stakeholder was of the view that solutions based on Digital Radio Trunking System like TETRA, DMR and P25 have been tried and tested for the Public safety agencies and cannot be replaced by standards PS-LTE suggested by 3GPP. However, both can co-exist if the need persists. Another stakeholder submitted that in the evolution to integrated broadband PPDR network based on LTE technology, PPDR agencies may continue using the TETRA network for voice-communication while assigning the broadband applications to the LTE PPDR network. The interconnection between the two may be done through a gateway.

2.6 One stakeholder has mentioned that the public networks such as 3G & 4G that enable video streaming & image transfer and social media networks that can spread warnings within minutes are important auxiliary modes of communications for first responders. However, during disaster, the public communication networks get entirely or partially damaged by disasters or become congested with exceptionally high levels of traffic. An additional threat to public networks, in the future, could be the use of distributed denial-of-service (DDoS) attack by terrorists against IP-networks, such as 4G LTE, prior to a terror act, thereby depriving the PPDR agencies from their auxiliary mode of communication. So, there is a need to develop a robust communication system that can be established rapidly, easily and cost effectively.

2.7 Another stakeholder has submitted that besides deploying a uniform radio technology for all the security agencies, it is also important for the agencies to have access to devices that support a harmonized frequency band dedicated for operations across the country. According to the stakeholder, this would allow the agencies to coordinate in real-time

during emergencies using the harmonized band as otherwise crucial time could be lost if using mechanisms to relay messages through more than one communication system.

Analysis

2.8 As highlighted in the CP, primary PPDR communication systems in India are designed and run by many independent state agencies. The present PPDR communication infrastructure is either old Analog Systems or it uses narrowband radio that supports only two way voice communication. These radios employ narrowband channels and are operated on spot frequencies that are assigned to different public safety entities on a case-by-case basis. Also, individually adopted technologies, spectrum, equipment, standards and protocols by the respective agencies do not allow them to communicate and share information with each other.

2.9 In today's connected world, there is a great need for enriched multimedia tools, data and video analytics and sophisticated applications for PPDR operations. By their nature, PPDR operations can derive significant benefits from the ability to access a wide variety of information, including informational databases, access to instant messaging, high-quality images and video, mapping and location services, remote control of robots, and other applications. In future, large deployments and proliferations of robotics, Machine-to-Machine (M2M) communication, Internet of Things (IoT) etc. will have a significant impact on PPDR operations and emergency rescue operations. However, such PPDR applications requires much higher bit-rates than what current narrowband PPDR technology can deliver.

2.10 In order to address the above issues, it will be prudent that we move towards an integrated approach to build/create a comprehensive model for PPDR communication network to serve the needs of the PPDR agencies in the national interest. There is a need to establish advanced public safety telecom system by using cutting-edge information and communications

technologies. Broadband networks are needed to support improved data and multimedia capabilities, which require higher data rates and higher capacity.

2.11 Deploying a uniform radio technology will solve the interoperability issue and enable the PPDR agencies to have access to devices that support a harmonized frequency band dedicated to operations across the country. The world's emergency services are increasingly looking at LTE as the technology of choice for mobile broadband PPDR network. LTE provides unprecedented capabilities for mobile broadband networks. Globally, many public safety and communications experts considers LTE to be the technology of choice for First Responder/Public Protection and Disaster Relief (PPDR) mobile broadband networks for years to come.

2.12 In view of the forgoing, the Authority holds the opinion that in order to fulfill the increasing demand from the public safety sector for better intelligence and situational awareness, there is a need to have a single unified framework with nationwide PPDR network coverage and enhanced broadband capabilities based on a uniform standard such as 3GPP PS-LTE. **Accordingly, the Authority recommends setting up a pan-India integrated Broadband PPDR (BB-PPDR) communication network (to be called "National BB-PPDR Network") based on 3GPP PS-LTE technology.**

B. Network Model

2.13 BB-PPDR communication systems can be realized through various ways such as deployment of dedicated PPDR networks, priority access over commercial networks or via a hybrid approach using dedicated network in some parts and sharing commercial network in the rest. When comparing the different alternatives, each approach can be seen offering both advantages and disadvantages. Table 2.1 compares various network models for the depoyement of BB-PPDR communication network.

Table 2.1: Comparison between various network models for the depoyement of BB-PPDR communication network

Network Model	Pros	Cons
Dedicated	Control over network resources	High upfront cost
	Hardened for critical communication	It will take time to build a dedicated network along the length and breadth of the nation
	Better Security	
Commercial	Instant coverage	Main focus on commercial service; No viable business model in PPDR domain since cost of network & spectrum are high
	Cost effective	Prone to heavy congestion during disaster
		Low commercial viability for coverage in sparsely populated areas
Hybrid	Provides flexibility, cost efficiency compared to dedicated model and less time to make the network operational.	Large cost compared to commercial model

2.14 In order to find the most suitable model for BB-PPDR communication network for Indian conditions, the Authority raised a question in the CP, and sought stakeholders' opinion regarding the network model (dedicated, commercial, hybrid) that should be adopted in India for the deployment of BB-PPDR communication network.

2.15 In response, many stakeholders submitted that hybrid model will be the most suitable BB-PPDR network deployment model in India. The stake holders highlighted the model of network implemented in the USA namely "FirstNet", as the most suitable form of network models for implementation in the Indian context.

2.16 One of the stakeholders supporting hybrid model was of the view that PPDR agencies need dedicated networks; however, it may not be economically viable to have both dedicated voice and data networks

nationwide. Therefore, the stakeholder suggested to select hybrid model in the following framework:

a. The first priority should be to set up next generation mission critical voice networks in each district HQ as well as each metro city. These Trunk radio networks should be linked to dispatch control centers in each metro/mega city and district HQ. The wireless network should cover the entire metro/district and the call center needs to be outsourced.
b. Dedicated Broadband Network in each metro/major cities where the Mobile Broadband Network is owned and operated by the PPDR Agencies themselves.
c. For areas outside the metro/major cities, mobile broadband services based on the common network infrastructure that is shared between PPDR and Commercial network subscribers. In this type of model the mobile broadband services to PPDR agencies are differentiated using user access barring, special QoS, on demand resource reservation, dedicated applications etc. Also this model can be based on various type of MVNO architecture.
d. For some of these areas, broadband PPDR services on LTE can also be implemented as an OTT application over existing mobile operators' network. This kind of arrangements can also be used in some bigger cities as an initial rollout to familiarize and train PPDR agencies officials.

2.17 Another stakeholder supporting hybrid network opined that planning, building and operating a dedicated nationwide broadband PPDR network in India could be time consuming and expensive. In such cases, it is advantageous to explore leveraging existing network infrastructure deployed by commercial carriers. Hybrid - RAN Sharing Model should be adopted to facilitate rapid deployment of nationwide

PPDR infrastructure. However, there is a possibility of having coverage holes in geographies not covered by commercial carriers. Government agencies need to explore appropriate models (e.g. CAPEX for deployments in coverage holes or providing other benefits) with commercial carriers for meeting this additional infrastructure meant to be used for PPDR usage.

2.18 To enable the deployment of suggested model, the stakeholder also submitted the following framework and its expected benefits:

Framework:

- Government to identify a dedicated spectrum
- Government select an operator who provides a commercially viable PPDR network through a tendering process and a service agreement to deliver PPDR services on the newly identified dedicated spectrum.
- Operator will be contracted to build & manage the PPDR communications network to ensure the availability of PPDR network resources with given capacity at any point of time, and paid for by the government as per the business arrangement.
- The operator may utilize the unused capacity for commercial services. For such usage, the operator may be required to pay to the Government. (Note: During the period that PPDR agencies are active and utilizing the resources, commercial carrier users might be restricted/less prioritized to use the network resources).
- Additionally, new mechanisms should be derived for the Government revenue generation based on further TRAI consultation. The mechanism combines the overall spectrum charge (combining spectrum acquisition charge + SUC) to be paid by operator to government for using PPDR spectrum.

Benefits of the proposed model:

- Government provides priority to mission critical communications platform for public safety services in a time bound manner.

- Government benefits from the additional revenue from the commercial usage of the PPDR spectrum.
- Operator benefits from the usage based payment mechanism for the PPDR spectrum which may be used for other than PPDR services.
- Offers significant benefits of a large and sustainable ecosystem development of devices for India market.

2.19 Another stakeholder supporting hybrid model opined that considering the service aspects and budgetary constraints, hybrid approach with dedicated spectrum should be used. In certain highly vulnerable and disaster-prone areas, a dedicated network could be set up by public safety organizations. This would ensure very high security and availability aspects for certain key areas. In other places, a large telecom operator may be engaged to plan, design, build and operate the network for public safety agencies using the spectrum allocated to public safety agencies. However, the core for PPDR/Emergency services may be separate from commercial operations. Moreover, the stakeholder suggested choosing different telecom operators in different parts of the country to provide diversity and redundant connectivity across them.

2.20 The stakeholder was of the view that to provide additional data and voice coverage and fallback in the event of a crisis, the LTE core can also be bridged to other commercial LTE and 3G radio networks. In all cases, additional coverage and capacity can be provided by a cell on wheels (CoW) for temporary expansion of the network in disaster areas – which can be dispatched together with emergency services.

2.21 The stakeholder further submitted that in the evolution to integrated broadband PPDR network based on LTE technology, PPDR agencies may continue using the TETRA network for voice-communication while assigning the broadband applications to the LTE PPDR network. The

interconnection between the two may be done through a gateway. The stakeholder mentioned that MCPTT (mission critical push-to-talk) has now been standardized in the 3GPP LTE standard and eases difficulties to migrate from narrowband with identical feature sets. MCPTT brings technical unity to commercial and public safety PTT communications.

2.22 On the contrary, few stakeholders were of the view that dedicated network should be deployed for BB-PPDR communication as it can offer availability, control and security. One of the stakeholders supporting dedicated network model submitted that dedicated network using spectrum in globally harmonized band for BB-PPDR is the best solution to provide reliable, independent, high performance and secure connectivity for PPDR services.

2.23 Another stakeholder supporting dedicated network model opined that commercial model is not suitable as debt laden operators are generally not willing to invest in PPDR and hybrid model will create confusion as to which are rural and which are urban areas and also create problems of interference resulting out of confusion.

2.24 One stakeholder mentioned that state and central security agencies deploy and manage state wide PPDR network through their wireless divisions in respective organization. According to the stakeholder it is necessary to integrate all these networks, enhance with broadband capabilities and create a nationwide BB-PPDR communication network under the overall coordination of a central agency. This framework would involve designation of a dedicated spectrum for PPDR operations.

2.25 One stakeholder opined that either hybrid model or the MNO-MVNO shared model should be implemented for the deployment of BB-PPDR network.

2.26 Another stakeholder submitted that first of all, a policy for PPDR communication network should be formulated and only then on the basis of technology to be deployed, timescales, requirement of users, within the framework of the policy, should further decisions be taken.

2.27 On the contrary, one stakeholder was of the view that commercial model similar to one followed by United Kingdom should be adopted in India. According to the stakeholder, it will ensure that the Government does not lose the opportunity of spectrum monetization and will also open an additional revenue generating model for TSPs in the country.

Analysis

2.28 Many stakeholders in their comments have suggested a model similar to United States's FirstNet for BB-PPDR network. The Authority while studying the model has observed that the US government established an independent authority within the National Telecommunications and Information Administration, named the First Responder Network Authority (FirstNet) to deliver a nationwide broadband network dedicated to public safety. It is led by a Board of leaders and executives from the public safety community; federal, state, and local governments; and the technology, finance, and wireless sectors.

2.29 A Public Safety Advisory Committee (PSAC) was also established to assist FirstNet in carrying out its duties to ensure the building, deployment, operation, and maintenance of the nationwide public safety broadband network (NPSBN) in matters involving shared intergovernmental responsibilities or administration. The PSAC consists of members who represent organizations from all disciplines of public safety as well as local, state, territorial, tribal, and federal governments.

2.30 Dedicated spectrum in band 14 (700 MHz), which is 2x10 MHz FDD band (788-798/758-768) have been allocated for this project. FirstNet

and the Department of Interior made the 25-year award/contract based on the determination of the overall best value solution for FirstNet and public safety. The buildup to the award/contract included a fair, competitive procurement process that began in January 2016 with release of the Network RFP. The procurement was open to all entities, whether traditional wireless companies or new entrants, provided their proposal could meet the RFP's statement of objectives. AT&T was selected on a best value award that considered financial sustainability and was based on more than just a technically acceptable solution at the lowest cost. The evaluation of proposals assessed the offerors' ability to submit a cost-effective and innovative model, and to meet or exceed the 16 objectives[1] and evaluation factors outlined in the FirstNet RFP.

2.31 20 MHz of federally owned spectrum and $6.5 billion[2] in initial funding is provided by FirstNet to this partnership; in return AT&T will deploy and operate a nation- wide high-speed broadband network for public safety over 25 years. AT&T is permitted to use FirstNet's spectrum for other commercial purposes, when it is not being used by public safety agencies; however, the company has to prioritize first responders over any other commercial users. With this partnership approach, FirstNet and AT&T do not need any additional federal funding to build and operate the Network – it will be a fully funded, self-sustaining Network.

2.32 While studying the suggested model similar to United Kingdom for BB-PPDR network in India, the Authority found that UK Home Office has set up a cross-departmental Emergency Services Mobile Communications Programme (ESMCP) to provide a more affordable, more capable and more flexible next generation communication system,

[1] https://www.fbo.gov/index?s=opportunity&mode=form&tab=core&id=7806696f4340f16474647ccc57805040&_cview=0

[2] US Congress used the sale of communications airwaves (or spectrum) to fund FirstNet's initial operations and help start network deployment

to be known as Emergency Services Network (ESN), for the 3 emergency services (police, fire, and ambulance) and other public safety users.

2.33 ESN will replace the existing system providing voice services by enhancing a commercial mobile network to provide secure and resilient voice communication; integrated broadband data services; public safety functionality; national coverage; high availability; end-to-end security; meet all users, PPDR and commercial requirements and cost less – about half what their existing system costs today.

2.34 Through tendering process, UK Home Office selected the following private sector partners who will develop and build the new ESN-

- **Mobile service Partner- Mobile network operator EE**

  The mobile services operator will provide broadband data service with full coverage in the defined area, along with extension services to offer coverage beyond the network.

- **User service Partner- Motorola Solutions**

  The user services provider will provide end-to-end systems integration for the ESN, public-safety application development and operation, and other services. They will cover customer and service support, develop new applications, provide some of network functions and provide an app-store and device approval service.

- **Delivery Partner- Kellog Brown Root**

  They will provide support to the programme with design, build, test and transition activities.

- **Devices Partner- Samsung**

  They will manufacture handheld devices for users to access the new service. Using a single ESN 4G device will be more effective, efficient and cheaper than using a combination of the existing Airwave devices and multiple commercial networks and standard 4G devices.

2.35 EE will host the new Emergency Services Network (ESN) on its existing 4G network,[3] which is already used to deliver mobile services to general public. EE would serve both ESN customers and EE's commercial customers in the same network using EE bands. Prioritization of public safety users and services will be done over regular subscribers and service. EE has stated that it will improve its network to provide nationwide coverage for critical communication.[4]

2.36 According to Ofcom's Cellular Frequency Chart January 2016[5], the bands allocated to EE are shown in table 2.2. EE has a total bandwidth of 10 MHz in <1 GHz spectrum and 160 MHz in >1 GHz spectrum that can be used to provide LTE mobile (access) services.

Table 2.2: Bands allocated to EE

Frequency band	**Bandwidth (MHz)**	**Frequency Range**	**LTE band[6]**
800 MHz	2x5	796-801/837-842	band 20
1800 MHz (1.8 GHz)	2x45	1831.7-1876.7/1736.7-1781.7	band 3
1900 MHz	10	1899.9-1909.9	-
2100 MHz	2x20	2149.7-2169.7/1959.7-1979.7	-
2600 MHz (2.6 GHz)	2x35	2655-2690/2535-2570	band 7

2.37 Any comprehensive public safety system must provide nationwide coverage whether it is dense urban area or sparsely populated rural areas. Planning, building and operating a dedicated nationwide broadband PPDR network in India would be time consuming and expensive. In such cases, it is advantageous to explore leveraging existing network infrastructure deployed by commercial carriers.

[3] http://www.telegraph.co.uk/finance/newsbysector/mediatechnologyandtelecoms/telecoms/11958367/EE-wins-landmark-contract-in-controversial-1.2bn-police-radio-replacement.html
[4] http://mccmag.com/Features/FeaturesDetails/FID/623/
[5] http://licensing.ofcom.org.uk/binaries/spectrum/mobile-wireless-broadband/cellular/licensee-frequency-technical-info/Cellular_Frequency_Chart_Jan_2016.pdf
[6] http://www.pcadvisor.co.uk/how-to/mobile-phone/how-tell-whether-phone-is-supported-by-your-network-3597426/

2.38 Commercial carrier networks are generally designed and deployed in geographies only with reasonable user density and traffic considerations, which makes economic sense for the commercial carriers. Therefore completely relying on commercial carrier network infrastructure, in the hour of need to be shared between PPDR first responders and commercial carrier network subscribers may not meet the reliable and redundant nationwide coverage requirement of PPDR agencies.

2.39 Moreover, the Indian TSPs have acquired spectrum through a competitive bidding process to provide commercial services. With the current market consolidation, there would be predominantly 4 players in India, who on an average are already serving 150-200 million subscribers. The attractive data plans are increasing the consumption of data and services by Indian subscribers. Due to competition, operators in India would always be forced to provide more GBs to end users, which will always create a spectrum crunch. In this scenario, providing a service like PPDR on commercial network only does not seem a feasible solution for Indian Market. Also it will not be a viable option to go for a pan-India dedicated PPDR network along the length and breadth of the country, considering its geographical vastness. The time period required to roll out such a network will deprive the PPDR agencies from reaping the benefits of available broadband technologies on offer today in their field of work.

2.40 In the United States, despite getting the spectrum for free and initial funding of $6.5 billion from FirstNet[7], AT&T is planning to spend about $40 billion over 25 years to build, deploy, operate and maintain the network, with the focus on ensuring robust coverage for public safety users as defined by FirstNet. AT&T will derive revenue from PPDR users as well as by monetizing the spectrum for commercial use. So it is important to identify a TSP partner who has financial stability (e.g. AT&T today has

[7] https://www.firstnet.gov/resources/fact-sheets#Fact%20Sheets%20and%20FAQs

Network Assets worth more than $180 billion) and can invest in a sustained manner so as to ensure reliable PS-LTE service over a span of 20-25 years.

2.41 Each market is unique in its nature and has its own regional challenges and priorities. While United States and United Kingdom are good reference models, India's model should be finalized keeping in mind the Indian Market Scenario and geographical conditions.

2.42 In view of the forgoing, the Authority holds the opinion that Hybrid Model is the most suitable model for Indian conditions in which dedicated network for BB-PPDR communication funded by government can be created in metro cities, border districts, disaster prone areas (identified by NDMA) and sensitive areas like Jammu & Kashmir (J&K) and North East & existing commercial network can be leveraged in other regions. This will meet the rigorous PPDR requirements in highly populated metro cities and disaster prone areas and enable cost effective and speedy deployment in other areas.

2.43 For dedicated network for BB-PPDR communication in metro cities, border districts, disaster prone areas (identified by NDMA) and sensitive areas like J&K and North East, a PSU like BSNL/MTNL should be tasked for the following reasons:

i. Better control of government over the operator
ii. Better coordination with other government PPDR agencies and availability of manpower in the event of disaster
iii. Vast existing presence across the length and breadth of the nation including very remote places including North East, J&K Left Wing affected areas etc
iv. Robust infrastructure

2.44 For commercial network for BB-PPDR communication for the rest of the country, any TSP can be identified through tendering process. This model

can be based on Mobile Virtual Network Operator (MVNO) architecture also.

2.45 Also, in order to encourage operators to become a part of BB-PPDR communication network, following incentives can be given to the operators-

i. Preferential access to BharatNet
ii. Right to utilize spare-able BB-PPDR spectrum for commercial operation
iii. Additional revenue generating model

2.46 **Accordingly the Authority recommends putting in place a hybrid model of BB-PPDR network in India in which dedicated network for BB-PPDR communication funded by government be created in metro cities, border districts, disaster prone areas (identified by NDMA) and sensitive areas like J&K and North East by a PSU like BSNL/MTNL. The existing commercial network can be leveraged in other regions through any TSP.**

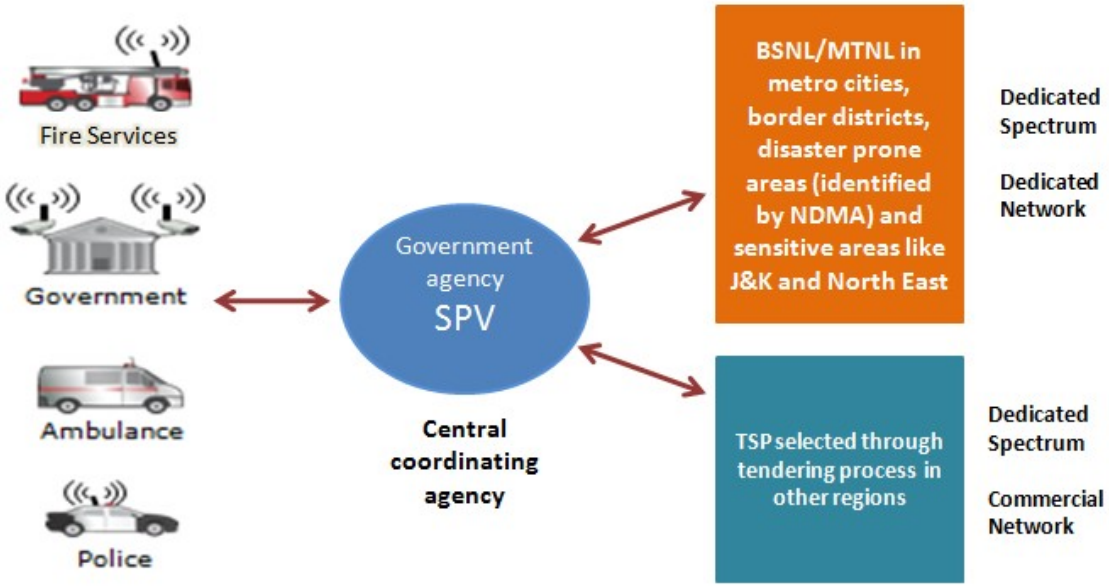

Figure 2.1: Framework for National BB-PPDR Network

2.47 PPDR operations are critical and thus it is important to have stringent SLAs (service level agreements) with operators in order to ensure high quality, reliable, secure, real-time communication. Stringent SLA with operators should be put in place by the SPV (as indicated in Para 2.61). In LTE Release 13, 3GPP MCPTT specification has defined Key Performance Indicators (KPIs 1,2,3,4). These KPI's should be agreed between Govt/Coordinating agencies & Operator. Legal advisors could help framing the right set of SLAs including appropriate contract termination rights.

2.48 Also, PPDR communication networks should be available at least 99.99% of the time. It should have sufficient capacity and redundancy to handle traffic during the peak operational conditions. It should provide extensive coverage in the geographic area and indoor coverage configurations must also be available, especially in basements and tunnels or large and crowded infrastructures. The operators chosen to implement PPDR network should upgrade their networks according to these rigorous requirements.

2.49 In order to build a robust integrated BB-PPDR communication network

- Nominated PSU can utilize its existing unused network to build dedicated BB-PPDR communication network.
- Short-Listed TSP has to upgrade its network to meet the PPDR communication requirements.
- There may be possibility of having coverage holes in geographies not covered by TSP. Therefore, additional infrastructure should be deployed to cover the maximum of geography.
- Operator should ensure the availability of PPDR network resources with given capacity at any point of time

2.50 During disasters, terrestrial communication network gets destroyed and affect relief and rescue operations of PPDR agencies. In such situations, nominated/ short-listed operators should be mandated to setup and

deploy dedicated mobile communication system at the disaster site within specified time period to resurrect the communication. The operator should provide rapidly deployable solutions such as mobile BTS, wearable, backpack devices during disasters. This would be over and above the satellite backup network presently in place.

2.51 **Accordingly the Authority recommends putting in place stringent SLAs by the SPV. Operators should be mandated to provide mobile BTS and backpack devices in case of disaster when terrestrial network gets damaged/ dysfunctional, in order to make available communication facilities for PPDR agencies with in specific time limits as derived in SLAs.**

C. Framework for National BB-PPDR Network

2.52 The Authority has further sought comments of stakeholders on earmarking PSUs for providing nationwide broadband PPDR communication network.

2.53 In response, some stakeholders were in agreement of the view that PSUs should be earmarked for providing nationwide broadband PPDR communication network. One of the stakeholders supporting this view submitted that it will help establish a single coordination framework for communication across the first responders that belong to multiple agencies i.e. through common dispatch and notification process during disaster management.

2.54 On contrary, few stakeholders were of the view that PPDR communication network should be built by most competitive network provider to bring in efficiency. There should not be any exclusivity to PSUs. An equal opportunity should be provided to all existing Private and Government telecom players. The Licensor should invite competitive bidding under USOF scheme for setting up of dedicated Next Generation Network for

PPDR services. The winner of bid should deploy and maintain PPDR network under the aegis of USO fund.

2.55 One stakeholder opined that one Single PSU/Operator cannot setup countrywide PPDR network. Further funds, technology inputs and operations require wider participation of various stakeholders. Therefore, the stakeholder recommended adopting "US's FirstNet model".

2.56 Another stakeholder was of the view that instead of entrusting to any of the commercial operators-PSU or Private, it may be worthwhile to hand it over to a third party or a neutral agency specialized in disaster management and co-ordination like NDMA, who could borrow multiple resources from a number of operators in different regions and have both technological, geographical and network diversity to mitigate network related risks.

2.57 One of the stakeholders mentioned that in areas outside the metro/major cities, commercial or hybrid model for BB-PPDR communication network can be built by leveraging the vast infrastructure and presence built by State owned TSPs viz. BSNL and MTNL. In these cases the PSU operators and the PPDR agencies may enter into stringent SLAs for operation and maintenance of such networks. Also, the optical fiber network of BharatNet and Polnet can also play a vital role in providing back haul connectivity for PPDR operations.

Analysis

2.58 The communication requirements of different PPDR agencies vary according to their local environment, jurisdiction, geography and history. To build an integrated nationwide BB-PPDR communication network, there is a need to carry out threat assessment in consultation with the central government, state government, their PPDR agencies and Ministry of Telecom to measure the risk associated to each state because of natural

as well as man-made disasters, public protection communication needs etc and build a comprehensive roadmap to make a robust framework to ensure a timely and effective deployment and operation of PAN India BB-PPDR communication network.

2.59 Also, there are various stakeholders involved in PPDR operations. Since an integrated pan-India network is being considered, a Special Purpose Vehicle (SPV) needs to be formed for planning, coordinating and steering the nationwide BB-PPDR communication network planning, implementation and its subsequent maintenance and operation. This agency shall oversee the planning and implementation of BB-PPDR network and ensure its smooth operation. This nodal agency will be a single point contact for all other stakeholders. This agency should be responsible for-

i. Creation of comprehensive roadmap for the implementation of BB-PPDR communication network in India in consultation with all stakeholders
ii. Extensive consultation with State Governments
iii. Specification about service requirements of PPDR agencies
iv. Funding arrangement
v. Selection of a PPDR network operator through bidding process
vi. Network planning and implementation (deployment and operation)
vii. Inter agency coordination (amongst various PPDR agencies; Central and state)
viii. Coordination with DoT for dedicated spectrum
ix. Coordination with selected operator
x. Export/Import of devices
xi. Testing of equipment
xii. Spectrum management of dedicated PPDR spectrum amongst PPDR agencies

2.60 Presently, the State PPDR agencies are coordinated by Directorate of Coordination Police Wireless (DCPW) under MHA. As the proposed Special Purpose Vehicle has to coordinate with all concerned stakeholders including State government's PPDR agencies, it is desirable to establish the SPV under Ministry of Home Affairs (MHA).

2.61 **Accordingly, the Authority recommends forming a Special Purpose Vehicle (SPV) under MHA to plan, coordinate and steer the nationwide BB-PPDR communication network implementation and its subsequent operation.**

2.62 For efficient deployment of nationwide PPDR communication network, the said SPV will require subject matter expertise from a public safety perspective, to ensure that the requirements and operational constructs necessary for critical public safety capabilities are included in the network. The SPV will also need assistance in matters involving governmental responsibilities and administration. **Accordingly, the Authority recommends forming an advisory committee which should include representatives from all disciplines of public safety, State Government, Central Government and Ministry of Communications, to provide domain specific advice to the SPV for conception, implementation, operation and maintenance of the BB-PPDR communication network.**

2.63 There are various state and central PPDR agencies. As per existing practice, every security and public safety agency has to set up its own network. They have to take CMRTS license and obtain approvals from various agencies including DoT and WPC on individual basis. They have to coordinate on regular basis with DoT/WPC for operation of the network and huge man days are invested in this process.

2.64 Following administrative challenges related to cost and procedures that are being faced by these PPDR agencies were highlighted by the stakeholders in their response-

i. Extremely high administrative spectrum and license fees for captive users [One stakeholder has stated that CMRTS licensees are paying almost 10 times the license fees in developed countries (typical spectrum fees for one pair of PPDR frequencies in many countries is between $100 to $400 as compared to $1000- $4000 in India)].

ii. Delay in issuing CMRTS license [One stakeholder has stated that it takes minimum 9 months to an average 12-18 months to get a CMRTS and spectrum license].

2.65 The Authority is of the opinion that PPDR agencies are primarily government entities working for social cause. The revenue from PPDR agencies is a book adjustment from one ministry to other. If this is done away with, it will help PPDR agencies in upgrading and improving their existing PPDR communication networks in less time with more funds. However, these PPDR agencies and details of equipment deployed can be asked to be registered with DoT through SPV.

2.66 **Accordingly, the Authority recommends that DoT should study the feasibility of doing away with CMRTS license for PPDR agencies in a phased manner. The SPV shall be the nodal agency to coordinate with DoT for allocation of spectrum and other issues. The PPDR agencies and details of equipment deployed by them can be registered with DoT through SPV.**

D. Existing network integration & up-gradation

2.67 There are large numbers of legacy analog and digital equipment deployed for narrowband PPDR network. The existing networks cannot be replaced or upgraded overnight as there are substantial costs associated with procurements, network roll out and operations. However, there is a need

to phase out the analog equipment and networks and no new import of analog systems should be permitted. During user interactions with PP agencies, it was learned that analog systems are very effective in certain specific operational conditions. Hence, minimum quantum of analog equipment required to meet operational needs is to be worked out and maintained.

2.68 **Accordingly, the Authority recommends that DoT should work out timelines to Phase out existing analog networks in PPDR in a phased manner. New spectrum assignments may be done only for deploying digital equipment.**

E. Pilot Testing

2.69 To study the efficacy of the proposed PPDR communication network, pilot testing for new system and integration of existing digital system a pilot testing should be carried out in five different geographical areas (zones). The project should be coordinated by the SPV with the participation of all state & central PPDR agencies, PSU and TSPs. It should be initiated and fully funded by the Central Government in collaboration with states in the country preferably having most number of disaster prone districts and rough terrain. It will give clarity on the efficacy of the proposed network model, resource requirements and the benefits that can be accrued from BB-PPDR communication networks.

2.70 **Accordingly, the Authority recommends carrying out pilot testing prior to the implementation of BB-PPDR dedicated network (dedicated spectrum and network) to be implemented through BSNL/MTNL, funded by the Central Government, at five zones identified as disaster prone/sensitive areas to evaluate the efficacy of the proposed network. The plan for migration of existing legacy equipment on to the new network is to be formulated after comprehensive study during this pilot testing.**

F. PPDR trunking service roaming on public telecom networks

2.71 Technological innovations has enabled and made it feasible for PPDR trunking service roaming on public network, trunking service on common carrier smartphone, interoperation between LTE and TETRA networks and interconnection to 2G/3G/PSTN/IP PBX through gateway. The captive PPDR users in addition to using its own network can also use public networks as well, thus making much better utilization of resources. However, in terms of equipment design, the mobile cellular handsets are not designed with the extent of robustness that trunked radios offer which is an important factor for end users who are operating in challenging work environment.

2.72 The Authority raised the issue in the CP and sought stakeholders view on whether it will be technically feasible and beneficial to permit PPDR trunking service roaming on public telecom networks. The Authority further asked the stakeholders to identify the challenges, if any, in the implementation of such an arrangement.

2.73 In response, many stakeholders submitted that PPDR trunking service roaming on commercial carrier networks is technically feasible and beneficial in scenarios where there are coverage holes. Therefore, integration of PSTN, IP Network based Interfaces and VoIP/VoLTE under licenses for VHF/UHF Narrowband Digital Two-Way Radios & Digital Radio Trunking Systems should be fully allowed.

2.74 One of the stakeholders supporting this view mentioned that the PPDR mobile applications can be installed on any commercial smartphone allowing the user to access PPDR PTT server and other backend servers, through the public network's data connection. Another stakeholder opined that the present LTE technology is able to provide critical enterprise communication services such as broadband trunking, video surveillance, data acquisition, broadband data access, and emergency communications

on a single network. Thus technological innovations has enabled and made it feasible for PPDR trunking service roaming on public network.

2.75 Certain challenges, as listed below, were identified by the stakeholders in the implementation of such arrangement-

- Congestion of network with high volume of traffic and congestion during disaster
- Security, Reliability, QoS and SLAs issues
- Interoperability issue between different service providers
- Handsets need to be customised for use of the PPDR agencies
- The devices and services deployed in PPDR network should be compatible or available in the public network

2.76 On the contrary, one stakeholder was of the view that PPDR trunking service roaming on public telecom networks should not be permitted for security reasons. However, priority services for mobile phones (as per TRAI recommendations on Priority Call Routing) of security personnel can be offered in addition to exclusive PPDR network.

2.77 Another stakeholder submitted that trunking services over public telecom network may be used only for non-mission critical requirements such as logistics, facility management among others.

Analysis

2.78 Due to absence of roaming policy for PPDR services over public telecom networks, most of the PPDR agencies/responders are not contactable when they are out of their captive network. The issues of coverage and roaming requirements may mainly arise in low population, hill or remote areas; however, some times the issue arises in urban/ populated areas as well.

2.79 The present LTE technology is able to provide critical enterprise communication services such as broadband trunking, video surveillance, data acquisition, broadband data access, and emergency communications on a single network. 3GPP has defined requirements for Mission Critical Push to Talk (MCPTT) application in LTE Release 13. The functionality from TETRA and P25 standards has also been included in LTE Release 13. Thus technological innovations has enabled and made it feasible for PPDR trunking service roaming on public network. The available LTE PPDR device ecosystem is also capable to support multiband operation.

2.80 It is possible that a captive PPDR user in addition to using its own network can also use public networks as well, thus making much better utilization of resources and it can provide the redundancy. Also, roaming and priority access for PPDR users, if allowed, on commercial broadband wireless networks can be helpful in order to fulfill additional coverage needs. The roaming arrangements of PPDR network with public networks to provide coverage outside PPDR network will also provide a fallback option in case of PPDR network outages.

2.81 **Accordingly, the Authority recommends testing the efficacy of PPDR trunking service roaming on public telecom networks during pilot testing, and if found feasible, it should be implemented on pan-India basis.**

CHAPTER III: SPECTRUM REQUIREMENTS AND RELATED ISSUES FOR BROADBAND PPDR COMMUNICATION NETWORKS

A. Spectrum model

3.1 The issue has been debated in the CP whether there is a necessity to identify exclusive spectrum band for PPDR applications in order to efficiently design the nationwide network for coverage and capacity requirements of PPDR networks or choose commercial spectrum.

3.2 In response, many stakeholders have stated that an exclusive frequency band for PPDR operations should be identified in order to efficiently design the nationwide network for coverage and capacity. According to the stakeholders it is the best solution to provide reliable, independent, high performance and secure connectivity for PPDR services.

3.3 One stakeholders further submitted that there will be periods of time when a dedicated broadband PPDR network will have unused capacity. The possibilities of sharing the spectrum on a commercial basis with non-PPDR users as an incentive to the efficient use of spectrum should be examined.

3.4 On the contrary, one stakeholder was of the opinion that adoption of the model followed by United Kingdom, in India, may be the most viable model, whereby commercial networks are used to provide PPDR services by Public Safety Agencies. It will ensure that the Government does not lose the opportunity of spectrum monetization, and will also open an additional revenue generating model for TSPs in the country.

Analysis

3.5 Dedicated spectrum offers availability, control and security. It ensures efficient compliance with the rigorous requirements set out for PPDR communications. However, government loses the opportunity of

spectrum monetization. On the other hand, if commercial spectrum is assigned for BB- PPDR, Government does not lose the opportunity of spectrum monetization, however, TSP may not meet the PPDR requirement due to limited spectrum.

3.6 Many stakeholders in their comments have submitted that on a social cost-benefit basis, the benefits of assigning broadband spectrum to dedicated PPDR services on an exclusive basis far outweigh the costs as measured by opportunity cost.

3.7 Dedicated spectrum for PPDR will ensure availability of the radio-wave for operations, when most needed. There can be no compromise on the availability and reliability of PPDR network at any time. Commercially allocated spectrum can get over-saturated in the event of a disaster and networks can get choked. A first responder will be able to render most critical assistance only if he has uninterrupted communication available. Hence dedicated spectrum should be assigned for BB-PPDR use in order to create a reliable nationwide PPDR network.

3.8 **Accordingly, the Authority recommends identifying dedicated spectrum for nationwide BB-PPDR communication network.**

B. Quantum of spectrum for PPDR

3.9 In the CP, the requirement of the amount of the spectrum for broadband PPDR has been discussed in detail. Examples of the various countries have also been discussed in order to ascertain minimum quantum of spectrum required. Most of the countries who have adopted broadband PPDR have identified and allocated 2x10 MHz spectrum in sub-GHz band to cater for the initial requirement. However, to cater for the blend of coverage and capacity, the assignment of 50 MHz in higher bands such as 4.9 GHz band has also been considered. Accordingly, the issue was raised in CP for the comments of the stakeholders.

3.10 In response, some stakeholders have stated that 2x10 MHz of spectrum will suffice to meet the PPDR requirements. 10 MHz downlink and 10 MHz uplink is in line with global practices being followed in early adoption countries.

3.11 One stakeholder has submitted that 2x5 MHz spectrum should be earmarked for BB-PPDR in lower frequency band. For additional capacity, 20-40 MHz in 5 GHz band should also be allocated for exclusive use of PPDR services.

3.12 One stakeholder has stated that award of 10 to 20 MHz for broadband PPDR is sufficient. Another stakeholder has submitted that LTE requires minimum of 1.4 MHz but realistically 10 MHz.

3.13 One stakeholder has categorically stated that spectrum in sub-GHz band preferably Band 27 (852/869/802-824 MHz) should be allocated for PPDR applications. The stakeholder has further stated that considering the large population in India, a contiguous frequency band of at least 20 MHz should be allocated for BB-PPDR. Depending on various scenarios, the data rate requirement may vary from 512 Kbps (daily law and order scenario) to 2 Mbps per video stream (for public events/emergency scenarios) for standards definition video.

Analysis

3.14 PPDR communication is critical for day-to-day functioning as well as to coordinate relief operations in the event of a disaster. BB-PPDR is expected to improve situational awareness of the first responders as well as resource controllers and there by assisting them in faster and efficient relief measures as well as enable efficient and optimum allocation of resources based on real time information. Availability of adequate spectrum to meet the high bandwidth communication requirements of BB-PPDR is a prerequisite to make the network operationally capable.

3.15 For broadband PPDR, South Korea and United States have allocated 2x10 MHz in 700 MHz band. Thailand has allocated 2x10 MHz in 800 MHz. UAE has allocated 2x10 MHz (for PPDR application) and 5 MHz (for direct mode operation) in 700 MHz band. Australia has allocated 10 MHz in 800 MHz band and 50 MHz in 4.9 GHz band. France has allocated 2x5 MHz and 2x3 MHz in 700 MHz band.

3.16 ECC report 199[8] on 'User requirements and spectrum needs for future European broadband PPDR systems (Wide Area Networks)' which is based upon the definitions in the Report ITU-R M.2033 describes the three PPDR operational environments, namely:

- day-to-day operations (category "PP1")
- large emergency and/or public events (category "PP2")
- disasters (category "DR")

The report suggests that spectrum amount in the range of 10 MHz for uplink and another 10 MHz for downlink are sufficient to cover the PP1, PP2 and early needs of a DR event.

3.17 Globally 2x10 MHz is earmarked for BB-PPDR communications. Keeping in view the geographical structure and density of population 2x10 MHz of dedicated spectrum would be sufficient for present and in the coming years.

3.18 As brought out in Para 3.5-3.7, the social cost of spectrum outweighs its commercial value. Hence it will be prudent to allocate dedicated 2x10 MHz of spectrum to the SPV formed for the implementation of BB-PPDR communication network on no-cost basis.

3.19 **Accordingly, the Authority recommends that 2x10 MHz of dedicated spectrum should be allocated nationwide to the SPV on no-cost basis for LTE based broadband PPDR networks.**

[8] http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP199.PDF

C. Spectrum band for broadband PPDR

3.20 In the consultation paper the issue was raised regarding which spectrum band will be most suitable for BB-PPDR.

3.21 In response, one stakeholder submitted that based on the global trends, band 28 should be earmarked for PPDR communications. APT 700MHz (Uplink: 713-748 MHz; Downlink: 768-803 MHz) is best for fulfilling the data service requirements of a PPDR network. Another stakeholder has suggested that PPDR networks should be allocated lower frequency spectrum band to ensure wider and deeper in-building coverage. The frequency bands which are not used or earmarked for commercial usage would be the best suitable for PPDR operations.

3.22 Some stakeholders consider 700 MHz/800 MHz band as most suitable. One stakeholder has submitted that 694-894 MHz band is having best coverage in terms of area of operation and suggested that the S-Band of unsold 700 MHz band can be identified for PPDR purpose.

3.23 One stakeholder stated that broadband PPDR in 700 and 800 MHz bands only are being recommended by ITU based on APT harmonization measures. According to Resolution 646, for narrowband PPDR, parts of 138-174 MHz, 351-370 MHz, 380-400 MHz frequency ranges have been adopted by Region 3 countries.

3.24 One stakeholder has suggested reserving 350-370 MHz and 380-400 MHz for PPDR digital trunking on a nationwide basis. In addition, parts of 138-174 MHz VHF should be made available for PPDR agencies on availability basis. The stakeholder has suggested 10+10 MHz in 700 (703-748/758-803 MHz) or 814-824/859-869 MHz as dedicated nation wide spectrum for PPDR LTE network.

3.25 Candidate bands for PPDR viz. 406.1-430 MHz, 440-470 MHz, 806-824/851-869 MHz, 4940-4990 MHz, 5850-5925 MHz, lowest frequency

around 700/800 MHz band, band 31, band 68 have been suggested by one stakeholder.

3.26 One stakeholder in detailed submission has proposed the following spectrum bands for BB-PPDR-

a. Use of Railway band (GSM-R) for areas away from railway track.
b. Allocate band as 703-748 for UL and 758-803 for DL, leaving 10 MHZ of central band. As per ITU APT for Region 3, any one or two 5+5 MHz or one 10+10 MHz channels can be used for broadband PPDR.
c. Other option is to allow LTE FDD mode in addition to PMRTS in 806-811 (5 MHz) paired with 851-856 MHZ (refer NFAP IND40) and bands 814-819 paired with 859-864 MHz (NFAP IND42).
d. There are multiple bands for PPDR and there is a need to allow Voice/GSM operation in the T-GSM (810 MHz) band. First responders may use tri-band phones supporting T-GSM band.

3.27 The stakeholder also proposed 40 MHz of spectrum 1452-1492 (within in 1427-1535 MHz) frequency band for mobile Broadband communications networks for setting up of secure and dedicated captive communication network for PPDR, Para-Military and State Governments and 40 MHz of spectrum in 3.3 GHz – 3.4 GHz frequency band for point to point (PTP) & PMP fixed wireless systems for setting up of secure and dedicated captive communication networks.

3.28 One stakeholder has suggested that PPDR networks should be developed in commercial bands which provides roaming, fall back, cost efficiencies due to ecosystem availability, costs and choice. The PPDR based on LTE can work in any IMT bands specified by 3GPP for LTE technology hence there is no need to earmark separate dedicated spectrum for PPDR. The stakeholder also submitted that the spectrum range in the sub-GHz range (852/869/802-824 MHz, in 694-894 MHz) could also be a better choice to provide a good blend of coverage, capacity, especially the deep

indoors or basements or interiors of localities typical of disaster incidents.

3.29 In response to the counter comments submitted by one stakeholder, another stakeholder pointed out erroneous submission through the counter comments. The stakeholder refers to the counter comments where is has been mentioned that the response is based on the Resolution 646 from WRC-12 and does not take into account the decisions taken by WRC-15. The gist of the reply submitted by the stakeholder is given as below:-

- It may be noted that while "Resolve 2" of WRC-15 of Resolution.646 (attached) encourages administrations to consider 694-894 MHz for PPDR (including broadband), "Resolve 3" from the same resolution clearly encourages administrations to further consider parts of 406.1-430 MHz, 440-470 MHz & 4940-4990 MHz for PPDR applications in Region 3 (where India belongs).
- "Resolve 3" provides the administrations to consider parts of the following regionally harmonized frequency ranges, for their PPDR applications in Region 3: 406.1-430 MHz, 440-470 MHz and 4940-4990 MHz.
- Additionally, the "Resolve 4" from the same Resolution mentions that "PPDR frequency arrangements within the frequency ranges specified in resolves 2 and 3, as well as countries' frequency arrangements for PPDR, should be included in Recommendation ITU-R M.2015;" hence if the country (India) decides to use 440-470 MHz band for BB-PPDR based on TRAI's recommendations, the finalized frequency arrangements may be submitted for inclusion in recommendation ITU-R M.2015.
- Therefore, in the light of the above clauses from Resolution 646, WRC-15, it can be mentioned that the suggestion to use 440-470 MHz for BB-PPDR is fully in line with the said Resolution.

3.30 The stakeholder, further mentioned few additional factors in his submission:-

- As has been observed in ITU-R M.2015, it should be noted that, "over time, narrowband PPDR applications, for example mission critical voice and low-data rate applications, may be provided by broadband systems".
- Since 400 MHz is already in use for PPDR applications in our country, it may be appropriate to designate the same frequency band for BB-PPDR considering the future migration path for narrowband to broadband PPDR system. It may also be easier to earmark this band for BB-PPDR since it is already in use for PPDR.
- A frequency band of at least 20 MHz may be required for BB-PPDR so that it could cater to the requirements of public safety communication in the country. Since 700 MHz band has been allocated for commercial IMT applications, it may be difficult to allocate 20 MHz spectrum for BB-PPDR in this frequency band.
- It can be said that the usage of 440-470 MHz for BB-PPDR is not only in line with Resolution 646, WRC-15 but is also an appropriate band for this purpose for our country

3.31 One stakeholder has categorically recommended to designate the band 440-470 MHz as the nationally harmonized spectrum dedicated for Broadband PPDR operations considering the following factors:

a. Since the frequency range of 440-470 MHz has been identified as one of the PPDR bands for Region 3 in WRC 15 Resolution 646, it should be considered for BB-PPDR applications. Designating this complete range (440-470 MHz) for BB-PPDR would help in harmonization as well as better alignment of NFAP with WRC 15-Resolution 646.
b. In terms of path loss in outdoor environments, performance in 400 MHz will be better than that of other higher frequency bands, say 700/800 MHz. Building penetration in urban areas, including indoor

coverage in difficult places such as stairwells, is also good for 400 MHz.

c. The communication network using 400 MHz band is likely to have lesser number of base stations than the one using 700/800 MHz band, which is expected to result in the reduction of CAPEX and OPEX.

d. Existing narrow band systems (TETRA/P25/DMR) are currently deployed in 400MHz/800MHz

Analysis

3.32 According to the National Frequency Allocation Plan (NFAP 2011) released by DoT [9], "*public protection and disaster relief (PPDR) communications including Broadband Wireless Access may be considered, as far as possible, in the Frequency band 380-400 MHz, 406.1-430 MHz, 440-470 MHz, 746-806 MHz, 806-824/851-869 MHz, 4940-4990 MHz and 5850-5925 MHz on a case-by-case basis depending on specific need and equipments availability*".

3.33 As mentioned in the CP, ITU's Resolution 646 (WRC-03)[10] states that for the purposes of achieving regionally harmonized frequency bands/ranges for advanced public protection and disaster relief solutions, consider following identified frequency bands/ranges or parts thereof when undertaking their national planning: 406.1-430 MHz, 440-470 MHz, 806-824/851-869 MHz, 4940-4990 MHz and 5850-5925 MHz. Additionally, according to the Resolution 646 (rev. WRC-12)[11]; some countries in Region 3 (Region 3 includes India too) have also identified the bands 380-400 MHz and 746-806 MHz for PPDR applications.

[9] http://www.wpc.dot.gov.in/Docfiles/National%20Frequency%20Allocation%20Plan-2011.pdf
[10] https://www.itu.int/dms_pub/itu-r/oth/0A/0E/R0A0E00006A0001MSWE.doc
[11] www.cept.org/files/9421/Resolution%20646%20(Rev.%20WRC-12).docx

3.34 The Resolution 646 (REV. WRC-15) [12] encourages administrations to consider parts of the frequency range 694-894 MHz, when undertaking their national planning for their PPDR applications, in particular broadband, in order to achieve harmonization. It further encourages administrations to also consider parts of the following regionally harmonized frequency ranges, for their PPDR applications: –

- *In Region 1:* 380-470 MHz
- *In Region 3:* 406.1-430 MHz, 440-470 MHz and 4940-4990 MHz

3.35 Exiting PPDR agencies are governed through the licensing norm defined under Captive Mobile Radio Trunking Service (CMRTS) category of license. Agencies are authorized to set up and run the network by these agencies for their captive purposes. DoT through a separate communication has informed that existing Captive networks are mainly in the bands indicated in the table below:-

Table 3.1: Frequency Bands -CMRTS

Sl No.	**Contiguous frequency band (MHz)**	**Sub-band (MHz)**	**Total Bandwidth**	**NFAP-2011 provision**	**No. of cities with captive networks**
1.	336-340/ 346-350	338-340/ 348-350	2.0 MHz	CMRTS and PMRTS	2
2.	351-358/ 361-368	351-356/ 361-366	5.0 MHz	Digital CMRTS	2
3.	380-389.9/ 390-399.9	380-389.9/ 390-399.9	9.9 MHz	Digital CMRTS and PMRTS	15
4.	806-824/ 851-869	806-811/ 851-856	5.0 MHz	CMRTS	28
5.		811-814/ 856-859	3.0 MHz	Digital CMRTS and PMRTS	9
6.		819-824/ 864-869			15

[12] https://www.itu.int/en/ITU-R/information/Documents/Res.646(WRC-15).pdf

3.36 The 700 MHz (3GPP band B28) band is being adopted as a prime band for LTE technology by a number of countries in the Asia-Pacific (APAC), Middle East, Europe and Latin American region. Commercial launches are already there in some of the countries and more are expected in near future. Some of the countries viz. United States, South Korea and Mexico have either deployed or has considered for deployment of PPDR services in 700 MHz band through commercial arrangement or exclusive basis.

3.37 In response to the issue raised in the CP, some stakeholders have preferred the PPDR networks to be deployed in 700 MHz band. These stakeholders were of the view that there is no need to have dedicated spectrum for broadband PPDR applications since PPDR based on LTE can work in any IMT bands specified by 3GPP for LTE technology. These stakeholders have also argued that such deployment offers significant benefits of a large and sustainable ecosystem, development of devices in band 28 for India market. Some other advantages as indicated by the stakeholders in order to consider the deployment in commercial bands are roaming, fall back cost efficiencies due to ecosystem availability, cost and choice.

3.38 GSMA in white paper 'Network 2020: Mission Critical Communications' published in 2017 has mentioned that-

'Regulatory challenges to spectrum for consumer mobile broadband access Mission Critical Communications applications, such as PPDR, are vital and must be supported. However, this need not, and should not, threaten affordable, widespread mobile broadband access for citizens and businesses. Any efforts to use part of the 700 MHz band's uplink or downlink channels for PPDR would reduce the amount available for mobile services which in turn can negatively impact the cost, coverage and capacity of mobile broadband. Instead, exclusive spectrum for PPDR services can be found outside of commercial mobile band plans.'

3.39 In India, as per policy of the government, 2x35 MHz frequency in 700 MHz band (band 28) is under consideration for auction to provide the IMT- Advanced mobile services in future. In the coming years, 700 MHz band is expected have major ecosystem for LTE-Advanced and future services worldwide. In the event, 2x5 MHz or 2x10 MHz is considered for the PPDR operations, remaining 25-30 MHz may not be sufficient to cater for the IMT- Advanced or 5G services in the country. Hence, the Authority is not in favor of assigning a portion of 700 MHz band for PPDR use.

3.40 As per the information provided by DoT, most of the PPDR networks are assigned spectrum in the frequency range 806-824/851-869 MHz. Out of this frequency range most of the assignment to PPDR agencies are in 806-811/851-856 MHz and 819-824/864-869 MHz frequency bands.

3.41 Keeping in view of the facts enumerated above, it appears that broadband PPDR can be considered in the frequency range 806-824/851-869 MHz band. Since substantial existing allocations for PPDR networks are in the sub-bands in the frequency range 806-824/851-869 MHz, the evolution/ migration to LTE based PPDR networks from the user's perspective would be better if considered in this band only.

3.42 Further, Asia-Pacific Telecommunity (APT)[13] report on 'Harmonization of frequency ranges for use by wireless PPDR applications in Asia-Pacific region' has been adopted by APT in April, 2017. Various frequency arrangements and other parameters have been listed in the report. Frequency arrangement number G3-1-4 in 800 MHz comprises for Channel arrangements for a combination of narrowband PPDR and broadband PPDR in the band 806-824/851-869 MHz**.**

[13] Source: APT

3.43 The arrangement shows how narrowband and broadband systems can be deployed in the band 806-824/851-869 MHz while ensuring the necessary protection of the APT 700 MHz band from adjacent band interference. The sub-band 806-813/851-858 MHz is used for narrowband systems with a channel bandwidth of 25 kHz; the sub-band 814-824/859-869 MHz is used for broadband (LTE) systems using carrier bandwidths of 5 to 10 MHz. The sub-band 813-814/858-859 MHz acts as guard band between narrowband and broadband systems.

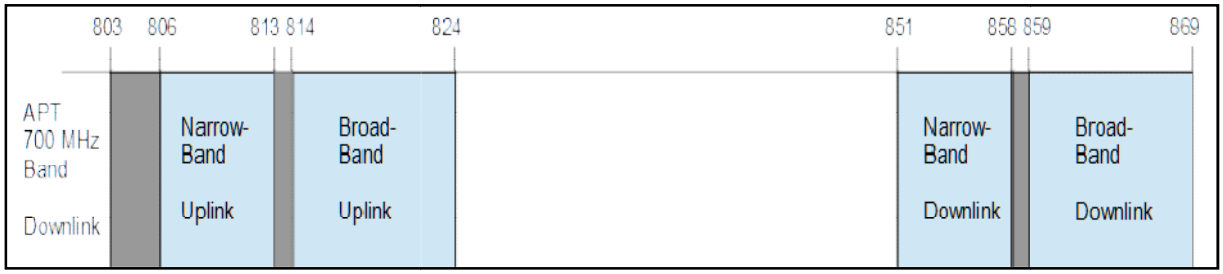

Figure 3.1: Example of frequency arrangement for a combination of narrowband and broadband systems

3.44 Through the arrangement described above, 10 MHz of the bandwidth in the frequency range 814-824 MHz can be assigned for broadband PPDR services in the country. For the frequency range 819-824/864-869 MHz; a portion 865-867 MHz of the frequency band has already been delicensed for the use of Low Power Equipment and further 867-868 MHz (1 MHz) has been recommended to be delicenced by the Authority for Machine-to-Machine (M2M) communications in its recommendations dated 5th September, 2017. Large ecosystem is expected to be deployed in this range for M2M based services on low power devices. However, DoT through a separate communication dated 6th February, 2018 has clarified that since the de-licensing is effected on a shared basis for low power applications (maximum power 1 Watt in 200 KHz bandwidth), it does not preclude the use of this band for various radiocommunication services, as per provisions made in the NFAP.

3.45 Presently there are certain assignments to PMRTS and CMRTS licensees in the frequency range 814-824/859-869 MHz. If the range is considered for broadband PPDR operations, then these assignments shall required to be refarmed to other sub-bands in the frequency range 806-814/851-859 MHz. Such migration can be done on a case-to-case basis with the coordination of DoT. The analog PMRTS services operating in this band can be refarmed to digital PMRTS services in 811-814/856-859 MHz band.

3.46 The frequency range of 440-470 MHz has been identified as one of the PPDR bands for Region 3 in WRC 15 Resolution 646. It has been suggested by one stakeholder to designate the band 440-470 MHz as the nationally harmonized spectrum dedicated for broadband PPDR operations. The stakeholder has mentioned that the 440-470 MHz band is advantageous due to better path loss in outdoor environments, performance in 400 MHz will be better than that of other higher frequency bands, say 700/800 MHz. Also building penetration in urban areas, including indoor coverage in difficult places such as stairwells, is also good for 400 MHz.

3.47 There are certain deployments in 400 MHz band for PMRTS and CMRTS services in India. As mentioned in the Table 3.2 above, major CMRTS licensees are operating in the frequency range 380-389.9/390-399.9 MHz. Out of these CMRTS licensees, there are very few PPDR agencies who are assigned spectrum in this frequency range. It is worth mentioning that TETRA and P25 networks are implemented in low frequency bands for better coverage, often using the 400 MHz band range.

3.48 Frequency range 440-470 MHz can be considered for broadband PPDR operations since the band has been identified as one of the PPDR bands for Region 3 in WRC 15.

3.49 While evaluating the options it appears that presently there is insufficient ecosystem for broadband PPDR in this frequency range. In future it is expected that advantages of propagation characteristics in 400 MHz band will help in the development of multiband operations. Hence it would be appropriate if 20 MHz of this band could be considered for future development of broadband PPDR.

3.50 **Accordingly, the Authority recommends that:**

(a) 2x10 MHz of the dedicated spectrum, 814-824/859-869 MHz, should be assigned for nationwide BB-PPDR services as per APT Frequency Arrangement number G 3-1-4. Necessary amendments may be made in the NFAP accordingly.

(b) 20 MHz of spectrum in the frequency range 440-470 MHz (preferably 450-470 MHz) should be allocated for future evolution of broadband PPDR. Necessary amendments may be made in the NFAP accordingly.

CHAPTER IV: SUMMARY OF RECOMMENDATIONS

4.1 The Authority recommends setting up a pan-India integrated Broadband PPDR (BB-PPDR) Communication Network (to be called "National BB-PPDR Network") based on 3GPP PS-LTE technology. [Para 2.12]

IMPLEMENTATION METHODOLOGY

4.2 The Authority recommends putting in place a hybrid model of BB-PPDR network in India in which dedicated network for BB-PPDR communication funded by government be created in metro cities, border districts, disaster prone areas (identified by NDMA) and sensitive areas like J&K and North East by PSU like BSNL/MTNL. The existing commercial network can be leveraged in other regions through any TSP. [Para 2.46]

4.3 The Authority recommends putting in place stringent SLAs by the SPV. Operators should be mandated to provide mobile BTS and backpack devices in case of disaster when terrestrial network gets damaged/ dysfunctional, in order to make available communication facilities for PPDR agencies with in specific time limits as derived in SLAs. [Para 2.51]

4.4 The Authority recommends forming a Special Purpose Vehicle (SPV) under MHA to plan, coordinate and steer the nationwide BB-PPDR communication network implementation and its subsequent operation. [Para 2.61]

4.5 The Authority recommends forming an advisory committee which should include representatives from all disciplines of public safety, State Government, Central Government and Ministry of Communications, to provide domain specific advice to the SPV for

conception, implementation, operation and maintenance of the BB-PPDR communication network. [Para 2.62]

4.6 The Authority recommends that DoT should study the feasibility of doing away with CMRTS license for PPDR agencies in phased manner. The SPV shall be the nodal agency to coordinate with DoT for allocation of spectrum and other issues. The PPDR agencies and details of equipment deployed by them can be registered with DoT through SPV. [Para 2.66]

4.7 The Authority recommends that DoT should work out timelines to Phase out existing analog networks in PPDR in a phased manner. New spectrum assignments may be done only for deploying digital equipment. [Para 2.68]

TRIALS

4.8 The Authority recommends carrying out pilot testing prior to the implementation of BB-PPDR dedicated network (dedicated spectrum and network) to be implemented through BSNL/MTNL, funded by the Central Government, at five zones identified as disaster prone/sensitive areas to evaluate the efficacy of the proposed network. The plan for migration of existing legacy equipment on to the new network is to be formulated after comprehensive study during this pilot testing. [Para 2.70]

4.9 The Authority recommends testing the efficacy of PPDR trunking service roaming on public telecom networks during pilot testing, and if found feasible, it should be implemented on pan-India basis. [Para 2.81]

SPECTRUM

4.10 The Authority recommends identifying dedicated spectrum for nationwide BB-PPDR communication network. [Para 3.8]

4.11 The Authority recommends that 2x10 MHz of dedicated spectrum should be allocated nationwide to the SPV on no-cost basis for LTE based broadband PPDR networks. [Para 3.19]

4.12 The Authority recommends that:

(a) 2x10 MHz of the dedicated spectrum, 814-824/859-869 MHz, should be assigned for nationwide BB-PPDR services as per APT Frequency Arrangement number G 3-1-4. Necessary amendments may be made in the NFAP accordingly.

(b) 20 MHz of spectrum in the frequency range 440-470 MHz (preferably 450-470 MHz) should be allocated for future evolution of broadband PPDR. Necessary amendments may be made in the NFAP accordingly. [Para 3.50]

LIST OF ACRONYMS

2G	2ND GENERATION OF WIRELESS TECHNOLOGY
3G	3RD GENERATION OF WIRELESS TECHNOLOGY
3GPP	3RD GENERATION PARTNERSHIP PROJECT
4G	4TH GENERATION OF WIRELESS TECHNOLOGY
APAC	ASIA-PACIFIC
APT	ASIA PACIFIC TELECOMMUNITY
BB-PPDR	BROADBAND PPDR
BSNL	BHARAT SANCHAR NIGAM LIMITED
BTS	BASE TRANSCEIVER STATION
CAPEX	CAPITAL EXPENDITURE
CMRTS	CAPTIVE MOBILE RADIO TRUNKED SYSTEMS
COAI	CELLULAR OPERATORS ASSOCIATION OF INDIA
CoW	CELL ON WHEELS
CP	CONSULTATION PAPER
DCPW	DIRECTORATE OF COORDINATION POLICE WIRELESS
DDoS	DISTRIBUTED DENIAL-OF-SERVICE
DL	DOWNLOAD
DMR	DIGITAL MOBILE RADIO
DoT	DEPARTMENT OF TELECOMMUNICATION
ECC	ELECTRONIC COMMUNICATION COMMITTEE
eMBMS	EVOLVED MULTIMEDIA BROADCAST MULTICAST SERVICES
ESMCP	EMERGENCY SERVICES MOBILE COMMUNICATIONS PROGRAMME
ESN	EMERGENCY SERVICES NETWORK
FDD	FREQUENCY DIVISION DUPLEX
GSM	GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS
HQ	HEADQUARTERS
IECRS	INTEGRATED EMERGENCY COMMUNICATION AND RESPONSE SYSTEM
IMT	INTERNATIONAL MOBILE TELECOMMUNICATIONS
IoT	INTERNET OF THINGS
IP	INTERNET PROTOCOL
IP PBX	PRIVATE BRANCH EXCHANGE WITH IP CONNECTIVITY
ITU	INTERNATIONAL TELECOMMUNICATION UNION
J&K	JAMMU & KASHMIR
KPI	KEY PERFORMANCE INDICATOR
LSA	LICENSED SERVICE AREA
LTE	LONG TERM EVOLUTION
M2M	MACHINE TO MACHINE
MCPTT	MISSION CRITICAL PUSH TO TALK
MHA	MINISTRY OF HOME AFFAIRS
MNO	MOBILE NETWORK OPERATOR

MTNL	MAHANAGAR TELEPHONE NIGAM LIMITED
MVNO	MOBILE VIRTUAL NETWORK OPERATOR
NDMA	NATIONAL DISASTER MANAGEMENT AUTHORITY
NFAP	NATIONAL FREQUENCY ALLOCATION PLAN
NPSBN	NATIONWIDE PUBLIC SAFETY BROADBAND NETWORK
OHD	OPEN HOUSE DISCUSSION
OPEX	OPERATING EXPENSES
OTT	OVER THE TOP
P25	PROJECT 25
PAN	PRESENCE ACROSS NATION
PBX	PRIVATE BRANCH EXCHANGE
PMP	POINT TO MULTI-POINT
PMRTS	PUBLIC MOBILE RADIO TRUNKING SERVICE
PP	PUBLIC PROTECTION
PPDR	PUBLIC PROTECTION AND DISASTER RELIEF
PSAC	PUBLIC SAFETY ADVISORY COMMITTEE
PS-LTE	PUBLIC SAFETY-LTE
PSTN	PUBLIC SWITCHED TELEPHONE NETWORK
PSU	PUBLIC SECTOR UNDERTAKING
PTP	POINT TO POINT
PTT	PUSH TO TALK
QoS	QUALITY OF SERVICE
RAN	RADIO ACCESS NETWORK
RFP	REQUEST FOR PROPOSAL
SLA	SERVICE LEVEL AGREEMENT
SPV	SPECIAL PURPOSE VEHICLE
SUC	SPECTRUM USAGE CHARGES
TETRA	TERRESTRIAL TRUNKED RADIO
TRAI	TELECOM REGULATORY AUTHORITY OF INDIA
TSP	TELECOM SERVICE PROVIDER
UHF	ULTRA HIGH FREQUENCY
UK	UNITED KINGDOM
UL	UPLOAD
USA	UNITED STATES OF AMERICA
USOF	UNIVERSAL SERVICE OBLIGATION FUND
UTs	UNION TERRITORIES
VHF	VERY HIGH FREQUENCY
VoIP	VOICE OVER IP
VoLTE	VOICE OVER LTE
WPC WING	WIRELESS PLANNING COORDINATION WING
WRC	WORLD RADIO COMMUNICATION CONFERENCES